# Summary Sheet:

If you have land and you want to make the best use of it. You may think that the best option is the one that gives the higher economic profit. But what about other aspects such as environmental, social, and suitability? You will ignore them!

In studying an option, economic, environmental, and social effects are crucial steps to determine the best use. In addition, measuring how much the land properties would contribute to deciding which facility to choose.

To achieve the best use of the land we defined certain metrics and applied them to study multiple options. We classified our metrics into economic, environmental, social, and suitability. To evaluate the economical metric, we used the Net Present Value metric to measure the profit of each facility considering the initial cost. To study the ecological impact, we used the Economical Footprint metric. And for social we combined two different metrics which are the Need of Society for a Facility and Community Engagement. In addition, we studied the suitability of the land by calculating the errors of several factors that are related to the land's nature. We used our metrics to decide which option of a list (football stadium, skiing facility, regenerative farm, solar array, agrivoltaic farm, agritourist center, and agroforestry farming) to found in an American land that exists in New York near Syracuse in a rural area. We divided it into three sections depending on its mutual geographical properties. And the best three projects which got the highest scores were the football stadium, regenerative farm, and solar arrays.

After that, we studied the effect of a nearby semiconductors fabrication facility on our options and re-evaluated our metrics. Moreover, we worked on measuring how much our model can be generalizable. This was done by implementing our model on "Al-Bassa" land from our country and discussing our metrics again.

Overall, we found that choosing a facility to found requires analyzing its economic, environmental, and social impacts and studying the land's geographical properties

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# 1 Introducing:

## 1.1 Background:

Land use has always gone through significant stages during human life. Long ago, humans used to hunt and utilize the land for subsistence and survival. As societies developed and became more organized, they started using land for cultivating and raising livestock. Over time, land use became more complex as the community grew and evolved. In the Middle Ages, feudal systems appeared in many parts of the world, where lords owned most lands for protection and resources in return. In the 19th century, the Industrial Revolution brought about significant changes in land usage, as cities grew and industrial activities were more widespread. In the 20th century, land use planning became a crucial tool for managing land use and development. With the growth of urbanization and suburbanization, there was a need to ensure that land was being used in a way that supported economic growth, social equity, and environmental sustainability. Governments started hiring urban planners to develop cities and regions.

Today, land use remains a critical issue, as global population growth and urbanization pose a challenge to land resources. Land use policies and practices must balance society, economy, and environmental needs. And ensure that land is being used sustainably over the long term.

## 1.2 Problem restatement:

Dividing the problem into smaller, more manageable components can facilitate comprehension and enable the construction of a cohesive and well-organized solution. By decomposing complex tasks into simpler subtasks, we can say that our job involves solving the following subtasks:

1- Set our different quantitative decision metrics.
2- Explain how would they contribute to defining the best use of the land.
3- Implement our metrics on the chosen options.
4- Construct our model that will Determine which facility is the best option for the land.
5- Discuss The impacts of a nearby semiconductor fabrication facility on our model.
6- Re-evaluate our options in the case of a nearby semiconductor fabrication facility.
7- Discuss how would our model work in another land that we are familiar with.
8- Evaluate how much our model appropriable and generalizable is.
9- Discuss the strengths and the limitations of our model.
10- Write a one-page letter to the Decision Makers that contains our piece of advice and provides an explanation of our results.

## 1.3 Basic assumptions with justifications

Here are the main and basic assumptions and justifications that will cover all the solution, each task will have its specific ones, they will be mentioned in the beginning of each task.

Assumption: the facilities in the land do not interact with each other.

Justification: in the problem we are discussing facilities those are not related strongly to each other, so the relation effect is neglected.

Assumption: the economic condition is affected by the feature disasters (e.g. viruses and wars), but will not be considered.

Justification: in the problem we are studying the metrics without any prediction for the upcoming disasters, these predictions are hard, not accurate and the disaster may happen suddenly in any time, in addition these disasters will make the economic metric not regularly to evaluate.

## 1.4 Glossary and variables

### 1.4.1Glossary

- Best use: this term will refer to the best possible facilities that we can put in the land, it does not mean that we will benefit from each meter from the land.
- The local Area: this term refers to the people who are living in Wayne, Seneca, Cayuga, Oswego, Onondaga, Yates and Ontario counties. These counties are the nearest ones to our land.

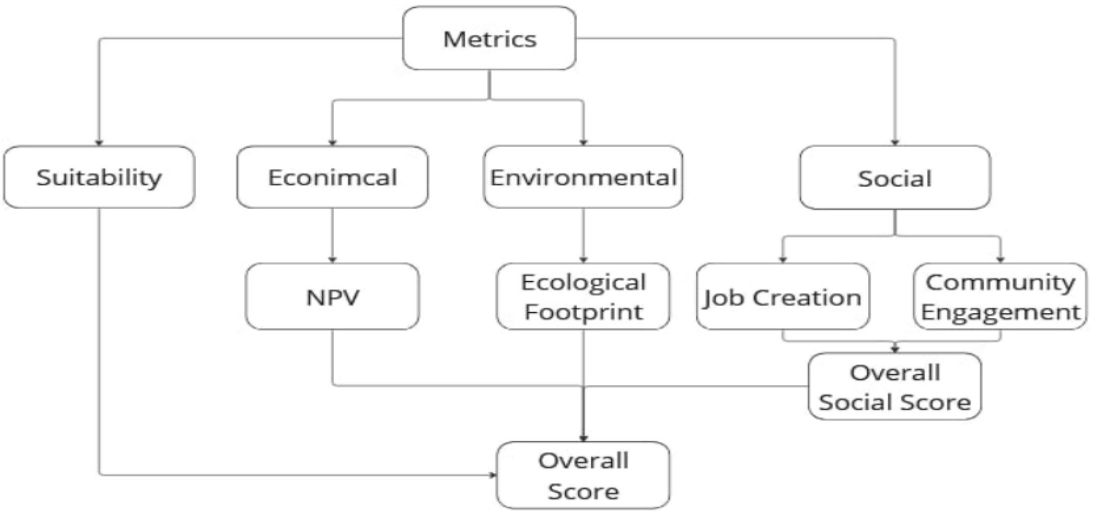
### 1.4.2 Variables

Here are the basic variables for all the solution, other variables will be in later sections Variables:

| Variable | Definition |
|---|---|
| $OS_i$ | The overall score for facility $i$ |
| $OS$ | The overall score for the land |

# 2 Quantitative decision metrics:

In order to compare between possible facilities, it is necessary to study their economic, environmental and social impacts. Therefore, three different types of metrics will be considered to determine the appropriate use of the land. As illustrated in the following concept map:




## 2.1 Economical Metrics:

The economic impact of each project will be measured by two metrics, related to the cost and profit.

### 2.1.1 Economical variables and constant:

| Variables and Constant | definition |
|---|---|
| $R_{i,t}$ | Is the revenue of the project $i$ in year $t$ |

| | |
|---|---|
| $C_{i,t}$ | Is the cost of the project $i$ in year $t$, |
| $r$ | Is the discount rate |
| $t$ | Is the year number |
| $i$ | Is the cost of capital or annual interest rate |
| $NPV_{i,t}$ | Is the net present value of project $i$ in the year $t$ |
| $n$ | Is the number of years |

### 2.1.2 Net present value (NPV):

NPV is one of the most common methods used to calculate the economic profit. It works by discounting all future cash flows (both in- and out-flow) which result from the innovation facility with a given discount rate and then summing them together, as follows:

$$NPV_i = \sum_{t=1}^{n} \frac{R_{i,t}}{(1+r)^t} - \sum_{t=0}^{n} \frac{C_{i,t}}{(1+r)^t} \qquad (1)$$

Where, $n$ the number of years, $t$ is the year number t $\in \{1,2,3, \dots, \text{ n}\}$, $NPV_i$ is the net present value of project $i$, $R_{i,t}$ is the revenue of the project $i$ in year $t$, $C_{i,t}$ is the cost of the project $i$ in year $t$, and $r$ is the discount rate. (Cost-effectiveness Analysis, 2021)

The discount rate reflects the opportunity cost of the capital mobilized, which increases with the estimated riskiness of the innovation opportunity. Typical discount rates used for corporate projects range from 10 percent to 15 percent (Zizlavsky, 2014), we can calculate it as follow:

$$r = (1+i)^n - 1 \qquad (2)$$

Where $i$ is the cost of capital or annual interest rate.

And the cash flow is the $R_{i,t} - C_{i,t}$

(See appendix A)

## 2.2 Environmental metrics:

### 2.2.1Environmental variables and constant:

| Variables and Constant | Definition |
|---|---|
| $n$ | Is number of factors |
| $EF$ | Is Ecological Footprint |
| $f_i$ | Is the factor $i$ |

Each facility has environmental influences like pollution and resources consumption and they must be considered to choose the best projects. Therefore, the following environmental metrics will be explained.

### 2.2.2 Ecological footprint:

measures the number of natural resources required to sustain human activities and is usually measured in terms of global hectares (gha). It takes into account the use of land, water, and energy resources, as well as the waste generated by human activities. The lower the ecological footprint, the more sustainable the land use.

( Wackernagel & Kitzes, 2008)

To illustrate ideas clearly, we divided the calculation of this metric into steps:

1- Defining the scope of the analysis:

This involves identifying the boundaries of the project or activity and determining the critical factors such as:

- Energy consumption (in kWh): is the total amount of energy required for a given process and is measured in kilowatt hours (kWh). This includes the use of electricity, gas, diesel, oil, and biomass. (Vosooghzadeh, 2020)
- Water consumption (in cubic meters): Water consumption refers to the amount of water that is used by an individual, a community, or a region for various purposes. It is the amount of water that is withdrawn from a water source and is either used or lost through evaporation or leakage. (Reig, 2013)
- Food consumption (in kilograms): is the amount of food and calories that are consumed by people. Calories measure the energy within foods (Global Food Consumption).
- Waste generation (in kilograms): includes all materials discarded, whether or not they are later recycled or disposed in a landfill. (Estimated Solid Waste Generation Rates)
- Carbon footprint (in kg $CO_2e$): is the total amount of greenhouse gases (including carbon dioxide and methane) that are generated by our actions. (Calculate Your Carbon Footprint)

2- Collecting data on resource use and emissions:
The next step is to collect data on the resource use and emissions associated with the project or activity. This can involve gathering information about the above factors.

3- Converting resource use and emissions into ecological footprint units:
After collecting the data, it should be converted into ecological footprint units (global hectares "gha") and here some conversions to gha:

| | |
|---|---|
| Energy consumption (1 kWh) | 0.0008 global hectares |
| Water consumption (1 cubic meters) | 0.0011 global hectares |

| | |
|---|---|
| Food consumption (1 kilograms) | 0.0074 global hectares |
| Waste generation (1 kilograms) | 0.0011 global hectares |
| Carbon footprint (1 kilogram) | 0.000136 global hectares |

4- Calculate the Ecological Footprint:
We can calculate the ecological footprint by adding all the factors up as shown in the following formula:

$$EF = \sum_{i=1}^{n} f_i \qquad (3)$$

Where $f_i$ is the factor $i$ and $EF$ is Ecological Footprint value.
(Wackernagel, Our Ecological Footprint: Reducing Human Impact on the Earth, 1996)

## 2.3 Social Metric:

The social acceptance of a project is one of the factors that affect the decision of the apt project. We suggested two main metrics to study the social impact shown below.

### 2.3.1 Social variables and constant:

| Variables and Constant | Definition |
|---|---|
| $NE$ | Is the number of employers |
| $LF$ | Is the number of labor force in the society |
| $NSF$ | Is the Need of Society to a Facility |
| $PI_i$ | Is the number of people involved in the |
| $TP$ | Is the total population |
| $CE_i$ | Is the Community Engagement of the facility $i$ |

### 2.3.2 Need of Society to a Facility:

This metric measures how much people need the facility. We can calculate it as follow:

$$NSF = \frac{LF - NE}{LF} \qquad (4)$$

Where $LF$ is the number of labor force (above 16 year), $NE$ is the number of employers provided from other facilities.

As a result, the society need the facility in the rate of $NSF$.

### 2.3.2 Community Engagement:

We believe that the project that had better impact on the society when more people benefit of its services. Therefore, this metric calculates the number of people involved in the project, and it could measure the acceptance of the project.

We can calculate as follow:

$$CE_i = \frac{PI_i}{TP} \qquad (5)$$

Where $PI_i$ is the number of people involved in the project $i$, and $TP$ is the total population.

### 2.3.3 Overall Social Score:

Now we can calculate the total social score by the following formula:

$$OSS = NSF \times CE_i \qquad (6)$$

## 2.4 Studying the suitability of the land for a project:

### 2.4.1Suitability Variables and constants:

| Variable or constant | Description |
|---|---|
| $Se$ | Is the slope error |
| $Sl$ | Is the slope of the land |
| $Sb$ | Is the best slope for founding the project |
| $Ce$ | Is the tree cover error |
| $Cl$ | Is the tree cover of the land |
| $Cb$ | Is the best tree cover for founding the project |
| $Te$ | Is the temperature error |
| $Tl$ | Is the temperature of the land |
| $Tb$ | Is he best temperature for founding the project |
| $Re$ | Is the rainfall amount error |
| $Rl$ | Is the rainfall amount of the land |
| $Rb$ | Is the best rainfall amount for founding the project |
| $SNe$ | Is the snowfall amount error |
| $SNl$ | Is the snowfall amount of the land |
| $SNb$ | Is the best snowfall amount for founding the project |
| $NH$ | Is the natural hazard metric |
| $HS$ | Is the safety from natural Hazards |
| $NE_i$ | the normalized error of the $i_{th}$ factor |
| $e_i$ | is the error value of the factor $i$ |
| $e_{max}$ | the maximum error value |

| | |
|---|---|
| $e_{min}$ | the minimum error value |
| $S_i$ | the suitability score of the factor $i$ |
| $SS$ | Is the overall suitability score |

We believe that studying the geographical properties of the land is necessary for avoiding many challenges that will be faced during the project's founding. These obstacles may be hard to study and cause loss.

The study will be done by finding the effect of the following factors.

### 2.4.2 Topographical

The topographical effect is represented by the following factors:

#### *2.4.2.1 The land slope*

Its effect differs from one project to another. For example, flat lands are more suitable for farming. On the other hand, skiing requires more sloped ones. (Çellek, 2020)

To measure the slope suitability, we will define a variable called slope error. It will be measured with the following formula:

$$Se = \left|\frac{Sl - Sb}{\max(Sb, 1)}\right| \tag{7}$$

Where:

$Se$ is the slope error.

$Sl$ is the slope of the land.

$Sb$ is the optimal slope for founding the project.

Note that the $Max(Sb, 1)$ is been considered to avoid dividing by 0 in case the Sb values is 0.

Whenever the $Se$ value is closer to 0, the slope will be considered more suitable.

#### *2.4.2.2 The land aspect*

The difference of aspects will lead to different amounts of sunlight that a site receives which will affect the suitability of a site for solar energy. In addition, the temperature will differ which will affect the suitability of the land for crops.

### 2.4.3 Tree cover

The lands that contain trees are less suitable for building structures. Cutting trees will cause negative environmental impacts and is denied in many countries. On the other hand, keeping them may support other projects.

Measuring the tree cover suitability will be done by calculating the tree cover error with the formula:

$$Ce = \left|\frac{Cl - Cb}{\max(Cb, 1)}\right| \tag{8}$$

Where:

$Ce$ is the tree cover error.

$Cl$ is the tree cover of the land.

$Cb$ is the optimal tree cover for founding the project.

### 2.4.4 Soil

The soil type defines the land stability for building structures. In addition, analyzing its properties will help the decision makers to decide the best crops to grow. This process will be done in 4 main steps which are: (Walworth)

1) soil sample collection,

2) laboratory analysis,

3) interpretation of results

4) fertilizer or other management recommendations.

the analyzing process will determine wither the soil is suitable or not.

### 2.4.5 Climate:

Its effect is represented in the following factors:

#### *2.4.5.1 Temperature*

High temperatures are proper to apply certain projects like growing some kind of crops. On the other hand, it has bad effect on other projects like solar panels. Therefore, the optimal temperature differs from one project to another.

Measuring the temperature suitability will be done by calculating the temperature error with the formula:

$$Te = \left| \frac{Tl - Tb}{\max(Tb, 1)} \right| \quad (9)$$

Where:

$Te$ is the temperature error.

$Tl$ is the temperature of the land.

$Tb$ is the optimal temperature for founding the project.

#### *2.4.5.2 Lightness*

High lightness degree is necessary for founding many projects such as crops and solar panels. On the other hand, it may affect other facilities negatively. Therefore, each project has a proper lightness degree.

#### *2.4.5.3 Rainfall*

Many crops require high amounts of rainfall. While others may be affected negatively. Each project has an optimal value of rainfall amount. And the rainfall suitability will be measured by calculating the rainfall amount error with the formula:

$$Re = \left|\frac{Rl - Rb}{\max(Rb, 1)}\right| \qquad (10)$$

Where:

$Re$ is the rainfall amount error.

$Rl$ is the rainfall amount of the land.

$Rb$ is the optimal rainfall amount for founding the project.

If the $Re$ value is greater than one, rainfall amount of the land will be considered unsuitable and the project will not be applied, for the large difference between the rainfall amount of the land and the optimal one.

*2.4.5.4 Snowfall*

Snow is necessary to create some projects such as skiing facility. Where it may cause damage to others like crops.

The snowfall amount suitability of each project will be measured by calculating the snowfall amount error with the formula:

$$SNe = \left|\frac{SNl - SNb}{\max(SNb, 1)}\right| \qquad (11)$$

Where:

$SNe$ is the snowfall amount error.

$SNl$ is the snowfall amount of the land.

$SNb$ is the optimal snowfall amount for founding the project.

2.4.6 Natural hazards

The land may be prone to natural hazards such as floods, earthquakes, or wildfires, which can affect the feasibility and safety of founding projects on it. The natural hazards affect will be measured with the following formula:

$$NH = \frac{NH_n}{n} \qquad (12)$$

Where:

$NH$ is the natural hazard metric which represents the possibility of their occurrence

$NH_n$ represents the number of natural hazards that happened in the last n years. And the value of n will be determined depending on data availability.

If the $NH$ value is greater than 1. It means that a natural hazard may happens each year. Therefore, the land will be considered risky and unsuitable to apply the project.

We will define a variable that represents the land safety from national hazards. Its value does not differ from one project to another and it will be calculated as follows:

$$HS = (1 - NH) \times 100\% \qquad (13)$$

Where $HS$ represents the safety from natural Hazards and $NH$ is the natural hazards metric.

**Calculating the Overall suitability score**

After calculating the error of each factor. The resulted values will be normalized using the formula:

$$NE_i = \frac{e_i - e_{min}}{e_{max} - e_{min}} \qquad (14)$$

Where:

$NE_i$ represents the normalized error of the $i_{th}$ factor

$e_i$ is the error value of the factor $i$

$e_{max}$ is the maximum error value.

$e_{min}$ is the minimum error value.

Then the suitability score of each factor will be calculated as follows:

$$S_i = 1 - NE_i \qquad (15)$$

Where $S_i$ represent the suitability score of the factor $i$

Finally, the overall suitability score will be calculated with the following formula:

$$SS = \frac{\sum_{i=1}^{6} w_i \times S_i}{\sum_{i=1}^{6} w_i} \qquad (16)$$

Where:

$SS$ is the overall suitability score

$w_i$ is the weight of the $i_{th}$ factor which represent its importance and it is defined according to the project's type.

$S_i$ is the suitability score of the $i_{th}$ factor.

## 2.4 Overall Score:

Best metric:

After define all four metrics we used AHP method to combine all metrics in one score to define the best use of the land. (Taherdoost, 2017)

First, we determined the relative importance of the different metrics as follow:

| | $NPV$ | $Ecological\ footprint$ | $Social\ Score$ | $suitability\ Score$ |
|---|---|---|---|---|
| $NPV$ | 1 | 3 | 2 | 5 |
| $Ecological\ footprint$ | 1/3 | 1 | 2 | 3 |
| $Social\ Score$ | 1/2 | 1/2 | 1 | 2 |
| $suitability\ Score$ | 1/5 | 1/3 | ½ | 1 |

Then we calculate the Pair-wise comparison matrix:

| | $NPV$ | $Ecological\ footprint$ | $Social\ Score$ | $suitability\ Score$ |
|---|---|---|---|---|
| $NPV$ | 1 | 3 | 2 | 5 |
| $Ecological\ footprint$ | 1/3 | 1 | 2 | 3 |
| $Social\ Score$ | 1/2 | 1/2 | 1 | 2 |
| $suitability\ Score$ | 1/5 | 1/3 | ½ | 1 |
| $SUM$ | 2.03 | 4.83 | 5.5 | 11 |

The pair-wise matrix is:

| | $NPV$ | $Ecological\ footprint$ | $Social\ Score$ | $suitability\ Score$ |
|---|---|---|---|---|
| $NPV$ | 1/2.03 | 3/4.83 | 2/5.5 | 5/11 |
| $Ecological\ footprint$ | 1/6.09 | 1/4.83 | 2/5.5 | 3/11 |
| $Social\ Score$ | 1/4.06 | 1/9.66 | 1/5.5 | 2/11 |
| $suitability\ Score$ | 1/10.15 | 1/14.49 | 1/11 | 1/11 |
| $SUM$ | 2.03 | 4.83 | 5.5 | 11 |

Then we calculate the metric weight, which is the mean value of each row.

| | $NPV$ | $Ecological\ footprint$ | $Social\ Score$ | $suitability\ Score$ | Metric weight |
|---|---|---|---|---|---|
| $NPV$ | 1/2.03 | 3/4.83 | 2/5.5 | 5/11 | 1.931 |
| $Ecological\ footprint$ | 1/6.09 | 1/4.83 | 2/5.5 | 3/11 | 1.007 |
| $Social\ Score$ | 1/4.06 | 1/9.66 | 1/5.5 | 2/11 | 0.713 |
| $suitability\ Score$ | 1/10.15 | 1/14.49 | 1/11 | 1/11 | 0.349 |

Therefore, the overall score could be calculated as follow:

$$overall\ score = 1.931 \times NPV + 1.007 \times EF + 0.713 \times SS + 0.349 \times suitability\ Score$$

# 3 Land Use Options:

## 3.1 Map Analyzation and Data Extraction:

To gain a better understanding of the land and extract relevant data, we utilized GIS technology to analyze maps and extract the necessary information. (See Appendix B)

## 3.2 Chosen projects

We will divide the studied land into smaller ones depending on the geographical properties of each part. The following projects which are football stadium, skiing facility, regenerative farm, solar array, agrivoltaic farm, agritourist center and agroforestry farming will be chosen to be studied and the best project will be determined after implementing our best metric. (See Appendix C)

## 3.3 projects Evaluating by Metrics:

### 3.3.1 Evaluating Economical Metric

We applied the NPV Formula (1) to calculate the Economical Score for each possible facility. We considered that the discount rate $r = 10\%$ and the number of years is $n = 5$. The results were:

| Facility | NPV | NPV score (normalization) |
|---|---|---|
| Football Stadium | $4,424,020 | 1 |
| Regenerative Farm | $404,958 | 0 |
| Solar Array | $478,577 | 0.183 |
| Agrivoltaic Farm | $640,308 | 0.0585 |
| Agritourist Center | $893,532 | 0.1215 |
| Agroforestry Farming | $500,662 | 0.0238 |
| Skiing | $532,823 | 0.0318 |

It can be noticed that the Football Stadium has the highest Economical Score for it can host large number of events and people. Contrary to Regenerative Farm which has the lowest Economical Score due to the initial investment required and the time it takes to rebuild soil health and achieve high yields.

(See Appendix D)

### 3.3.2 Evaluating Environmental Metric

After applying the EF (formula (3)) to calculate the Environmental Score for each possible facility we got the following results:

| Facility Option | Environmental Footprint ($gha$) | Environmental Footprint Score (Normalization) |
|---|---|---|
| Regenerative Farm | 29.7 | 1 |
| Solar Array | 40.1 | 0.9488 |
| Agroforestry Farm | 82.7 | 0.7389 |
| Agritourist Center | 119.4 | 0.5581 |
| Agrivoltaic Farm | 170.9 | 0.3044 |
| Skiing Facility | 157.2 | 0.3719 |
| Football Stadium | 232.7 | 0 |

Regenerative farming has been identified as the best option ecologically because it has the lowest Environmental Footprint value out of all the options considered due to its practices which involve the use of cover crops, crop rotation, and natural fertilizers, which help to maintain soil fertility, reduce water consumption, and minimize greenhouse gas emissions. On the other hand, Football stadium is the worst Ecologically for it require a significant amount of land, energy, resources and a large number of raw materials such as concrete, steel, and glass to construct and maintain.

N/A indicates that the corresponding metric is not applicable on the corresponding facility. (See Appendix D)

### 3.3.3 Evaluating Social Metric

To measure the need of society to a facility we depend on the number of labor force in Oswego, Wayne, Cayuga, Seneca, Yates, Ontario and Onondaga. And the work opportunities provided from other facilities.

We assumed that the job opportunities would be obtained from people close to the facility. Therefore, we calculated the labor force only in five counties.

After implementing the formula (4), we found the value of $NSF = 5.95 \times 10^{-4}$

Community Engagement:

To calculate the $CE$ for the projects we used the formula (5), and the following table shows the values:

| Facility | Community Engagement $CE$ | Scaled SS |
|---|---|---|
| Skiing | 0.038 | 0.276 |
| Solar array | $1.83 \times 10^{-3}$ | 0.005 |
| Football stadium | 0.132 | 1 |
| Agrivoltaic Farm | $2.62 \times 10^{-3}$ | 0.012 |
| Agritourist center | $2.84 \times 10^{-3}$ | 0.013 |
| Regenerative farm | $1.5 \times 10^{-3}$ | 0.0026 |
| Agroforestry farm | $1.14 \times 10^{-3}$ | 0 |

(See Appendix D)

### 3.3.4 Evaluating the land suitability metric

After we collected data about the factors optimal values of each facility, we discussed our suitability metrics for each part and got the following results:

We can admit that the land is suitable for skiing due to its proper slope and cold climate. However, the skiing lasts for 3 months per year. Which may affect the economic side.

| | **First part** | | **Second part** | | **Third part** | |
|---|---|---|---|---|---|---|
| | **Overall error** | **Project suitability score** | **Overall error** | **Project suitability score** | **Overall error** | **Project suitability score** |
| **Football stadium** | 4.98523 | 0.82245 | 5.45335 | 0.8043 | 3.7596 | 0.8699 |
| **Regenerative farm** | 2.945 | 0.9014 | 3.2341 | 0.8902 | 2.87425 | 0.9042 |
| **Solar array** | 21.61225 | 0.1788 | 26.23025 | 0 | 19.0059 | 0.2797 |
| **Agrivoltaic farming** | 1.7031 | 0.9495 | 2.0496 | 0.9361 | 1.6316 | 0.9523 |
| **Agritourist center** | 1.584 | 0.9541 | 1.5825 | 0.9542 | 1.5275 | 0.9563 |
| **Agroforestry farming** | 1.505 | 0.9572 | 1.472625 | 0.9584 | 1.387625 | 0.9617 |
| **skiing** | 0.399 | 1 | 0.50975 | 0.9957 | 0.48305 | 0.9967 |

On the contrary, the land is not proper for founding projects that require cutting trees such as Solar arrays and Football stadium. (See Appendix D)

# 4 the impact of a nearby semiconductor fabrication facility:

The existence of the new facility will affect the value of the metrics. Therefore, some projects became more appropriate than other, we can study its influence for each metric:

## 4.1 Assumptions and Justifications:

Assumption: The ecological effects are neglected

Justification: The new factory that will open in Syracuse near the land, have to throw out and clean its waste materials, so that it will not affect the environment.

Assumption: The new factory will also employ people from other counties (not just from Wayne, Cayuga, Seneca, Onondaga, Oswego, Yates and Ontario).

Justification: The number of unemployment people in these counties is 26847 which is smaller from the sum of the needed workers in our land and factory.

Assumption: the construction stage of the new factory will continue for two years.

Justification: the approximate value for building very large semiconductor fabrication facility is between 18 months and 28 months. Therefore, two years is an average value.

Assumption: We assumed that the project will hire 20,000 from the local worker.

Justification: the opportunities are directed to specific career. Therefore, not all the workers find jobs in this facility.

## 4.2 The Economic Influence:

During the construction the new facility provides nearly 49000 work opportunity, and in this period the annual costs of our project will increase in two sides. First, because of the variety in jobs chance, the costs will increase due to the increase in wages, and the percent of the increasing will be 20% on average. Also, the number of local workers (workers from Wayne, Cayuga, Seneca, Onondaga, Oswego, Yates and Ontario), while not be enough to meet the needs of facilities, so new workers from far counties should travel daily, which add more transport costs, we can as follow:

$$C'_{i,t} = 0.8 \times C_{i,t} - Tc_i \quad (17)$$

Where $Tc_i$ is the transport costs for project $i$ and $t \in \{1,2\}$ .

After two years the work opportunities provided by the semiconductor fabrication facility will decrease to nearly 10000. Therefore, this influence will last for only the first two years and the economic cost will become normal again

| **Facility** | **Initial Investment** | **Cash Flows (including salaries)** | **NPV** | **NPV scaled score (normalization)** |
|---|---|---|---|---|
| Football Stadium | \$10,000,000 | Year1: \$1,434,384, Year2:\$1,594,384, Year3: \$2,200,000, Year4: \$2,400,00 Year5: \$2,600,000 | \$2,925,000 | 1 |
| Regenerative Farm | \$800,000 | Year1: \$110,128, Year 2: \$122,928 Year 3: \$172,800, Year 4: \$190,080 Year 5: \$209,088 | \$392,000 | 0.068 |
| Solar Array | \$1,000,000 | Year 1: \$158,128, Year 2: \$174,128 Year 3: \$242,000, Year 4: \$266,200 Year 5: \$292,820 | \$434,000 | 0.083 |
| Agrivoltaic Farm | \$1,500,000 | Year 1: \$222,128, Year 2: \$246,128 Year 3: \$341,000, Year 4: \$375,100 Year 5: \$412,610 | \$673,000 | 0.171 |
| Agritourist Center | \$2,000,000 | Year 1: \$316,256, Year 2: \$348,256 Year 3: \$484,000, Year 4: \$532,400 Year 5: \$585,640 | \$664,000 | 0.19 |
| Agroforestry Farming | \$1,200,000 | Year 1: \$174,128, Year 2: \$191,728 Year 3: \$266,200, Year 4: \$292,820 Year 5: \$322,102 | \$316,256 | 0.0405 |

| | | | | |
|---|---|---|---|---|
| Skiing | \$3,500,000 | Year 1: \$106,384, Year2:\$134,384<br>Year 3: \$210,000, Year 4:\$245,000<br>Year 5: \$280,000 | \$205,945 | 0 |

## 4.3 The Social influence:

The new project will provide more opportunities, which mean that the number of unemployment will decrease and to decrease $NSF$. The effect on the social impact could illustrated as follow:

$$NSF' = NSF - \frac{NE}{LF} \quad (18)$$

Where $NE$ is the new employees from local workers in the semiconductor fabrication facility. Then the value of $NSF'$ is 1.5%.

And the social score would be as following:

| Facility | Number of people involved in the project | Community Engagement $CE$ | Social Score SS | Scaled SS |
|---|---|---|---|---|
| Skiing | 35781 | 0.038 | 0.00057 | 0.281 |
| Solar array | 1714 | $1.83 \times 10^{-3}$ | 0.00027 | 0.128 |
| Football stadium | 123542 | 0.132 | 0.00198 | 1 |
| Agrivoltaic Farm | 2446 | $2.62 \times 10^{-3}$ | 0.000039 | 0.0112 |
| Agritourist center | 2652 | $2.84 \times 10^{-3}$ | 0.000042 | 0.0127 |
| Regenerative farm | 1405 | $1.5 \times 10^{-3}$ | 0.0000225 | 0.0028 |
| Agroforestry farm | 1070 | $1.14 \times 10^{-3}$ | 0.000017 | 0 |

The decrease in the value of $NSF$ mean decrease in the society need to our projects.

## 3.4 Environment influence:

Due to the need of the transport, more carbon is being produced, the following formula explain the influence:

$$EF_i' = \sum_{j=1}^{n} f_{i,j} + AC_i \quad (19)$$

Where $AC_i$ is the amount of carbon produced by the transports of project $i$.

| Facility Option | Water Consumption $(m^3/yr)$ | Carbon Footprint $(t\ CO2e/yr)$ | Carbon Produced By The Transports $(t\ CO2e/yr$ | Energy Use $(MWh/yr)$ | Food Consumption $(meals/yr)$ | Waste Generated $(t/yr)$ | Environmental Footprint $(gha)$ | Environmental Footprint Score (Normalization) |
|---|---|---|---|---|---|---|---|---|
| Regenerative Farm | 5,000 | 1,200 | 5.8906 | 2,500 | N/A | 50 | 29.704 | 1 |
| Solar Array | 10,000 | 1,500 | 5.8906 | 20,000 | N/A | 20 | 40.104 | 0.9487 |
| Agroforestry Farm | 15,000 | 3,500 | 5.8906 | 3,500 | N/A | 75 | 82.704 | 0.7389 |
| Agritourist Center | 25,000 | 4,500 | 11.7812 | 5,000 | 15,000 | 200 | 119.408 | 0.5581 |
| Agrivoltaic Farm | 40,000 | 6,000 | 5.8906 | 7,500 | N/A | 125 | 170.904 | 0.3044 |
| Skiing Facility | 2,000 | 10,000 | 17.6718 | 30,000 | 50,000 | 100 | 157.212 | 0.3719 |
| Football Stadium | 50,000 | 15,000 | 17.6718 | 10,000 | 200,000 | 500 | 232.712 | 0 |

## 4.5 Overall score:

| | NPV | SS | EF | Suit | Overall |
|---|---|---|---|---|---|
| Football Stadium | 1 | 1 | 0 | 0.82245 | 2.931 |
| Regenerative Farm | 0.068 | 0.0028 | 1 | 0.9014 | 1.454 |
| Solar Array | 0.083 | 0.128 | 0.9487 | 0.1788 | 1.260 |
| Agrivoltaic Farm | 0.171 | 0.0112 | 0.3044 | 0.9495 | 0.976 |
| Agritourist Center | 0.19 | 0.0127 | 0.5581 | 0.9541 | 1.27 |
| Agroforestry Farming | 0.0405 | 0 | 0.7389 | 0.9572 | 1.156 |
| Skiing | 0 | 0.281 | 0.3719 | 1 | 0.923 |

5 Familiar Environment (from our country)

Assumption: the prices, salaries and the other economical principals (e.g discount rate) are the same in the world.

Justification: to compare between the two lands, we have to use the same economic conditions, because all of the pricing and salaries vary depending in the land's country.

"Al-Bassah" municipality is located southeast of the city Latakia, Syria, about 6 km away, faces the Mediterranean Sea from the west side, its eastern end passes the international road Latakia-Damascus, separating it from the city by "Al-Kabir Al-Shamali" River, and in its south, the seasonal river "Al-Sanoubr", its height does not exceed 10 m from the surface sea, and the total area of the municipality About 15 $km^2$. On the western side of the municipality there is land with an area of about 1.5 $km^2$, it is completely empty of any agricultural, economic or service business, it is distinguished by its shallow coastline, and its proximity to the city center of Latakia, dominated by sand from sedimentary waves of the sea, the land is known for its richness with fresh groundwater, despite its proximity to sea water, but it has its own unique characteristics It remained without investment over the years.
(See Appendix E) to see the land.

This land is very different from the previous land, because of its natural resources, location and the demographic.

In the economical metrics, the location near the city center of Latakia will provide more services to the land which will decrease the $C_{i,t}$, in addition, getting employers will be easier because of the lack of jobs in Syria duo to the conflict, these two main statuses will increase the $NPV_i$. In the environmental metrics, there is just one principle that we can discuss easily, it is the Carbon footprint, it will be very low, because the employers and suppliers will be close to the land, that will improve the environmental metric. The NSF social metric will increase hugely, because of the big number of unemployment people near the land, also the $CE_i$ will increase, because of the need of projects in Syria, these two social metrics will increase the overall social score. Finally, about the most important metric which is the suitability, this land is varied in terrains from the previous one, here in this land we can find these facts:

1. There are no trees.
2. The location is beside the sea.
3. 87% of the land's slope is equal to 0° and the remaining slopes are very small.

These terrain properties will change the possible facilities to build, for example: regenerative farm, agritourist, agroforest, crop farm and grazing farm cannot be used because of the sandy soil that is poor of required materials for the plants to grow. Moreover, skiing is imposable in this land because of the climate in Latakia, the lowest temperature is 9.31℃ which is equal to 48.758°F (The World Bank Group, 2021) and because of the sea. Agrivoltaic will as same as the solar panels because as we mentioned we cannot plant on the sand soil. The solar panels can be a good project.

## 6 Strengths and Weaknesses of our model

### 6.1 Strengths of our model

1- The high precision of our model:
In our model we discussed four different types of metrics, also we went deep and included many factors in some of them such as the suitability metric.

2- All of the terrain land data are obtained from the GIS technology:

This technology helps our model to get accurate data about the land, which can make the dividing the land into parts for the facilities more efficient and accurate.

6.2 Weaknesses of our model

1- The lack of the discussed environmental factors:
In our model we discussed just five environmental factors, while there are other factors that we did not talk about the bad effect of the manufacturing process, if we discussed this, we will get a lower environmental metric for all the facilities, for example, solar panels manufacturing is so bad for the environmental, because it costs lot of water.

2- The project social spread is not taken in account:
The project will spread between people by social media, word of mouth and other. This metric will increase the social overall score hugely, because it increases the people who are involved in the project, but the evaluation of this metric is quite hard.

# 7 Conclusion

We built our solution in several stages. Firstly, we decided on the environmental, economic, social, and suitability metrics to use, secondly, we implemented our metrics in many projects (projects from the problem and a project of our choice), then we calculated the overall score for each facility using the AHP method to choose the best three facilities to use together, next in the third task we discussed the effect of other competitive facilities in our model and evaluations, finally, the fourth task we discussed concisely how our model and metrics work with different land, so we chose a land in Syria which is different from the land in the problem, so we can discuss many changes in the metrics measurements.

# 8 Letter to Decision Makers

Dear decision makers' committee.

We are writing this letter to you to present our new mathematical model which we developed to determine the facilities to be found on the land you asked us for, depending on several metrics. We divided the area into three parts depending on suitability metric that we evaluated using some map analyzing sites such as Cal Topo. We are going to show you the results and analyses we got from our model.

Firstly, the complex sport (football stadium in our model) is very bad for the environment because of its zero-environment value, but it is the best option between the facilities, because it has a high economic value (high profit), maximum social value (many people are interested in football), and the land is very suitable to build a stadium on it (in the land there are some areas with very low slope which is good to build a stadium).

The solar panels are also a good option, but their overall score is almost half of the complex sport overall score. The solar panels have very low profit compared to complex sport. In addition, comparing them, we can say that solar panels have no remarkable social effect. However, the solar panels have excellent environmental impact compared to the complex sport.

Moreover, not only solar panels are the second-best facility, there is another one which is a regenerative farm. Actually, in one site the regenerative farm is the second-best facility, while in the other two land parts, the regenerative farm is considered in general the third best facility.

Generally, if you want to select a specific metric, regardless of the overall score, you can select complex sport as the economic and social project, regenerative farming as the environmental project, and skiing as the most suitable.

Next, we started testing our model in two ways. The first one, was studying the effect of other competitors who will take many of the employers in the local area, this will affect our facilities badly. We analyzed these effects on social, economic and environmental metrics. The second way was to check how much our model is flexible in other lands, so we chose a land in our country. This land differs from the one in the main problem, so we can discuss several changes in the model output. We discussed them briefly without evaluations

Best regards.

IMMC Team

# 9 Appendix

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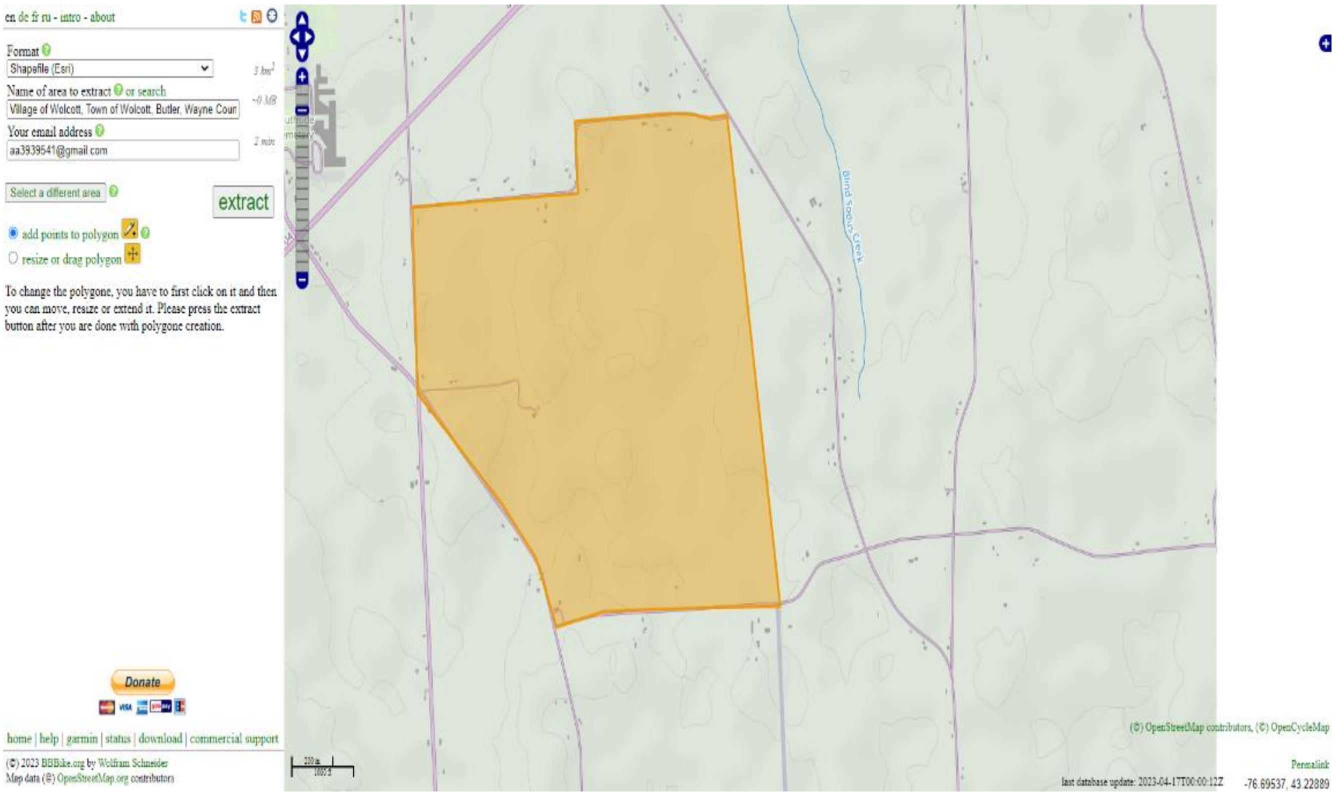
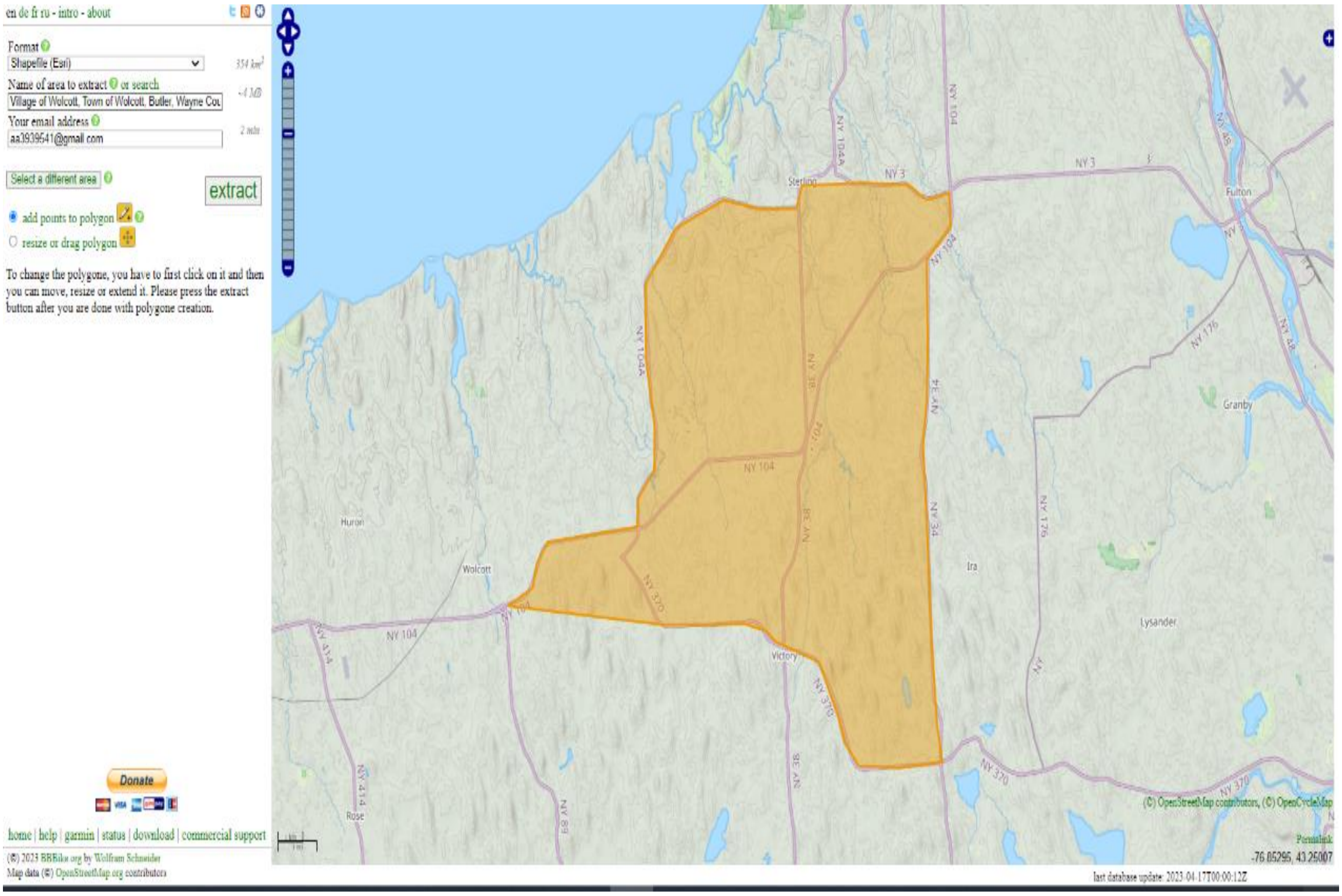
Appendix A: Economical Metrics python code:

```
In [1]: class EconomicMetric:
            def __init__(self, discount_rate):
                self.discount_rate = discount_rate

            def calculate_npv(self, cash_flows):
                npv = 0
                for i, cash_flow in enumerate(cash_flows):
                    npv += cash_flow / ((1 + self.discount_rate) ** i)
                return npv
        # Get cash flows and discount rate from user input
        cash_flows = []
        while True:
            cash_flow = input("Enter cash flow for year " + str(len(cash_flows)) + " (or 'q' to quit): ")
            if cash_flow == 'q':
                break
            else:
                cash_flows.append(float(cash_flow))
        discount_rate = float(input("Enter discount rate (as a decimal): "))

        # Create EconomicMetric object and calculate NPV
        econ_metric = EconomicMetric(discount_rate)
        npv = econ_metric.calculate_npv(cash_flows)

        # Print NPV
        print(f"The net present value is: {round(npv, 2)}")
```

Appendix B: Map Analyzation Using GIS technology:






## points

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|---|---|---|---|---|
| 0 | 211249280 | | | traffic_signals |
| 1 | 211253731 | | | crossing |
| 2 | 211260981 | | | crossing |
| 3 | 211283214 | | | crossing |
| 4 | 211283446 | | | crossing |
| 5 | 211319984 | | | crossing |
| 6 | 211341827 | | | crossing |
| 7 | 211343729 | | | crossing |
| 8 | 211402981 | | | crossing |
| 9 | 211404679 | | | crossing |
| 10 | 211428729 | | | crossing |
| 11 | 309780138 | | | crossing |
| 12 | 309780146 | | | crossing |
| 13 | 357649371 | | Cuyler Elementary School | school |
| 14 | 357649374 | | Red Creek Junior-Senior High School | school |
| 15 | 357653659 | | Forscutt Cemetery | grave_yard |
| 16 | 543598840 | | Stewart B. Lang Memorial Library | library |
| 17 | 543598852 | | Fair Haven Public Library | library |
| 18 | 543615695 | | Red Creek Free Library | library |
| 19 | 585385261 | | Butler P-5 | mine |
| 20 | 648736574 | | | crossing |
| 21 | 648736613 | | | crossing |
| 22 | 648737136 | | | crossing |
| 23 | 648737152 | | | crossing |
| 24 | 648737159 | | | crossing |
| 25 | 648737178 | | | crossing |
| 26 | 837172873 | | | crossing |
| 27 | 837172958 | | | crossing |
| 28 | 837172974 | | | crossing |
| 29 | 1696089364- | | | crossing |
| 30 | 1696089331- | | | crossing |
| 31 | 41335353- | | | stop |
| 32 | 306036014 | | Wolcott Medical Center | bus_stop |

# waterways

| FID | osm_id | name | type | width |
|---|---|---|---|---|
| 0 | 146832980 | | stream | 0 |
| 1 | 146832983 | | dam | 0 |
| 2 | 146832987 | Red Creek | stream | 0 |
| 3 | 254049168 | Ninemile Creek | stream | 0 |
| 4 | 254049184 | Ninemile Creek | stream | 0 |
| 5 | 254049185 | Ninemile Creek | stream | 0 |
| 6 | 254056884 | Sterling Creek | stream | 0 |
| 7 | 310930998 | Blind Sodus Creek | stream | 0 |
| 8 | 699017770 | Red Creek | stream | 0 |
| 9 | 699017772 | Blind Sodus Creek | stream | 0 |
| 10 | 699017773 | Blind Sodus Creek | stream | 0 |
| 11 | 974846375 | Sterling Valley Creek | stream | 0 |
| 12 | 974864087 | | stream | 0 |
| 13 | 974864088 | | stream | 0 |
| 14 | 974864089 | | stream | 0 |
| 15 | 974864090 | | stream | 0 |
| 16 | 974864091 | | stream | 0 |
| 17 | 974864092 | | stream | 0 |
| 18 | 974864095 | | stream | 0 |
| 19 | 974864096 | | stream | 0 |
| 20 | 1011539832 | Red Creek | stream | 0 |
| 21 | 1011936909 | | stream | 0 |
| 22 | 1011936910 | | stream | 0 |
| 23 | 1011936911 | | stream | 0 |
| 24 | 1011936912 | | stream | 0 |
| 25 | 1011936913 | | stream | 0 |
| 26 | 1011936914 | | stream | 0 |

# roads

| FID | osm_id | name | ref | type | oneway | bridge | |
|---|---|---|---|---|---|---|---|
| 0 | 20021549 | Follett Road | | residential | 0 | 0 | 0 |
| 1 | 20021606 | Red Creek Road | | residential | 0 | 0 | 0 |
| 2 | 20021750 | Upton Road | | residential | 0 | 0 | 0 |
| 3 | 20021754 | Mott Road | | residential | 0 | 0 | 0 |
| 4 | 20021957 | | | service | 0 | 0 | 0 |
| 5 | 20021962 | | | service | 0 | 0 | 0 |
| 6 | 20021987 | | | residential | 0 | 0 | 0 |
| 7 | 20022037 | | | service | 0 | 0 | 0 |
| 8 | 20022127 | | | residential | 0 | 0 | 0 |
| 9 | 20022132 | | | residential | 0 | 0 | 0 |
| 10 | 20022411 | | | residential | 0 | 0 | 0 |
| 11 | 20022428 | | | track | 0 | 0 | 0 |
| 12 | 20022461 | | | service | 0 | 0 | 0 |
| 13 | 20022462 | | | service | 0 | 0 | 0 |
| 14 | 20022472 | | | residential | 0 | 0 | 0 |
| 15 | 20022492 | | | residential | 0 | 0 | 0 |
| 16 | 20022533 | | | residential | 0 | 0 | 0 |
| 17 | 20022585 | | | track | 0 | 0 | 0 |
| 18 | 20022599 | | | service | 0 | 0 | 0 |
| 19 | 20022765 | County Line Road | | residential | 0 | 0 | 0 |
| 20 | 20022795 | Maroney Road | | residential | 0 | 0 | 0 |
| 21 | 20022825 | West Mechanic Street | | residential | 0 | 0 | 0 |
| 22 | 20022857 | Deforest Lane | | residential | 0 | 0 | 0 |
| 23 | 20022864 | Queens Farm Road | | residential | 0 | 0 | 0 |
| 24 | 20022908 | Sanford Road | | residential | 0 | 0 | 0 |
| 25 | 20022983 | Mc Gibben Road | | residential | 0 | 0 | 0 |
| 26 | 20022992 | Platt Street | | residential | 0 | 0 | 0 |
| 27 | 20023113 | Ladue Road | | residential | 0 | 0 | 0 |
| 28 | 20023162 | North Street | NY 34 | primary | 0 | 0 | 0 |
| 29 | 20023313 | South Lake Street | | residential | 0 | 0 | 0 |
| 30 | 20023407 | Cosgrove Road | | residential | 0 | 0 | 0 |
| 31 | 20023465 | Veley Lane | | residential | 0 | 0 | 0 |
| 32 | 20023607 | West Main Street | NY 370 | trunk | 0 | 0 | 30 |
| 33 | 20023742 | Ross Hill Road | | residential | 0 | 0 | 0 |
| 34 | 20023785 | Thompson Road | | residential | 0 | 0 | 0 |
| 35 | 20023832 | Ira Station Road | | tertiary | 0 | 0 | 0 |
| 36 | 20023850 | Ira Station Road | | tertiary | 0 | 0 | 0 |
| 37 | 20023860 | Woods Road | | residential | 0 | 0 | 0 |
| 38 | 20023879 | Pople Road | | tertiary | 0 | 0 | 0 |
| 39 | 20023906 | Pople Road | | residential | 0 | 0 | |
| 40 | 20023910 | Pople Road | | residential | 0 | 0 | 0 |
| 41 | 20023911 | Pople Road | | residential | 0 | 0 | 0 |
| 42 | 20023912 | Pople Road | | residential | 0 | 0 | 0 |

## places

| FID | osm_id | name | type | population |
|---|---|---|---|---|
| 0 | 158293873 | Bethel Corners | hamlet | 0 |
| 1 | 158330012 | Cato | hamlet | 0 |
| 2 | 158337004 | North Victory | hamlet | 0 |
| 3 | 158346553 | Westbury | hamlet | 0 |
| 4 | 158550782 | Fintches Corners | hamlet | 0 |
| 5 | 158600799 | Martville | hamlet | 0 |
| 6 | 158619675 | Cains Corners | hamlet | 0 |

## buildings

| FID | osm_id | name | type |
|---|---|---|---|
| 0 | 146832992 | | house |
| 1 | 329451076 | | |
| 2 | 827759709 | | |
| 3 | 827759718 | | |
| 4 | 827759723 | | |
| 5 | 827759729 | | |
| 6 | 827759730 | | |
| 7 | 827759735 | | |
| 8 | 827759737 | | |
| 9 | 827759738 | | |
| 10 | 827759739 | | |
| 11 | 827759753 | | |
| 12 | 827759792 | | |
| 13 | 827759795 | | |
| 14 | 827759811 | | |
| 15 | 827759817 | | |
| 16 | 827759823 | | |
| 17 | 827759825 | | |
| 18 | 827759828 | | |
| 19 | 827759845 | | |
| 20 | 827759848 | | |
| 21 | 827759855 | | |
| 22 | 827759860 | | |
| 23 | 827759885 | | |
| 24 | 827759896 | | |
| 25 | 827759911 | | |
| 26 | 827759934 | | |
| 27 | 827759949 | | |
| 28 | 827759975 | | |
| 29 | 827759982 | | |
| 30 | 827759993 | | |
| 31 | 827759994 | | |
| 32 | 827760002 | | |
| 33 | 827760005 | | |
| 34 | 827760016 | | |
| 35 | 827760029 | | |

Appendix C: The Three Parts of the Land

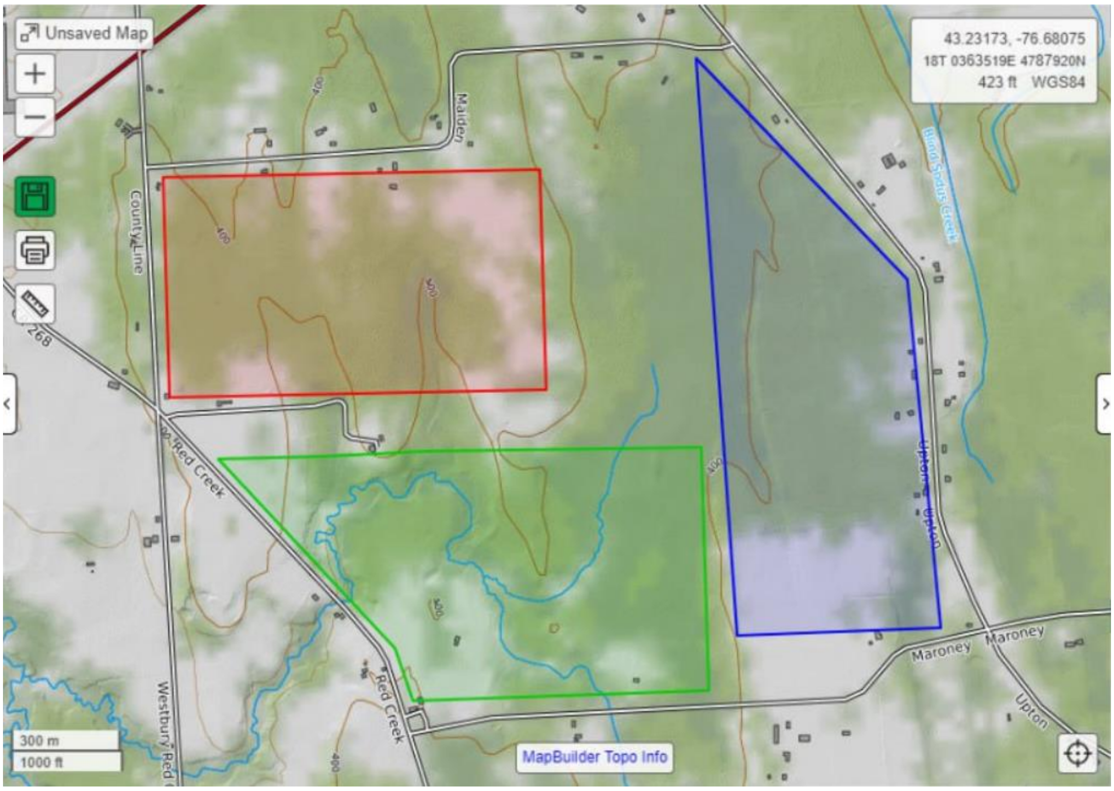
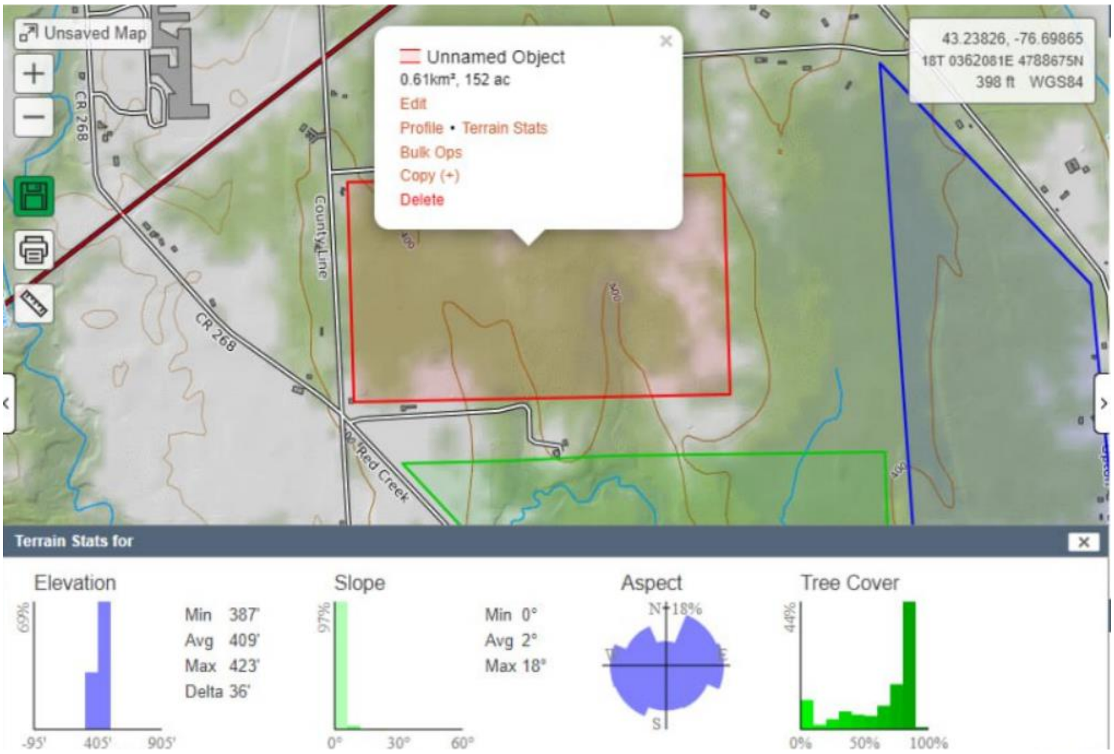
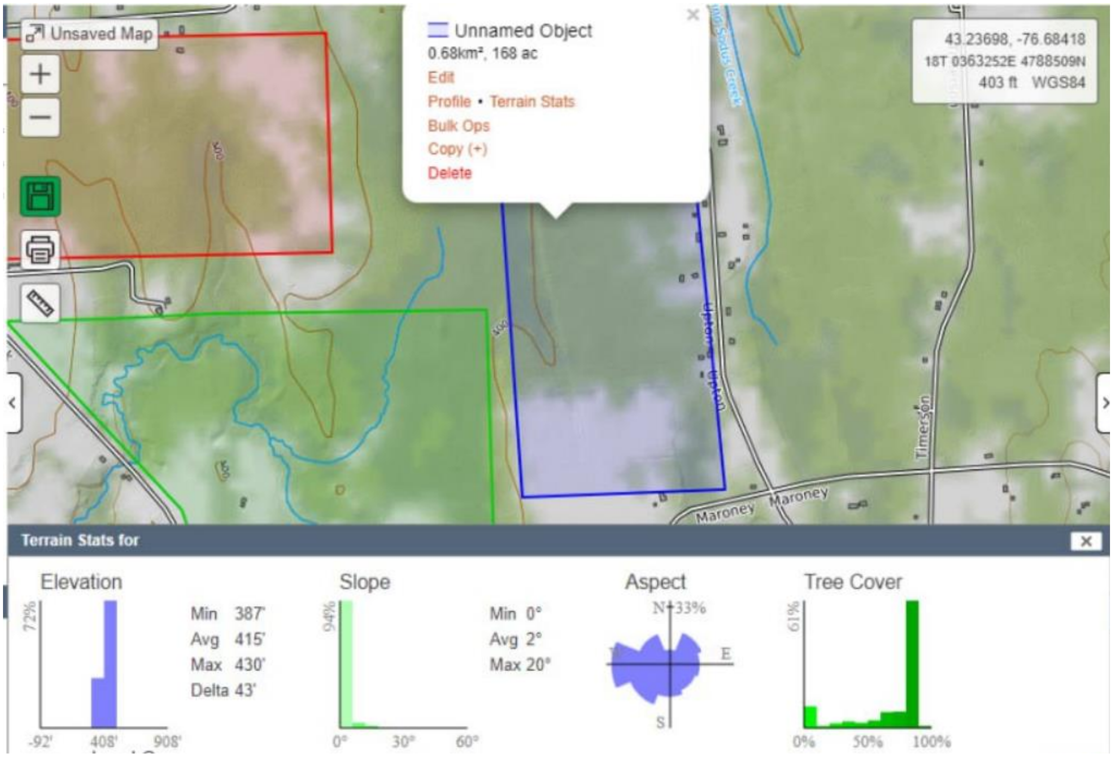



*Figure 1 this photo represents the land after we divided it into three sections. The red is the first one, the green is the second one and the blue is the third one.*




Unsaved Map
Unnamed Object
0.68km², 168 ac
Edit
Profile • Terrain Stats
Bulk Ops
Copy (+)
Delete
43.23698, -76.68418
18T 0363252E 4788509N
403 ft WGS84
Maroney
Timerson
Upton
Terrain Stats for
Elevation
Min 387'
Avg 415'
Max 430'
Delta 43'
-92' 408' 908'
Slope
Min 0°
Avg 2°
Max 20°
0° 30° 60°
Aspect
N 33%
E
S
Tree Cover
0% 50% 100%


Unsaved Map
Unnamed Object
0.69km², 170 ac
Edit
Profile • Terrain Stats
Bulk Ops
Copy (+)
Delete
43.22307, -76.70865
18T 0361235E 4787004N
359 ft WGS84
Red Creek
Westbury
Maroney
Upton
Terrain Stats for
Elevation
Min 366'
Avg 386'
Max 420'
Delta 54'
-107' 393' 893'
Slope
Min 0°
Avg 3°
Max 19°
0° 30° 60°
Aspect
N 18%
S
Tree Cover
0% 50% 100%

| Variable name | Value for the first part | Value for the second part | Value for the third part |
|---|---|---|---|
| slope | $0° - 10°$ | $0° - 7°$ | $0° - 5°$ |
| Tree cover percentage | 45% | 61% | 44% |
| Average annual temperature | 53.4°F | 53.4°F | 53.4°F |
| Average temperature in winter | 32.9°F | 32.9°F | 32.9°F |
| Annual rainfall average | $113.9cm$ | $113.9cm$ | $113.9cm$ |
| Annual snowfall height | $25.32cm$ | $25.32cm$ | $25.32cm$ |
| Winter snowfall height | $68.475cm$ | $68.475cm$ | $68.475cm$ |
| Natural Hazard metric (earthquake occurring possibility) | 0.54% | 0.54% | 0.54% |

*Figure 2 Land parts data*

Appendix D:

1) NPV values:

| **Facility** | **Initial Investment** | **Cash Flows (including salaries)** | **NPV** | **NPV score (normalization)** |
|---|---|---|---|---|
| Football Stadium | \$10,000,000 | Year1:\$1,800,000, Year2:\$2,000,000 Year3:\$2,200,000, Year4:\$2,400,000 Year 5: \$2,600,000 | \$4,424,020 | 1 |
| Regenerative Farm | \$800,000 | Year 1: \$140,000, Year 2: \$156,000 Year 3: \$172,800, Year 4: \$190,080 Year 5: \$209,088 | \$404,958 | 0 |
| Solar Array | \$1,000,000 | Year 1: \$200,000, Year 2: \$220,000 Year 3: \$242,000, Year 4: \$266,200 Year 5: \$292,820 | \$478,577 | 0.183 |
| Agrivoltaic Farm | \$1,500,000 | Year 1: \$280,000, Year 2: \$310,000 Year 3: \$341,000, Year 4: \$375,100 Year 5: \$412,610 | \$640,308 | 0.0585 |
| Agritourist Center | \$2,000,000 | Year 1: \$400,000, Year 2: \$440,000 Year 3: \$484,000, Year 4: \$532,400 Year 5: \$585,640 | \$893,532 | 0.1215 |
| Agroforestry Farming | \$1,200,000 | Year 1: \$220,000, Year 2: \$242,000 Year 3: \$266,200, Year 4: \$292,820 Year 5: \$322,102 | \$500,662 | 0.0238 |

| | | | | |
|---|---|---|---|---|
| Skiing | \$3,500,000 | Year 1: \$140,000, Year2: \$175,000<br>Year 3: \$210,000, Year 4: \$245,000<br>Year 5: \$280,000 | \$532,823 | 0.0318 |

2) Ecological Footprint Values:

| Facility Option | Water Consumption ($m^3/yr$) | Carbon Footprint ($t\ CO2e/yr$) | Energy Use ($MWh/yr$) | Food Consumption ($meals/yr$) | Waste Generated ($t/yr$) | Environmental Footprint ($gha$) | Environmental Footprint Score (Normalization) |
|---|---|---|---|---|---|---|---|
| Regenerative Farm | 5,000 | 1,200 | 2,500 | N/A | 50 | 29.7 | 1 |
| Solar Array | 10,000 | 1,500 | 20,000 | N/A | 20 | 40.1 | 0.9488 |
| Agroforestry Farm | 15,000 | 3,500 | 3,500 | N/A | 75 | 82.7 | 0.7389 |
| Agritourist Center | 25,000 | 4,500 | 5,000 | 15,000 | 200 | 119.4 | 0.5581 |
| Agrivoltaic Farm | 40,000 | 6,000 | 7,500 | N/A | 125 | 170.9 | 0.3044 |
| Skiing Facility | 2,000 | 10,000 | 30,000 | 50,000 | 100 | 157.2 | 0.3719 |
| Football Stadium | 50,000 | 15,000 | 10,000 | 200,000 | 500 | 232.7 | 0 |

3) Social Score Values:

| Facility | Number of people involved in the project | Community Engagement $CE$ | Social Score SS | Scaled SS |
|---|---|---|---|---|
| Skiing | 35781 | 0.038 | 0.0022 | 0.276 |
| Solar array | 1714 | $1.83 \times 10^{-3}$ | 0.00010 | 0.005 |
| Football stadium | 123542 | 0.132 | 0.0078 | 1 |
| Agrivoltaic Farm | 2446 | $2.62 \times 10^{-3}$ | 0.00015 | 0.012 |
| Agritourist center | 2652 | $2.84 \times 10^{-3}$ | 0.00016 | 0.013 |
| Regenerative farm | 1405 | $1.5 \times 10^{-3}$ | 0.00008 | 0.0026 |
| Agroforestry farm | 1070 | $1.14 \times 10^{-3}$ | 0.00006 | 0 |

4) Optimal values for each facility factors

| | ideal value of slope degree | ideal value of tree cover percentage | ideal value of average annual temperature | ideal value of annual rainfall average | ideal value of annual snowfall height |
|---|---|---|---|---|---|
| Football stadium | 0.85° | 5% | 70°F | $60.96cm$ | 0 |
| Regenerative farm | 2° | 30% | 70°F | $76.2cm$ | 0 |
| Solar array | – | 0% | 68°F | $31.75cm$ | $1cm$ |
| Agrivoltaic farming | 2° | 30% | 70°F | $76.2cm$ | 0 |
| Agritourist center | 2° | 50% | 70°F | $76.2cm$ | 0 |
| Agroforestry farming | 2° | 50% | 70°F | $114.3cm$ | 0 |
| skiing | 15° | 32% | 26°F | $67.2\ cm$ | $80cm$ |

5) Part one of the land:

| | Slope | | tree cover percentage | | average annual temperature | | annual rainfall average | | annual snowfall height | | Overall error | Project suitability score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Error value | weight | Error value | weight | Error value | weight | Error value | weight | Error value | weight | | |
| Football stadium | 4.15 | 50% | 8 | 20% | 0.237 | 15% | 0.868 | 10% | 25.32 | 5% | 4.98523 | 0.82245 |
| Regenerative farm | 1.5 | 5% | 0.5 | 25% | 0.215 | 30% | 0.495 | 30% | 25.32 | 10% | 2.945 | 0.9014 |
| Solar array | 0 | 0% | 45 | 40% | 0.215 | 45% | 0.495 | 10% | 24.32 | 5% | 21.61225 | 0.1788 |
| Agrivoltaic farming | 1.5 | 5% | 0.5 | 30% | 0.215 | 30% | 0.495 | 30% | 25.32 | 5% | 1.7031 | 0.9495 |
| Agritourist center | 1.5 | 5% | 0.1 | 30% | 0.215 | 30% | 0.495 | 30% | 25.32 | 5% | 1.584 | 0.9541 |
| Agroforestry farming | 1.5 | 10% | 0.1 | 35% | 0.215 | 25% | 0.0035 | 25% | 25.32 | 5% | 1.505 | 0.9572 |
| skiing | 0.67 | 40% | 0.289 | 10% | 0.21 | 5% | 0.695 | 5% | 0.144 | 40% | 0.399 | 1 |

6) Part two of the land

| | Slope | | tree cover percentage | | average annual temperature | | annual rainfall average | | annual snowfall height | | Overall error | Project suitability score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Error value | weight | Error value | weight | Error value | weight | Error value | weight | Error value | weight | | |
| Football stadium | 3.65 | 50% | 11.2 | 20% | 0.237 | 15% | 0.868 | 10% | 25.32 | 5% | 5.45335 | 0.8043 |
| Regenerative farm | 1.5 | 5% | 1.63 | 25% | 0.237 | 30% | 0.495 | 30% | 25.32 | 10% | 3.2341 | 0.8902 |
| Solar array | 0 | 0% | 61 | 40% | 1.255 | 45% | 0.495 | 10% | 24.32 | 5% | 26.23025 | 0 |
| Agrivoltaic farming | 1.5 | 5% | 1.63 | 30% | 0.237 | 30% | 0.495 | 30% | 25.32 | 5% | 2.0496 | 0.9361 |
| Agritourist center | 0.75 | 5% | 0.22 | 30% | 0.215 | 30% | 0.495 | 30% | 25.32 | 5% | 1.5825 | 0.9542 |
| Agroforestry farming | 0.75 | 10% | 0.22 | 35% | 0.215 | 25% | 0.0035 | 25% | 25.32 | 5% | 1.472625 | 0.9584 |
| skiing | 0.767 | 40% | 0.906 | 10% | 0.4 | 5% | 0.695 | 5% | 0.144 | 40% | 0.50975 | 0.9957 |

7) Part three of the land:

| | Slope | | tree cover percentage | | average annual temperature | | annual rainfall average | | annual snowfall height | | Overall error | Project suitability score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Error value | weight | Error value | weight | Error value | weight | Error value | weight | Error value | weight | | |
| Football stadium | 1.65 | 50% | 7.8 | 20% | 0.312 | 15% | 0.868 | 10% | 25.32 | 5% | 3.7596 | 0.8699 |
| Regenerative farm | 0.25 | 5% | 0.467 | 25% | 0.215 | 30% | 0.495 | 30% | 25.32 | 10% | 2.87425 | 0.9042 |
| Solar array | 0 | 0% | 44 | 40% | 0.312 | 45% | 0.495 | 10% | 24.32 | 5% | 19.0059 | 0.2797 |
| Agrivoltaic farming | 0.25 | 5% | 0.467 | 30% | 0.215 | 30% | 0.495 | 30% | 25.32 | 5% | 1.6316 | 0.9523 |
| Agritourist center | 0.25 | 5% | 0.12 | 30% | 0.215 | 30% | 0.495 | 30% | 25.32 | 5% | 1.5275 | 0.9563 |
| Agroforestry farming | 0.25 | 10% | 0.12 | 35% | 0.215 | 25% | 0.0035 | 25% | 25.32 | 5% | 1.387625 | 0.9617 |
| skiing | 0.833 | 40% | 0.375 | 10% | 0.4 | 5% | 0.695 | 5% | 0.144 | 40% | 0.48305 | 0.9967 |

Appendix E: « Al-Bassah» map

https://caltopo.com/m/8FB2D