IMMC 2023 International Round
IMMC 2023045
Using Land: A Valuable Resource

1. Summary Sheet
Approximately 29% of the total area of the earth is covered by land. The land structure could be classified with the aid of climate, topography and soil compositions. The proper planning for usage of land is an important process that involves evaluation of the land and its potentiality in enhancing the environment. However, there may be some shortcomings in the pathway of proper land analysis. Our goal was to create a sustainable model to ensure proper usage of the land without jeopardizing the available environmental resources.

In this report, we examined several factors that are crucial when modeling a decision metric, including the slope and shape of the land, the area, cell coverage, budget, revenue, and climate. We then developed a mathematical model that underwent several stages. Initially, we used the MCDM and AHP method to assign weights to the aforementioned factors, and from there we built a decision metric that took into account all of the outcomes. We placed a high priority on considering the short and long-term effects of our results. Ultimately, we determined that the decision metric with the highest percentage of priority would be the best choice for optimizing the use of the land and achieving desirable results. Our analysis was based on comprehensive data and produced a realistic and effective decision metric.

As for sensitivity analysis, we used different values of the same parameters to evaluate the change in the final decision produced by our model and how much of an impact a small change will cause. Variation is done in the area parameter for the skiing project and the solar array project for the sensitivity analysis.

Our proposal outlines a systematic approach to improve the utilization of land resources, which can lead to a reduction in poverty, improvement in economic conditions, and a decrease in the emission of harmful pollutants that contribute to global warming. We have developed a sustainable model that takes into account all the essential factors that determine the optimal use of land.

2. Letter to the Decision Makers

Dear Sir/Madam,

We, the members of Team 2023045, are writing to update you on our latest research. We appreciate your confidence in our team, and we are pleased to inform you that we have finished our report on the most efficient way to utilize your land, which will undoubtedly result in increased revenue for you.

When determining the optimal use of the land, we have prioritized its environmental impact. We have carefully considered the fact that 38% of the land is covered by trees, and have implemented strategies to ensure their preservation. It is important to recognize the vital role that trees play in producing oxygen, which is essential for human survival, as well as their ability to mitigate greenhouse gas emissions by absorbing carbon dioxide from the atmosphere. In summary, trees are critical to sustaining life on Earth.

In this report, we have used mathematical modeling techniques to figure out ways of proper land use optimization. By analyzing the parameters on which the productivity of a project depends, a model has been developed which produces the best choice that can be built on the land. However, this model also uses some assumptions and depends on the topography of the given land in question. So, the model requires further work to be implemented in a generalized way and we have made slight progress in that regard too within this report towards the last.

We trust that you are content with the outcome of our efforts. If you have any inquiries, please do not hesitate to contact us. We appreciate you taking the time to review our message and sincerely hope that our discoveries and proposals offer the most suitable options for the appropriate utilization of your land.

Sincerely yours,

Team 2023045

Contents

3. Introduction

3.1. Background

Optimizing land use is crucial in today's world, as it ensures the sustainable utilization of resources and the preservation of the environment for future generations. The optimization of land use involves careful planning and allocation of land for various purposes to ensure that it is used to its maximum potential, while minimizing negative impacts on the environment and society.

One of the critical factors in optimizing land use is considering the future impact of emerging technologies and industries. For example, the construction of a semiconductor fabrication facility could have a significant impact on the surrounding land use and infrastructure. Therefore, it is essential to model and evaluate the potential impact of such facilities on the land use, environment, and society.

To achieve the best optimization of land use, a model is required that considers the various factors that affect land use and their interactions. Such a model should be able to incorporate the dynamic and complex nature of land use and the diverse factors that affect it. By developing a comprehensive and flexible model, we can simulate various scenarios and assess the potential outcomes of land use decisions, including the impact of the semiconductor fabrication facility. This will enable us to make informed decisions and implement effective strategies for optimizing land use.

3.2. Restatement of Problem

1. To instill confidence in the final choice of land use, we must define a quantitative decision metric that outlines what is considered the optimal option. This metric should take into consideration both the immediate and future benefits and drawbacks associated with the decision.
2. Select a minimum of two choices from the aforementioned options and calculate their values using the "best" metric. Justify and support our values, or use a range of values to gain a deeper understanding of the impact and sensitivity of our assumptions.
3. Evaluate the impact the construction of a sizable semiconductor facility by Micron Technology, USA in Clay, NY, USA will have on the decision metric.
4. Provide a brief discussion on the suitability of our model for use in a setting we are acquainted with. Assess the level of generalizability of our model to other locations.

4. Definitions and Assumptions

4.1 Definition of Variables

- **Variables for AHP (Analytical Hierarchy Process):**

The data analysis procedure involves the following steps. First the pairwise comparison matrix which is called matrix A is extracted from the data collected. The principal right eigenvector of the matrix A is computed as'w'.

If $a_{ik} \cdot a_{kj} = a_{ij}$ is not confirmed for all $k,\ j,\ and\ i$ The Eigenvector method is selected (Jalaliyoon, et al., 2012).
If the matrix is incompatible and in case of incomplete consistency, the pair comparisons matrix cannot be used to normalize the column to get Wi. For a positive and reversed matrix, Eigenvector technique can be used which in it:

$$e^T = (1, 1, \ldots, 1)$$

$$w = \lim_{k \to \infty} \frac{A^k . e}{e^T . A^k . e}$$

To reach a convergence among the set of answers into successive repetition of this process, calculation should be repeated several times in order to take a decision when facing an incompatible matrix. Then, the following formula is applied to transform the raw data into meaningful absolute values and normalized weight $w = (w1,\ w2,\ w3\ldots\ w_n)$:

$$Aw = \lambda_{max} w, \lambda_{max} \geq n$$

$$\lambda_{max} = \frac{\sum a_j w_j - n}{w1}$$

$$A = \{a_{ij}\}\ with\ a_{ij} = \frac{1}{a_{ij}}$$

A: $pairwise\ comparison$
w: $normalized\ weight\ vector$
λ_{max}: $maximum\ eigen\ value\ of\ matrix\ A$
a_{ij}: $numerical\ comparison\ between\ the\ value\ i\ and\ j$

In the next step, in order to validate the results of theAHP, the consistency ratio (CR) is calculated using the formula, CR = CI/RI in which the consistency index (CI) is, in turn, measured through the following formula:

$$CI = \frac{\lambda_{max} - n}{n-1}$$

- **Variables for MCDM (Mathematical Criterion Decision Making):**

$$s_j = \sum_{i=1}^{n} w_{ij} x_{ij}$$

Where s_j represents the level of suitability to the land-use category j, n is the number of criteria related to category j, $w_{ij}(0 - 1)$ represents the weight criterion i of category j, and x_{ij} represents scores of criterion i in criterion j. We used this relation to get data evaluated in **Table 5.2.3.**

4.2. <u>General Assumptions and Justifications</u>

1. Since the soil is said to be rich and fertile enough for production, the soil fertility is taken constant in every part of the land. This makes it easier for the model development due to reduction of a variable.
2. The land lies in a favorable elevation with not so much elevation difference across different parts. So, it is assumed that the elevation doesn't play any role in the choice of the decision makers.
3. Due to the temperate marine climate being relatively constant and supportive of all the different choices throughout the year, the choice of the decision makers is taken to be independent of the climatic conditions.

5. Requirements

5.1. Factors taken into consideration

When it comes to land management, there are several crucial factors to consider. One of the most important is the area of land. The size of the land can determine what type of land use is appropriate, such as agricultural, residential or commercial. In addition, larger land areas may require more resources and time to manage effectively.

Another important factor is the slope of the land. This can affect the potential for erosion, water drainage, and the suitability of the land for construction or agricultural purposes. Steep slopes can also increase the risk of landslides and other natural disasters.

Distance from the areas with high population density is another important factor to consider when managing land. Being closer to a large city can have an effect on the flow of the people to the land considered for the project.

Cell coverage is also important for land management. Having good cell coverage can make it easier to stay connected and manage land operations from remote locations. It can also be helpful for communication with workers and contractors on the land during the construction of a project. Similarly, projects where there is constant engagement of the people need proper cell coverage.

The current land usage is an important consideration as well. Understanding what the land is currently being used for, and the surrounding land uses, can help determine the best use for the land and potential conflicts that may arise. It is difficult to construct project in a land with certain usage such as it might be possible to construct a building over a wetland

Aspect, or the direction the land faces, is another important factor for agricultural purposes as well as for projects such as skiing, agrivoltaic farming and solar array. The direction of the sun can impact the growth and yield of crops, as well as the overall health of the land.

Budget and revenue are perhaps the most important factors for land management, as they determine the financial feasibility of any project. Budgeting for a project is essential to ensure that the project is financially viable, while revenue is the ultimate measure of success. In order to maximize revenue, it is important to carefully consider all of the other factors mentioned above and ensure that the land is used in the most effective and efficient way possible.

5.2. Construction of Model

For the construction of the model, we used the mathematical modeling techniques AHP (Analytic Hierarchy Process) and MCDM (Multi-Criterion Decision Making). From all the factors mentioned above, we used AHP to calculate the weightage of each factor in the final decision making and MCDM to choose the "best" option among the different ones.

We calculated the weightage of the solar array option via AHP using the above-mentioned factors and compared the importance of different factors with each other to get the decision matrix and weightage of the different factors.

With respect to *AHP priorities*, which criterion is more important, and how much more on a scale 1 to 9?

	A - wrt AHP priorities - or B?		Equal	How much more?
1	Area	Slope	1	2 3 4 5 6 7 8 9
2	Area	Distance	1	2 3 4 5 6 7 8 9
3	Area	Budget	1	2 3 4 5 6 7 8 9
4	Area	Revenue	1	2 3 4 5 6 7 8 9
5	Area	Cell Coverage	1	2 3 4 5 6 7 8 9
6	Area	Current land usage	1	2 3 4 5 6 7 8 9
7	Area	Aspect	1	2 3 4 5 6 7 8 9
8	Slope	Distance	1	2 3 4 5 6 7 8 9
9	Slope	Budget	1	2 3 4 5 6 7 8 9
10	Slope	Revenue	1	2 3 4 5 6 7 8 9
11	Slope	Cell Coverage	1	2 3 4 5 6 7 8 9
12	Slope	Current land usage	1	2 3 4 5 6 7 8 9
13	Slope	Aspect	1	2 3 4 5 6 7 8 9
14	Distance	Budget	1	2 3 4 5 6 7 8 9
15	Distance	Revenue	1	2 3 4 5 6 7 8 9
16	Distance	Cell Coverage	1	2 3 4 5 6 7 8 9
17	Distance	Current land usage	1	2 3 4 5 6 7 8 9
18	Distance	Aspect	1	2 3 4 5 6 7 8 9
19	Budget	Revenue	1	2 3 4 5 6 7 8 9
20	Budget	Cell Coverage	1	2 3 4 5 6 7 8 9
21	Budget	Current land usage	1	2 3 4 5 6 7 8 9
22	Budget	Aspect	1	2 3 4 5 6 7 8 9
23	Revenue	Cell Coverage	1	2 3 4 5 6 7 8 9
24	Revenue	Current land usage	1	2 3 4 5 6 7 8 9
25	Revenue	Aspect	1	2 3 4 5 6 7 8 9
26	Cell Coverage	Current land usage	1	2 3 4 5 6 7 8 9
27	Cell Coverage	Aspect	1	2 3 4 5 6 7 8 9

Resulting Priorities

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	Area	10.0%	4	5.6%	5.6%
2	Slope	4.5%	5	3.4%	3.4%
3	Distance	4.4%	6	3.2%	3.2%
4	Budget	23.4%	2	13.9%	13.9%
5	Revenue	41.6%	1	27.9%	27.9%
6	Cell Coverage	2.0%	8	1.2%	1.2%
7	Current land usage	10.4%	3	6.5%	6.5%
8	Aspect	3.7%	7	1.9%	1.9%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2	3	4	5	6	7	8
1	1	3.00	5.00	0.17	0.14	6.00	2.00	2.00
2	0.33	1	0.33	0.14	0.12	6.00	0.17	3.00
3	0.20	3.00	1	0.20	0.17	3.00	0.25	0.50
4	6.00	7.00	5.00	1	0.20	7.00	4.00	6.00
5	7.00	8.00	6.00	5.00	1	8.00	6.00	7.00
6	0.17	0.17	0.33	0.14	0.12	1	0.25	0.50
7	0.50	6.00	4.00	0.25	0.17	4.00	1	5.00
8	0.50	0.33	2.00	0.17	0.14	2.00	0.20	1

Number of comparisons = 28
Consistency Ratio CR = 15.3%

Principal eigen value = 9.503
Eigenvector solution: 7 iterations, delta = 1.4E-8

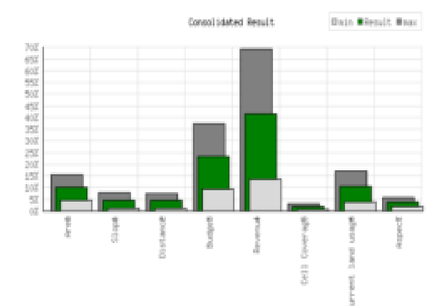


Table 5.2.1: Determining the weightage percentage of all the different factors for the solar array option.

Doing the same for skiing option, we get the following data:

	A - wrt AHP priorities - or B?		Equal	How much more?
1	Area	**Slope**		4
2	**Area**	Distance		7
3	Area	**Budget**		7
4	Area	**Revenue**		8
5	**Area**	Cell Coverage		3
6	Area	**Current land usage**		4
7	Area	**Aspect**		7
8	**Slope**	Distance		5
9	**Slope**	Budget		2
10	**Slope**	Revenue		3
11	**Slope**	Cell Coverage		7
12	**Slope**	Current land usage		5
13	Slope	**Aspect**		8
14	Distance	**Budget**		7
15	Distance	**Revenue**		8
16	Distance	**Cell Coverage**		3
17	Distance	**Current land usage**		5
18	Distance	**Aspect**		7
19	Budget	**Revenue**		3
20	**Budget**	Cell Coverage		6
21	**Budget**	Current land usage		2
22	Budget	**Aspect**		6
23	**Revenue**	Cell Coverage		5
24	**Revenue**	Current land usage		4
25	Revenue	**Aspect**		5
26	Cell Coverage	**Current land usage**		3
27	Cell Coverage	**Aspect**		7
28	Current land usage	**Aspect**		4

Resulting Priorities

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	Area	4.1%	6	3.2%	3.2%
2	Slope	17.2%	2	10.8%	10.8%
3	Distance	1.8%	8	1.5%	1.5%
4	Budget	10.5%	4	6.1%	6.1%
5	Revenue	15.3%	3	8.7%	8.7%
6	Cell Coverage	2.6%	7	1.4%	1.4%
7	Current land usage	6.5%	5	3.6%	3.6%
8	Aspect	42.0%	1	34.4%	34.4%

Number of comparisons = 28
Consistency Ratio CR = 16.7%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2	3	4	5	6	7	8
1	1	0.25	7.00	0.14	0.12	3.00	0.25	0.14
2	4.00	1	5.00	2.00	3.00	7.00	5.00	0.12
3	0.14	0.20	1	0.14	0.12	0.33	0.20	0.14
4	7.00	0.50	7.00	1	0.33	6.00	2.00	0.17
5	8.00	0.33	8.00	3.00	1	5.00	4.00	0.20
6	0.33	0.14	3.00	0.17	0.20	1	0.33	0.14
7	4.00	0.20	5.00	0.50	0.25	3.00	1	0.25
8	7.00	8.00	7.00	6.00	5.00	7.00	4.00	1

Principal eigen value = 9.637
Eigenvector solution: 9 iterations, delta = 5.3E-9

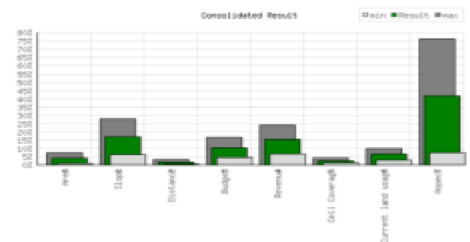


Table 5.2.2: Weightage of data for skiing option.

MCDM Decision

A	B	C	D	E	F	G	H	I	J	K
Average weightage	8.03	16.46	25.1	33.6	8.7	9.1	Preference Score	Ranking		
Beneficial or not beneficial	B	B	N	B	B	N				
Projects	Area (sq. km)	Average Slope (Degrees)	Budget	Revenue	Aspect	Land Usage				
Agritourist Center	2.07	2	3	5	3	0.93	0.6113	1		
Solar array	0.9	2	5	4	5	2.1	0.3894	3		
Skiing	0.93	17	4	3	6	2.07	0.5342	2		
								Budget	Revenue	Aspect importance
							very low	1	1	1
							low	2	2	2
							medium	3	3	3
							high	4	4	4
							very high	5	5	5
							extreme	6	6	6

Table 5.2.3: Decision Table using MCDM method

Note:
We have assigned specific values to each word as the budget and revenue are recorded verbally. The area designated for skiing is determined based on the topography of the land. For instance, only 31% of the total land is appropriate for skiing, which equates to 0.93 when multiplied by 3.

5.3. Sensitivity Analysis of Parameters

By the means of Sensitivity Analysis, the effect in the calculation of the project suitability can be determined for different projects with respect to the variation in the values of the selected parameters. It can assist in comparison between different projects.

Consideration of a large number of parameters for the project selection brings about challenges in the sensitivity analysis. The accurate analysis can only be performed after the sensitivity analysis of each parameter for each project in our model. However, for a weight based model such as MDCM where weightage for each parameter is calculated using methods such as AHP, it can be observed that the parameter with high weightage value proves to be the most sensitive value.

For the proper project selection, it is necessary to calculate the AHP based parameter weightage for all the project options considered. Upon the calculation of these weightages and determination of the most sensitive parameters for each of the project options, decision tree based models considering complex combinations of factors for parameters for project selection or direct elimination/selection of projects based upon the positive support or negative support of the most sensitive parameter in the real project site/land can be used for the selection of the most suitable project.

Skiing project (Area Parameter)

Variation in the weighted value of project suitability for skiing projects with the change in the value of the area parameter for the project is calculated and plotted.

Almost 92% of slope values in the land lie in between 0-6 degrees based upon the data. We have considered a skiing area of 150000 to 600000 m2. Distance for cities is considered from nearest 50 km to southern large city of Atlanta at 1250 km. Revenue based on people in the 3 months of operations are considered as min 20 ($200 per day for 90 days) and max 30. Areas covered by crops are observed to be most suitable for the establishment of skiing facilitiy. North Facing Aspects are suitable for skiing as ice formation is essential for skiing

parameter	weighing factor	avg value	scale factor	
area	4.1	375000	3	12.3
slope	17.2	3	3	51.6
distance	1.8	650	3	5.4
budget	10.5	17500	3	31.5
revenue	15.3	450000	3	45.9
cell coverage	2.6	80	3	7.8
current land use	6.5	15	3	19.5
aspect	42	90	3	126
Range of parameter values:				300
area	150000	600000	m2	
slope	6	0	deg	
distance	1250	50	km	
budget	10000	25000	dollar	
revenue	360000	540000	dollar	
cell coverage	70	90	%	
current land use	30	0	(crops)	
aspect	0	360		
sensitivity for area:				
weight	variable value	functional value		
1	150000	291.8		
1.5	206250	293.85		
2	262500	295.9		
2.5	318750	297.95		
3	375000	300		
3.5	431250	302.05		
4	487500	304.1		
4.5	543750	306.15		
5	600000	308.2		

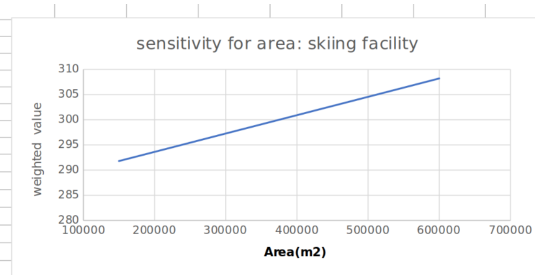


Table 5.3.1: Sensitivity for Area: Skiing facility

Solar Array Project (Area Parameter)

Variation in the weighted value of project suitability for solar projects with the change in the value of the area parameter for the project is calculated and plotted. Similar values as that of skiing projects are considered for the parameters for relative analysis.

parameter	weighing factor	avg value	scale factor	
area	10	375000	3	30
slope	4.5	3	3	13.5
distance	4.4	650	3	13.2
budget	23.4	17500	3	70.2
revenue	41.6	450000	3	124.8
cell coverage	2	80	3	6
current land use	10.4	15	3	31.2
aspect	3.7	90	3	11.1
Range of parameter values:				300
area	150000	600000	m2	
slope	6	0	deg	
distance	1250	50	km	
budget	10000	25000	dollar	
revenue	360000	540000	dollar	
cell coverage	70	90	%	
current land use	30	0	(crops)	
aspect	0	360		
sensitivity for area:				
weight	variable value	functional value		
1	150000	280		
1.5	206250	285		
2	262500	290		
2.5	318750	295		
3	375000	300		
3.5	431250	305		
4	487500	310		
4.5	543750	315		
5	600000	320		

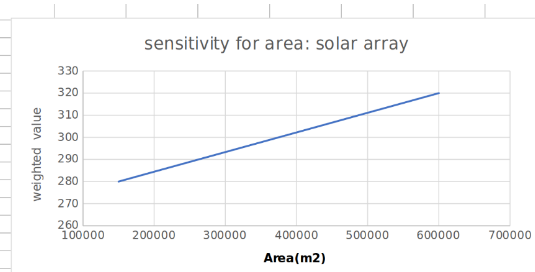


Table 5.3.2: Sensitivity for Area: Solar Array

5.4. Effect on decision due to establishment of semiconductor facility

Micron is the fifth largest semiconductor company in the world by revenue ($21.4 billion in 2020) and operates in 17 countries. The processors and microchips that Micron produces are used in computers, consumer electronics, automobiles, and telecommunications. The manufacturing of semiconductors is an energy-intensive process that can create significant carbon emissions and involve high energy costs. Micron has formed specialized teams to focus on these gases with the goal to transition to gases that potentially contribute less to global warming, and the company also has a longer-term goal of achieving a net-zero manufacturing process.

Establishment of a $100 billion semiconductor plan with the capability to create almost 40,000 jobs will have an impact on the population of the nearby areas to the facility causing the increase in flow of people there and also the increase in the traffic. Micron, which is taking advantage of the state's Green CHIPS program, has said that it aims to use 100% renewable energy at the New York facility in line with the company's commitment to 100% renewable energy across its U.S. operations by 2025.

Based upon it we can analyze the impact that the establishment of a project such as solar array, focused on the generation of renewable energy can have on the environment as well as the success of large projects like Micron chip fab having high positive impact on the nearby areas and New York state. Presence of a large number of solar farms in New York and nearby areas further supports the feasibility of establishment. We have performed the design and cost benefit analysis for a solar array project which can be constructed on the land.

5.4.1. Solar Array project design and Cost Benefit Analysis

Assumption of values:

Irradiance = 1000 W/m^2

Temperature = 25 °C

PV array characteristics:

Electrical Characteristics

- Module name : Aavid Solar ASMS -165P
- Maximum power of unit module : 164.85 W
- Open circuit voltage (Voc) :43.5 V
- Short-circuit current : 5.25 A

- Voltage at maximum power : 35 V

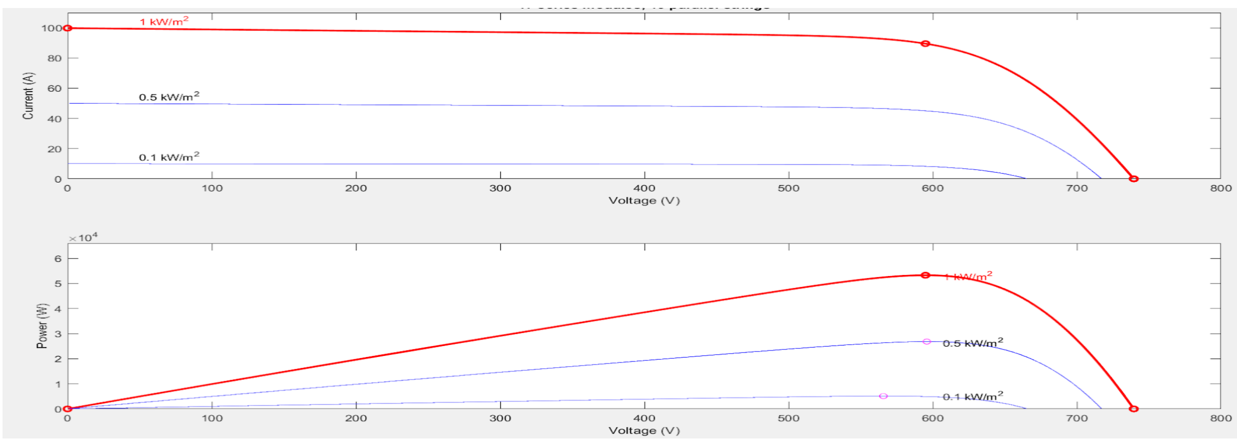


Fig : IV and PV characteristics of system at different irradiances

We researched the extraction of maximum power from a PV panel.Maximum Power point tracking (MPPT) algorithm is used to extract the maximum power from a PV panel. There are different MPPT algorithms available out of which we used Perturb and observe (P&O) algorithms for maximum power extraction.

Mechanical characteristics

- Cell type : Poly
- Length (m) : 1.575 m
- Width (m): 0.826 m
- Cross sectional area of module: 1.3 m2

Calculation of number of PV module:

Cell per module = 72

Let us assume, the grid is operated at 400 V (line rms) such that input to the inverter is around 600 V.

Here, Voltage at maximum power = 35 V

So, No. of series connected strings = 600/35 V = 17.14V ~ 17 V

Actual operating voltage that corresponds to maximum power = 17*35 = 595 V

Here, Total available area for solar power plant design = Area of (Crops + Developed + Shrubs)

= 30% + 12 % + 1% = 43 % of 3 KM2

= 1.29 Km2

Total number of PV module that can be adjusted in given area = (1.29 *1000 *1000/1.3)

= 992308

Total Power that can be generated by Solar system = 992308 * 164.85

= 163.5 MW

Now, Total no. of parallel connected module = (163.5 *10^6)/(17*164.85) = 58370

Calculation of total energy Consumption per day:

Total input power (Pin) = 163.5 KW

Let, solar panel efficiency = 20 %

Inverter efficiency = 90 %

Total output power (Pout) = 163.5 *0.2 *0.9 = 29.43 MW

Assume , 7 hr/day peak sunshine

Total energy consumption = 29.43 * 7 = 206.01 MWh

= 206.01 *1000

= 206010 KWH

Calculation of Payback period :

For New York, USA

Unit cost of electricity for industrial use = 16.48 cents/unit

= 0.1648 $/unit

Total revenue by selling electricity to semiconductor industry = 0.1648 * 206010

= 33950 $/day

Total annual revenue by selling electricity = 33950 *365 = $ 12391750

Investment calculation:

As of April 2023, the average solar panel cost in New york is $ 0.9/Watt

Total investment cost = 163.5 *10^6*0.9 = $147150000

Total operation and maintenance cost = 0.5 % of total investment cost = $735750

Replacement cost = 0.1% of investment cost = $147150

Total annual expenses = $(735750 + 147150) = $882900

Payback Period = (Investment cost / Annual income) =147150000/(12391750 - 882900)

= 12.78 Yrs ~ 13 Yrs

If we consider forest area as well for the solar power plant design,

Total area available for solar plant = (38 +43) % of 3 KM2 = 2.43 KM2

Total number of PV module that can be adjusted in given area =(2.43 *1000*1000/1.3)

= 1869230

Total power generated by solar = 1869230 *164.85 = 308 MW

Total output power = 308*0.2*0.9 = 55.44 MW

There is an increase in the Total power generated by the project due to the increase in the number of the solar panels in the area. Similarly, calculation on the payback period for this case (deforestation) can be done.

A payback period of 13 years for a solar power plant may be considered relatively long compared to other types of investments. However, solar power plants are typically designed to operate for 20 to 30 years or more, so the project could still generate significant cash flows after the payback period is reached. Additionally, solar power plants provide a renewable source of energy and can help reduce greenhouse gas emissions, which can provide environmental and social benefits that are not captured in the payback period calculation.

5.5. Generalization of Model to Other Locations

The model mentioned above is highly beneficial as it can be generalized to other locations beyond this given piece of land in NY, USA. We can just tweak the values of the parameters like topographical factors to obtain a completely different result. Also,it can be used to optimize land use in completely opposite corners of the world too by changing the assumptions. By changing the climatic conditions and/or elevation and/or soil fertility, we are left with a diverse range of solutions. For erratic and variable climate, we can introduce another parameter in the form of climate and model its variation along with how it impacts the optimization process by calculating its required weightage via AHP.

We can use this model to estimate the best land use in our own environment too. Nepal being a part of semi-arid climate, has a completely different climatic condition than that of the land in question. However, some factors bear a certain level of similarity in the two places. The elevation and the soil condition of the land is something we are familiar with as well. Along with that, a lot of other topographical factors also match out similarly enough. And in certain parts of Nepal, even the climate is similar. But in most of the places the climate is very different from the land of NY. Due to less precipitation than required normally, agriculture is not the best option. Also, the high temperature and hotty days of the environment in such a climate allows for efficient use of solar arrays. So, in our environment, since most of the parameters except climatic conditions remain the same and the climate supports solar arrays, solar arrays would be the best option in such a land in our environment.

6. Strengths and Limitations of Model

6.1. Strengths of Model

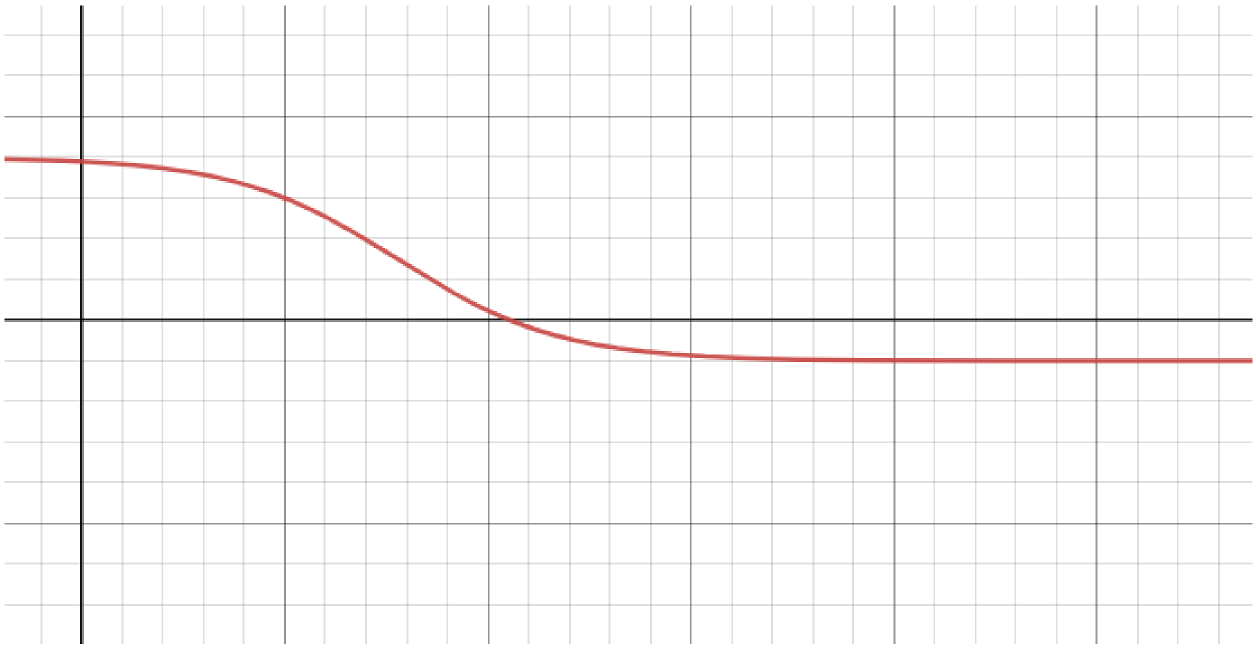
- Our model consists of the most important factors that affect the land suitability, including the standardized AHP and MCDM techniques, allowing us to determine the best alternative accurately.
- Our model has been accompanied by simple equations, ideas and techniques which makes it convenient for people of every age group and backgrounds.
- Models presented above are realistic and based on the real time experiences which ensures high accuracy and also assists in reducing the degradation of the environment.

6.2. Limitations of Model

- For the ease of simulation, a large number of assumptions has been made that influences the desired output in the real life practices.
- The techniques can only be applied with adequate data along with essential factors to be considered.

7. Appendices

The benefit of the project varies with the budget of the project as:



Graph showing variation of benefit of project with budget of project

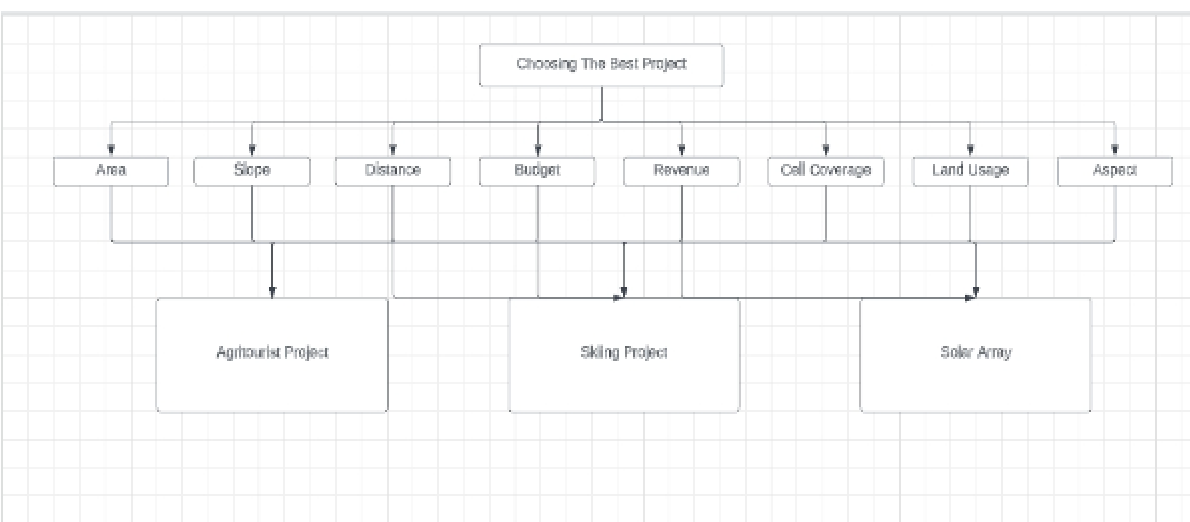
Here, the X-axis represents the budget of the project and the Y-axis represents the benefit of the project. The point at which the curve intersects the X-axis is the maximum budget of the owners. If the cost of the project exceeds their maximum budget, the project very rapidly becomes not so beneficial. However, if the cost of the project is below their budget, the project turns out fruitful.

An equation which can model such graph for the range [-1,1] is:

$$y=\frac{8.165}{4+e^{\frac{1(x-a)}{2}}}-1$$

Here, 'a' determines the maximum budget of the owner.

Fig : Map showing contour, structure, slope and angle shading



8. References

- Zhang, Z., Zhou, M., Ou, G., Tan, S., Song, Y., Zhang, L., & Nie, X. (n.d.). Land Suitability Evaluation and an Interval Stochastic Fuzzy Programming-Based Optimization Model for Land-Use Planning and Environmental Policy Analysis https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=3c95ea0d7c3a136fcbfcacc7805b8da2a82d6591
- Duc, T. T. (2006, November). Using GIS and AHP technique for land-use suitability analysis. In International symposium on geoinformatics for spatial infrastructure development in earth and allied sciences (Vol. 1, No. 6).
- Aşılıoğlu, F. (2015). Land Suitability Analysis by GIS and MCDM Techniques. In (pp. 766-782). ISBN: 978-954-07-3999-1. https://www.researchgate.net/publication/309202459_Land_Suitability_Analysis_by_GIS_and_MCDM_Techniques
- Salman, S., AI, X., & WU, Z. (2018). Design of a P-&-O algorithm based MPPT charge controller for a stand-alone 200W PV system. Protection and Control of Modern Power Systems
- How Much Do Solar Panels Cost In 2023? https://www.forbes.com/home-improvement/solar/cost-of-solar-panels/
- Simulated historical climate & weather data for Red Creek https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/red-creek_united-states_5133538
- Investing in the Future, Sustainability report 2022, Micron https://media-www.micron.com/-/media/Client/Global/Documents/General/About/2022/2022_Micron_Sustainability-Report.pdf
- Jalaliyoon, N., Bakar, N. A., Taherdoost, H. (2012). Accomplishment of Critical Success Factor in Organization; Using Analytic Hierarchy Process. International Journal of Academic Research in Management, Helvetic Editions Ltd, 1(1); 1-9
- Saaty, T. L. (1980). The Analytic HierarchyProcess: Planning, Priority Setting, ResourcesAllocation. London: McGraw-Hill.
- Golden, B. L. & Wang, Q. (1990). An AlternativeMeasure of Consistency. In: B. L. Golden, A. Wasil& P.T. Harker (eds.) Analytic Hierarchy Process:Applications and Studies, 68-81, New-York:Springer Verlag.