

APPLICATION OF THE ANALYTIC HIERARCHY PROCESS (AHP) IN THE SELECTION ECOLOGICAL ACTIVITIES AND PROJECTS IN WIELICZKA

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ABSTRACT

Over the past decades, the environmental problem has only gotten worse, which affects the whole world. This leads to various other troubles such as water shortage, resource scarcity and others. The locality of Wieliczka is not free of the contamination problem, which has led to seeking solutions. This paper aims to respond to this search with a proposal to help solve the question. This will be done using an AHP model with the software Super Decisions considering many important factors that have effect on the proposal selected.

INTRODUCTION

Nowadays, the environmental protection issue is gaining greater importance due to the massive damages that are taking place in different regions of the world due to high levels of pollution and global warming. Because of this situation, the UN declared on July 28, 2022, that all people in the world have the right to a healthy environment. For this reason, each city, province and country must distribute part of its resources to safeguard the environment that surrounds its population. In the case of Wieliczka, a small town (around 13.4 km²) located about 12 km south-east of Krakow in Poland, its authorities have a special interest in managing activities aimed at strengthening the protection of the environment and creating new ecological projects along with system monitoring. However, selecting which activity or project is the best option for society results in a complicated situation because of two main reasons: many different valuation criteria can be considered and there can be different levels of importance for each stakeholder interested in complying with the UN's order.

Therefore, with the objective to find a solution to this problem, the present study aims to explain the whole selection process of three alternatives focused on strengthen the environment protection in Wieliczka -which are native plant reforestation, impulsing bicycle use and avoiding salt overproduction- based on a series of criteria and stakeholders preferences having all of them normally hierarchical using AHP, a technique which works as a measurement tool that through various pairwise comparisons -which are based on experts' judgments- provides priority scales (Russo & Camanho, 2015) and allows rationally selecting the best alternative from a series of options that were evaluated with multiple criteria, incorporating both the rational and the intuitive (Hillier & Price, 2005). Finally, even if it is important to have previous experts' judgments, due to the little information found about the state of the environment and the authorities' opinion about certain decision criteria, it was decided to use the authors' judgment. Nevertheless, this does not suggest that new work can be carried out in the future, taking these aspects into consideration.

LITERATURE REVIEW

To carry out this test, short-term information about the city of *Wieliczka* has been considered that will help us to assign weights to each criterion. First, the article used to carry on the investigation regarding the Wieliczka Salt Mine:

<https://www.wieliczka-saltmine.com/individual-tourist/about-the-mine/geology-of-the-mine>

Next, the article used to obtain information on the Niepolomice Forest:

<https://www.wieliczka-city.pl/dzialy/atracje-turystyczne/puszcza-niepolomicka/>

Lastly, to have more information on incentivizing bicycle use:
<https://www.tandfonline.com/doi/full/10.1080/21650020.2013.866875>

OBJECTIVE/HYPOTHESIS

The main objective of this investigation is to elaborate an AHP model to choose which project to implement to have better environmental conditions in Wieliczka. The hypothesis would be that with the software Super Decisions, using an AHP model, the investigation could propose a project to make better environmental conditions in Wieliczka.

METHODOLOGY

The model came to be and started to expand by defining the goal, and then, defining the most important decision criteria. From there on, in each of these, decision factors were established. After this, stakeholders were defined. Each of these three -decision criteria, decision factors and stakeholders- were chosen based on the literature review and information on Wieliczka. After this, on the pairwise comparison, information found was also used, and the one that wasn't found, criteria based on the literature review was useful. There were no inconsistency problems.

DATA/MODEL ANALYSIS

First, the most influential criteria and decisive factors are defined to choose the best alternative.

Decision criteria	Decision factors
Economic	Investment Savings Earnings Profitability Operational Costs Taxes
Ecological	Carbon footprint impact NR-E Resources usage R-E Resources usage SDG Contribution Pollution
Operational	Maintenance Set up time Planning Time Location convenience Employee Capacity Execution Time
Organizational	Members approval New hirings Organizational Capacity Resources Complexity
Social	Community Participation Impact Negative Externalities Positive Externalities Community approval

Picture 1. Own elaboration. Sample of most influential criteria and decisive factors.

Before obtaining results, pairwise comparisons must be done. This consists in giving importance subjectively between the factors given a criteria and between the stakeholders given a factor considered in the model (Annex 1-9).

LIMITATIONS

The biggest limitation of the investigation would be not knowing Wieliczka and not having much information about it. This limits the model in the way that not having much knowledge about it, the model doesn't have every aspect in detail that could have been considered if we had more information. However, it was still possible to make a good model with the information and investigation made.

RESULTS AND CONCLUSION

Name	Graphic	Ideals	Normals	Raw
Impulse bicycle use		0.727741	0.283039	0.070466
Reduce overproduction of salts		1.000000	0.388928	0.096829
Reforestation		0.843431	0.328034	0.081669

Focusing on projects to reduce overproduction of salts for the long term is the best option.

Inconsistency: 0.05291		
Ecological		0.37312
Economic		0.16548
Operation~		0.07538
Organizat~		0.08819
Social		0.29783

The most influential criteria would be the ecological factor followed by the social one.

By increasing the importance of the ecological criteria, the reforestation project would become the most important one. However, by increasing any of the other criteria, the best project would not change (Annex 10-14).

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Official tourism website of the Małopolska Region. Town and Commune Office, Wieliczka. Retrieved from https://visitmalopolska.pl/en_GB/obiekt/-/poi/urząd-miasta-i-gminy-wieliczka

ANNEXES

Decision Criteria-Factors:

- **Annex 1: Organizational:**

Resource complexity is 2 times more important than Org

Inconsistency	Employee n~	Organizati~	Resource ~
Aproval ~	← 4	← 3.0000	← 2
Employee n~		↑ 2	↑ 2
Organizati~			↑ 2

- **Annex 2: Ecological:**

Carbon footprint impact is 2 times more important than Non-renewabl

Inconsistency	Non-renew~	Pollution ~	Renewable ~	SDO objec~
Carbon fo~	← 2	↑ 2	← 3	← 3
Non-renew~		↑ 4	← 1	← 2
Pollution ~			← 3	← 4
Renewable ~				← 0

- **Annex 3: Operational:**

Convenience of location is 2 times more important than Employee capacity

Inconsistency	Employee ~	Execution ~	Maintenanc~	Planning ~	Preparatio~
Convinci~	← 2	↑ 2	← 3	← 4	← 4
Employee ~		← 3	← 3	← 2	← 2
Execution ~			← 3	← 1	← 1
Maintenanc~				↑ 2	↑ 2
Planning ~					← 0

- **Annex 4: Social:**

Community aproval is 1 times more important than Community particip

Inconsistency	Community ~	Impact ~	Negative ~	Positive ~
Community ~	← 1	↑ 3.0000	↑ 2	↑ 2
Community ~		↑ 3.0000	↑ 2	↑ 2
Impact ~			← 2	← 2
Negative ~				← 0

- **Annex 5: Economic:**

Investment is 2 times more important than Earnings

Inconsistency	Investment~	Operation~	Profitabil~	Savings ~	Taxes ~
Earnings ~	↑ 2	← 2	← 2	← 1	← 5
Investment~		← 2	← 3	← 1	← 3.000
Operation~			↑ 2	↑ 2	← 3.000
Profitabil~				← 2	← 3.000
Savings ~					← 4

Decision Factors-Stakeholders:

Some examples:

- **Annex 6: Organizational-Approval:**

Citizens is 1 times more important than Enviornmentalists

Inconsistency	Enviornment~	Polish sta~	Regional ~
Citizens ~	← 1	↑ 5	↑ 5.99998
Enviornment~		↑ 5.99998	↑ 7.00000
Polish sta~			↑ 2

- **Annex 7: Organizational-New Hirings:**

Inconsistency	Enviornment~	Polish sta~	Regional ~
Citizens ~	← 1	↑ 3.00000	↑ 3.00000
Enviornment~		↑ 4	↑ 4
Polish sta~			← 0

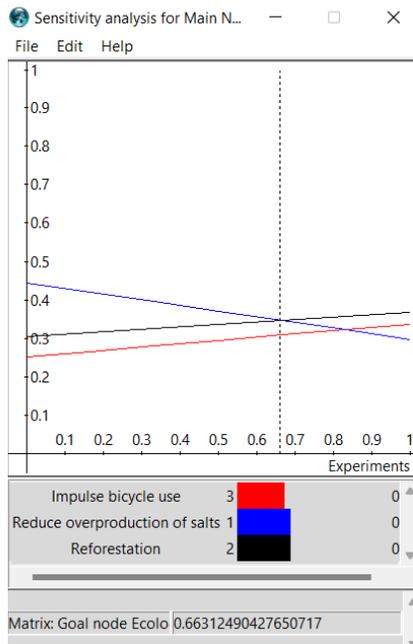
- **Annex 8: Organizational-Organization Capacity:**

Inconsistency	Enviornment~	Polish sta~	Regional ~
Citizens ~	← 1	↑ 4	↑ 5
Enviornment~		↑ 5	↑ 5.99998
Polish sta~			↑ 2

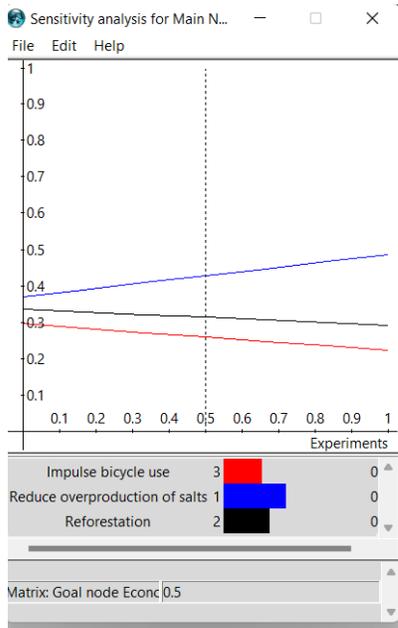
- **Annex 9: Organizational-Resource Complexity:**

Inconsistency	Enviornent~	Polish sta~	Regional~
Citizens ~	← 1	↑ 4	↑ 5
Enviornent~		↑ 5	↑ 5.99998
Polish sta~			↑ 2

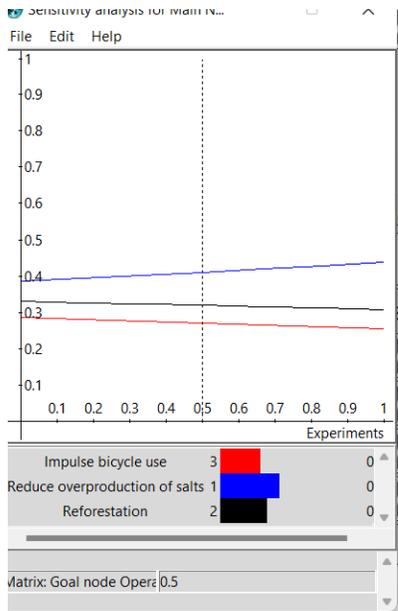
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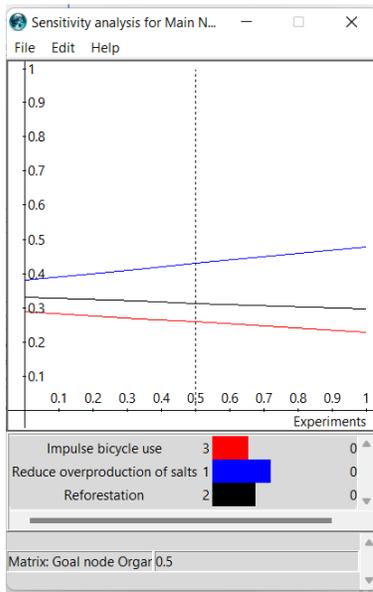
Annex 11:



Annex 12:



Annex 13:



Annex 14:

