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Scenario Analysis of Water Resources Planning Using PROMETHEE Method

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Abstract

Water resource planning involves estimating future water demand, evaluating potential new water sources, protecting water resources, and expanding environmental regulations. Better water resource management benefits society and the government alike. Water management makes it possible to save water and sewer costs, improve summertime irrigation control, and spend less energy. Water is kept clean and safe thanks to good management, which safeguards the general public's health. The Priority Ranking for Institutional Method for Enrichment Evaluation (PROMETHEE), a technique, aids decision-makers in a university in choosing the best candidates for admission. The Prometheus and Gaia approach was created in the early 1980s and has since undergone substantial research and development. It is based on mathematics and sociology. It is utilised globally in a variety of decision-making circumstances in industries like business, government, transportation, healthcare, and education. It has a specific application in decision-making. Development of new groundwater resources close to Kitchener-Waterloo under Build dual-purpose recharge and recovery wells at the Mannheim site in accordance with A3, Aquifer Recharge, Option 1 (AQ), with a capacity of 10 million imperial gallons per day (MIGD), in accordance with A1, Groundwater, Option 1 (GW1); A2, Groundwater, Option 2 (GW2)—The creation of additional fields with groundwater resources, primarily in the South Woolwich, Roseville, and St. Agatha sectors; and A4, (GR): Use the Grand River to obtain water when necessary; A5, Grand River Low Flow Augmentation (LF1)—Construct West Montrose Dam to boost the Grand River's water flow; A6, Grand River Low Augment (LF2), which will increase the amount of water pumped into the Grand River; A7, Grand River Low Flow Augmentation (LF3), which increases the flow of the Great River by piping water from Lake Huron into it; A8, Pipeline (PL1), a high-pressure water pipeline that supplies the region with water a high-pressure pipeline that uses to transport water from Lake Erie to the region; A10, Pipeline (PL3)—Use to transport water in God's Country to the area. INVEST (−) is in the highest value is the RISK (−) lowest value.

Introduction

Water resource planning involves estimating future water demand, evaluating potential new water sources, protecting water resources, and expanding environmental regulations. Better water resource management benefits society and the government alike. Water management makes it possible to save water and sewer costs, improve summertime irrigation control, and spend less energy. Water is kept clean and safe thanks to good management, which safeguards the general public's health. The Priority Ranking for Institutional Method for Enrichment Evaluation (PROMETHEE), a technique, aids decision-makers in a university in choosing the best candidates for admission. The Prometheus and Gaia approach was created in the early 1980s and has since undergone substantial research and development. It is based on mathematics and sociology. It is utilised globally in a variety of decision-making circumstances in industries like business, government, transportation, healthcare, and education. It has a specific application in decision-making. The PROMETHEE approach assists decision-makers in locating the finest alternative for their objective and comprehension of the issue, as opposed to pointing to a "right" choice. It offers a thorough and logical framing choice, locating measuring its conflicts and convergences, clusters of actions, emphasising important options, outlining structured reasoning. The following is a description of the index number-based criteria's detailed meanings: (1) Investment: The investment cost for the project in Danger: risk of the execution; (3) QUAL: the project's water quality; (4) Supply: The amount of water that the project can supply (in millions of imperial gallons); Impacts on the environment of the project (ENVIR); Project flexibility (FLEX); (7) Public: Social Perception of the Project's Acceptability. There are ten potential solutions. The outcomes for the MCDM issue are shown in Table 2. Risk, environmental consequences, and effect data were evaluated according to what the Associated Engineering reported [15]. It is determined that The larger the effect, as indicated by "+" in the better for Supply, Quall, General, and Flex; other criteria are unfavorable preferences scales. The short descriptions of all 10 of these options, together with their respective code numbers, are provided below.

Water Resources Planning

Although the RDM-real preferences application is constrained to a single river basin, comparable problems with coping with uncertainty pervade the planning of water resources, and it is anticipated that numerous general-interest discoveries will come from this work. To begin with, dividing uncertainty into probabilistic and probabilistic risk categories is a difficult step in this technique explains in more detail this integrated the utilization of a to address water resources planning problems. Presented is starts off by providing a general review of the hydro political context, then describes the analysis's particular models and underlying assumptions, including the definition of scenarios, and presents case study's findings. Provide some more broad findings and discuss the ramifications of the analyses [1]. The primary planning system for Water resources means ensuring that water institutions exist acting promptly appropriately guarantee supply in the face of all pressures. Any new strategy for mitigating centres this goal. We acknowledge, in particular with regard to the ninth principle, are subject to a number of methodological presumptions and do not take into account all sources of climate uncertainty, As with other sources of uncertainty in water resources planning [2]. The planning approach for water resources is built planning for water resources has traditionally taken into account the impact that changing weather patterns have on hydrology and water demand during the dry season. Water resources planning involve more than just predicting the water supplies in the future. It is also difficult to forecast future demand. In response to requests effective water use, water providers have developed a number of efforts to cut consumption. The efficiency of various demand control programmers, however, as well as how much less individuals are willing and able to tolerate, remain unknowns [3]. Arranging for the supply of water Investment decisions include deciding how much money to invest, relevant non-structural measures as well as the types, sizes, locations, and modes of operation of facilities must be in operation. The relative accuracy and precision of the variables influencing the planning or investment decision have often received minimal consideration in water resources planning. Rarely has sensitivity analysis been a key component of planning for water resources (or other public works). [7]. A region's crops could die during a single dry month, leaving no chance for new crop growth until the following growing season, which is usually twelve months away. As a result, planning for agricultural water resources must take into account the temporal variability of agricultural systems and its fundamental cause, climate variability [9]. Creating alternate optimal and nearly optimal solutions for the decision model in use is one method to achieve this. In reality, it seems that models for planning water resources have a lot of practically optimal solutions, i.e., their objective function values are little different from the ideal objective function value [10]. The water sector is currently preparing to take advantage of the new UKCP09 probabilistic climate change projections, but these present significant conceptual and practical difficulties. In addition to exploring the challenges the sector is currently facing in responding to climate change, this study describes how the processes for incorporating climate change information into water resource planning have changed through time [11]. Planning and development of water resources in the 20th century relied on projections of future demographics, per capita water demand, agricultural output, and economic productivity levels. Water needs have always been anticipated to increase because each of these factors has been predicted to increase. Because of this, conventional water planning frequently comes to the conclusion that future water demands would inevitably increase and eventually outpace developed water supplies [18]. Water resource planning is traditionally relied on recorded hydrological and weather data that is thought to be stationary, however climate change calls into question the dependability of water resources quality available water, challenging standard water utility planning techniques. This stationary suggests that weather statistics and variability, as well as hydrology, will not considerably differ from the known historical conditions and are accurate predictors of the conditions [21]. Examine availability water resources, various climate scenarios must be considered, which makes it difficult to couple the prior methodologies with water resources planning models for long periods of time [22].

PROMETHEE method

The articles on themes like energy management, social issues, Chemistry, logistics and transportation, manufacturing and assembly, and other subjects, as well as business and financial management are included in the application fields. The last section includes papers that have been published in a variety of disciplines, including government, sports, agriculture, medicine, and education. The academic articles are further categorised according to their publication year, journal, and authors' nationality, country of origin, application of PROMETHEE with other MCDA methods, and application of PROMETHEE with the use of a GAIA (Geometrical Analysis for Interactive Aid) plane. It is envisaged that the document would be able to satisfy practitioners' and researchers' needs for quick references to PROMETHEE [1]. PROMETHEE techniques require weights, or quantitative measures of criterion importance, on a scale of ratio as a result, [3]. It can also assist the investor in strengthening the framework of industry evaluation and business evaluation by using the PROMETHEE approach for sensitivity analysis of the results [4]. The analysis of PROMETHEE, which served as the foundation for this study, also resulted in the creation of several alternative approaches and an alternative formulation of PROMETHEE. These approaches would require a computational effort similar to that of PROMETHEE but would produce results that would more accurately reflect how all portfolios are ranked. The two main contributions of our study are the development of several, computationally "light" strategies for portfolio selection based on the PROMETHEE method and a computational investigation comparing the quality of solutions obtained with these methods and PROMETHEE [5]. Prior to ranking the different milling machines using the PROMETHEE approach, a specific preference function (PF) with associated thresholds is developed for each criterion. The decision-making team formed at the start of the application has defined preference functions and threshold values. These values were established by the decision-making team by taking into account the characteristics of various MMs and the company's purchasing policy [7]. The following is a description of the index number-based criteria's detailed meanings: (1) Investment: the amount invested in the project supply capacity (million imperial gallons); (2) Risk: the implementation risk; Project water quality; Project supply; Project environmental impacts; and Project supply quality (6) FLEX: demonstrate capacity to respond to shifts in demand; (7) Public: How the project is viewed by the general public. There are ten potential solutions. The outcomes for the MCDM issue are shown in 2. Risk, environmental consequences, and effect data were evaluated according to what the Associated Engineering reported [15]. It is determined that Supply, Qual, General, and Flex are positive preference scales; other criteria are negative choice scales. The short descriptions of all 10 of these options, together with their respective code numbers, are provided below. Development of new groundwater resources closes to Kitchener-Waterloo under A1, Groundwater, Option 1 (GW1); Risk, environmental consequences, and effect data were evaluated according to what the Associated Engineering reported [15]. It is determined that The larger the effect, as indicated by "+" in Table 2, the better for Supply, Qual, General, and Flex; other criteria are negative preference scales. The short descriptions of all 10 of these options, together with their respective code numbers, are provided below. Development of new groundwater resources close to Kitchener-Waterloo under A1, Groundwater, Option 1 (GW1); A6, Grand River Low Augment (LF2) would pipe water from Georgian Bay into the Grand River; Grand River Low Flow Augmentation (LF3) would pipe water from Lake Huron into the Great River; Pipeline (PL1) would use a high-pressure pipeline to deliver water from Lake Ontario to the area; Pipeline (PL2) would use the Nanticoke Water Treatment Facility; and Pipeline (PL3) would use high-pressure pipeline deliver water from Lake Erie to the area. INVEST (−) is in the highest value is the RISK (−) lowest value.

Table.1 Water Resources Planning

	GW1	GW2	AQ	GR	PL1	LF1
INVEST (−)	100	55	60	36	80	88
QUAL (+)	40	40	50	80	60	60
SUPPLY (+)	75	80	70	30	30	60
RISK (−)	29	25	40	54	50	50
FLEX (+)	40	40	45	40	70	50
ENVIR (−)	70	85	50	70	65	60
PUBLIC (+)	60	70	60	60	85	70
Max	100	85	70	80	85	88
Min	29	25	40	30	30	50
max-Min	71	60	30	50	55	38

Table 1 shows the Water Resources Planning Alternative: INVEST (−), QUAL (+), SUPPLY (+), RISK (−), FLEX (+), ENVIR (−), PUBLIC (+). Evaluation Preference: GW1, GW2, AQ, GR, PL1, LF1. shows the maximum and minimum output of each value.

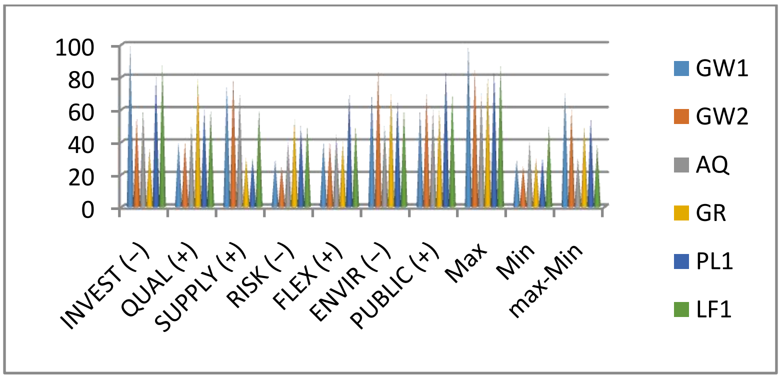

FIGURE 1. Water Resources Planning

Figure 1 shows the Water Resources Planning Alternative: INVEST (−), QUAL (+), SUPPLY (+), RISK (−), FLEX (+), ENVIR (−), PUBLIC (+). Evaluation Preference: GW1, GW2, AQ, GR, PL1, LF1.

TABLE 2. Normalized matrix of Sensitivity analysis promethee

	GW1	GW2	AQ	GR	PL1	LF1
INVEST (−)	1	0.5	0.66667	0.12	0.909091	1
QUAL (+)	0.154929577	0.25	0.33333	1	0.545455	0.263158
SUPPLY (+)	0.647887324	0.916667	1	0	0	0.263158
RISK (−)	0	0	0	0.48	0.363636	0
FLEX (+)	0.154929577	0.25	0.16667	0.2	0.727273	0
ENVIR (−)	0.577464789	1	0.33333	0.8	0.636364	0.263158
PUBLIC (+)	0.436619718	0.75	0.66667	0.6	1	0.526316

Table 2 shows the Normalized matrix of Sensitivity analysis promethea the Alternative: INVEST (−), QUAL (+), SUPPLY (+), RISK (−), FLEX (+), ENVIR (−), PUBLIC (+). Evaluation Preference: GW1, GW2, AQ, GR, PL1, LF1.normalization are shown in the above tabulation. Table 2 shows the default matrix of Prometheus for the sensitivity analysis shown in the table above.

TABLE 3. Pair wise Comparison

Pair wise Comparison						
	GW1	**GW2**	**AQ**	**GR**	**PL1**	**LF1**
D12	0.845070423	0.25	0.33333	-0.88	0.363636	0.736842
D13	0.352112676	-0.41667	-0.3333	0.12	0.909091	0.736842
D14	1	0.5	0.66667	-0.36	0.545455	1
D15	0.845070423	0.25	0.5	-0.08	0.181818	1
D16	0.422535211	-0.5	0.33333	-0.68	0.272727	0.736842
D17	0.563380282	-0.25	0	-0.48	-0.09091	0.473684
D21	-0.84507042	-0.25	-0.3333	0.88	-0.36364	-0.73684
D23	-0.49295775	-0.66667	-0.6667	1	0.545455	0
D24	0.154929577	0.25	0.33333	0.52	0.181818	0.263158
D25	0	0	0.16667	0.8	-0.18182	0.263158
D26	-0.42253521	-0.75	0	0.2	-0.09091	0
D27	-0.28169014	-0.5	-0.3333	0.4	-0.45455	-0.26316
D31	-0.35211268	0.416667	0.33333	-0.12	-0.90909	-0.73684
D32	0.492957746	0.666667	0.66667	-1	-0.54545	0
D34	0.647887324	0.916667	1	-0.48	-0.36364	0.263158
D35	0.492957746	0.666667	0.83333	-0.2	-0.72727	0.263158
D36	0.070422535	-0.08333	0.66667	-0.8	-0.63636	0
D37	0.211267606	0.166667	0.33333	-0.6	-1	-0.26316
D41	-1	-0.5	-0.6667	0.36	-0.54545	-1
D42	-0.15492958	-0.25	-0.3333	-0.52	-0.18182	-0.26316
D43	-0.64788732	-0.91667	-1	0.48	0.363636	-0.26316
D45	-0.15492958	-0.25	-0.1667	0.28	-0.36364	0
D46	-0.57746479	-1	-0.3333	-0.32	-0.27273	-0.26316
D47	-0.43661972	-0.75	-0.6667	-0.12	-0.63636	-0.52632
D51	-0.84507042	-0.25	-0.5	0.08	-0.18182	-1
D52	0	0	-0.1667	-0.8	0.181818	-0.26316
D53	-0.49295775	-0.66667	-0.8333	0.2	0.727273	-0.26316
D54	0.154929577	0.25	0.16667	-0.28	0.363636	0
D56	-0.42253521	-0.75	-0.1667	-0.6	0.090909	-0.26316
D57	-0.28169014	-0.5	-0.5	-0.4	-0.27273	-0.52632
D61	-0.42253521	0.5	-0.3333	0.68	-0.27273	-0.73684
D62	0.422535211	0.75	0	-0.2	0.090909	0
D63	-0.07042254	0.083333	-0.6667	0.8	0.636364	0
D64	0.577464789	1	0.33333	0.32	0.272727	0.263158
D65	0.422535211	0.75	0.16667	0.6	-0.09091	0.263158
D67	0.14084507	0.25	-0.3333	0.2	-0.36364	-0.26316
D71	-0.56338028	0.25	0	0.48	0.090909	-0.47368
D72	0.281690141	0.5	0.33333	-0.4	0.454545	0.263158
D73	-0.21126761	-0.16667	-0.3333	0.6	1	0.263158
D74	0.436619718	0.75	0.66667	0.12	0.636364	0.526316
D75	0.281690141	0.5	0.5	0.4	0.272727	0.526316
D76	-0.14084507	-0.25	0.33333	-0.2	0.363636	0.263158

Table 3 shows the Pair Wise Comparison of table 2 the INVEST (−), QUAL (+), SUPPLY (+), RISK (−), FLEX (+), ENVIR (−), PUBLIC (+). comparing each row with other row on the tabulation.

TABLE 4. Preference Value

Preference Value							
	0.2336	0.1652	0.3355	0.1021	0.0424	0.1212	Sum value
D12	0.197408	0.0413	0.111833	0	0.015418	0.089305	0.455265
D13	0.082254	0	0	0.012252	0.038545	0.089305	0.222356
D14	0.2336	0.0826	0.223667	0	0.023127	0.1212	0.684194
D15	0.197408	0.0413	0.16775	0	0.007709	0.1212	0.535368
D16	0.098704	0	0.111833	0	0.011564	0.089305	0.311406
D17	0.131606	0	0	0	0	0.057411	0.189016
D21	0	0	0	0.089848	0	0	0.089848
D23	0	0	0	0.1021	0.023127	0	0.125227
D24	0.036192	0.0413	0.111833	0.053092	0.007709	0.031895	0.282021
D25	0	0	0.055917	0.08168	0	0.031895	0.169491
D26	0	0	0	0.02042	0	0	0.02042
D27	0	0	0	0.04084	0	0	0.04084
D31	0	0.068833	0.111833	0	0	0	0.180667
D32	0.115155	0.110133	0.223667	0	0	0	0.448955
D34	0.151346	0.151433	0.3355	0	0	0.031895	0.670175
D35	0.115155	0.110133	0.279583	0	0	0.031895	0.536766
D36	0.016451	0	0.223667	0	0	0	0.240117
D37	0.049352	0.027533	0.111833	0	0	0	0.188719
D41	0	0	0	0.036756	0	0	0.036756
D42	0	0	0	0	0	0	0
D43	0	0	0	0.049008	0.015418	0	0.064426
D45	0	0	0	0.028588	0	0	0.028588
D46	0	0	0	0	0	0	0
D47	0	0	0	0	0	0	0
D51	0	0	0	0.008168	0	0	0.008168
D52	0	0	0	0	0.007709	0	0.007709
D53	0	0	0	0.02042	0.030836	0	0.051256
D54	0.036192	0.0413	0.055917	0	0.015418	0	0.148826
D56	0	0	0	0	0.003855	0	0.003855
D57	0	0	0	0	0	0	0
D61	0	0.0826	0	0.069428	0	0	0.152028
D62	0.098704	0.1239	0	0	0.003855	0	0.226459
D63	0	0.013767	0	0.08168	0.026982	0	0.122428
D64	0.134896	0.1652	0.111833	0.032672	0.011564	0.031895	0.488059
D65	0.098704	0.1239	0.055917	0.06126	0	0.031895	0.371676
D67	0.032901	0.0413	0	0.02042	0	0	0.094621
D71	0	0.0413	0	0.049008	0.003855	0	0.094163
D72	0.065803	0.0826	0.111833	0	0.019273	0.031895	0.311404
D73	0	0	0	0.06126	0.0424	0.031895	0.135555
D74	0.101994	0.1239	0.223667	0.012252	0.026982	0.063789	0.552584
D75	0.065803	0.0826	0.16775	0.04084	0.011564	0.063789	0.432346
D76	0	0	0.111833	0	0.015418	0.031895	0.159146

Table 4 shows the Performance value of the Wise Comparison of table 2 the INVEST (−), QUAL (+), SUPPLY (+), RISK (−), FLEX (+), ENVIR (−), PUBLIC (+).When compare to all others. And the last one is the sum of the same row.

TABLE 5. Sum of Performance Value

	GW1	GW2	AQ	GR	PL1	LF1	GW1	Positive flow
INVEST (−)	0	0.455265	0.22236	0.6841939	0.535368	0.311406	0.189016	0.799202
QUAL (+)	0.089848	0	0.12523	0.2820207	0.169491	0.02042	0.04084	0.242616
SUPPLY (+)	0.180666667	0.448955	0	0.6701745	0.536766	0.240117	0.188719	0.755133
RISK (−)	0.036756	0	0.06443	0	0.028588	0	0	0.043257
FLEX (+)	0.008168	0.007709	0.05126	0.1488264	0	0.003855	0	0.073271
ENVIR (−)	0.152028	0.226459	0.12243	0.4880595	0.371676	0	0.094621	0.485091
PUBLIC (+)	0.094162545	0.311404	0.13555	0.5525843	0.432346	0.159146	0	0.561732
Negative Flow	0.187209737	0.483264	0.24042	0.9419531	0.691412	0.244982	0.171065	

Table 5 shows the sum of all rows and column are applied on the last row. The sum of all row of performance value are arranged above tabulation and the diagonal value are zero.

TABLE 6. Positive flow, Negative flow, Net flow, Rank

	positive flow	Negative Flow	Net flow	Rank
INVEST (−)	0.799202	0.18721	0.611992	1
QUAL (+)	0.242616	0.483264	-0.24065	5
SUPPLY (+)	0.755133	0.240416	0.514716	2
RISK (−)	0.043257	0.941953	-0.8987	7
FLEX (+)	0.073271	0.691412	-0.61814	6
ENVIR (−)	0.485091	0.244982	0.240109	4
PUBLIC (+)	0.561732	0.171065	0.390667	3

Table 6 shows the Water Resources Planning ranking for the INVEST (−), QUAL (+), SUPPLY (+), RISK (−), FLEX (+), ENVIR (−), PUBLIC (+). In the above tabulation the INVEST (−) is in the first rank and the second rank is SUPPLY (+) and the PUBLIC (+) third rank, ENVIR (−) forth rank, QUAL (+) fifth rank, FLEX (+) sixth rank, last rank is RISK (−). INVEST (−) is in the highest value is the RISK (−) lowest value.

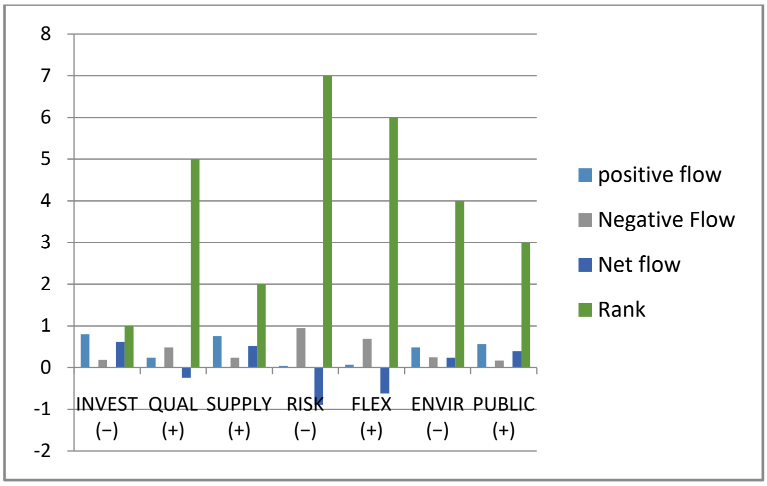

FIGURE 2. Positive flow, Negative flow, Net flow, Rank

Figure.2 shows the Water Resources Planning ranking for the INVEST (−), QUAL (+), SUPPLY (+), RISK (−), FLEX (+), ENVIR (−), PUBLIC (+). In the above tabulation the INVEST (−) is in the first rank and the second rank is SUPPLY (+) and the PUBLIC (+) third rank, ENVIR (−) forth rank, QUAL (+) fifth rank, FLEX (+) sixth rank, last rank is RISK (−). The final result is done by using the PROMETHEE method. INVEST (−) is in the highest value is the RISK (−) lowest value.

Conclusion

Water resource planning involves estimating future water demand, evaluating potential new water sources, protecting water resources, and expanding environmental regulations. Better water resource management benefits society and the government alike. Water management makes it possible to save water and sewer costs, improve summertime irrigation control, and spend less energy. Water is kept clean and safe thanks to good management, which safeguards the general public's health. The Priority Ranking for Institutional Method for Enrichment Evaluation (PROMETHEE), a technique, aids decision-makers in a university in choosing the best candidates for admission. The Prometheus and Gaia approach was created in the early 1980s and has since undergone substantial research and development. It is based on mathematics and sociology. It is utilised globally in a variety of decision-making circumstances in industries like business, government, transportation, healthcare, and education. It has a specific application in decision-making. The PROMETHEE approach assists decision-makers in locating the finest alternative for their objective and rather than directing the reader to the "best" course of action. It provides a comprehensive and logical framework for organising choice problems, identifying and quantifying conflicts and convergences, clusters of actions, emphasising key options, and employing organised reasoning. Project supply capacity is measured in million imperial gallons. Project environmental impacts are assessed. Project flexibility is measured by how quickly it can adapt to demand fluctuations. (7) General: Social view of the project's acceptability. There are ten potential solutions. The outcomes for the MCDM issue are shown in Table 2. Risk, environmental consequences, and effect data were evaluated according to what the Associated Engineering reported [15]. It is determined that Supply, Qual, General, and Flex are positive preference scales (the greater the effect, the better, as denoted by "+" in Table 2); other criteria are negative choice scales (the lower the effect, the better, as indicated by "-" in Table 2). The short descriptions of all 10 of these options, together with their respective code numbers, are provided below. A1, Development of new groundwater resources close to Kitchener-Waterloo under Option 1 (GW1) for Groundwater; A2, Groundwater resource development in new fields, particularly in the South Woolwich, Roseville, and St. Agatha areas (GW2); build dual-purpose recharge and recovery wells at the Mannheim site in accordance with A3, Aquifer Recharge, Option 1 (AQ), with a capacity of 10 million imperial gallons per day (MIGD); A4, Grand River (GR) – When there is a great need, draw water from the Grand River; A5, Grand River Low Flow Augmentation (LF1)—Build West Montrose Dam to increase water flow in the Grand River; Grade River Low Augment, A6 the piping of water to the Grand River; A7 on the Grand River Water from Lake Huron is piped into the Great River; the A8 Pipeline (PL1), a pipeline with high pressure that transports water to the area; and a high-pressure pipeline that brings water to region's Nanticoke Water Treatment Facility. Transport water from Lake Huron in God rich to the area using a high-pressure pipeline. INVEST (−) is in the highest value is the RISK (−) lowest value.

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