Selection Methodology Approach to Preferable and Alternative Sites for the First NPP Project in Yemen

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1. Introduction

The purpose of this paper is to briefly present the methodology and results of the first siting study for the first nuclear power plant (NPP) in Yemen. In this study it has been demonstrated that there are suitable sites for specific unit/units power of 1000 MWt (about 300 MWe) nuclear power plant. Other issues relevant to siting criteria for an NPP in Yemen are also discussed.

To perform the site selection, a systematic selection method was developed. The method uses site-specific data gathered by literature review and expert judgement to identify the most important site selection criteria.

A two-step site selection process was used. Candidate sites were chosen that meet a subset of the selection criteria that form the most important system constraints. These candidate sites were then evaluated against the full set of selection criteria using the Analytical Hierarchy Process Method (AHP). Candidate sites underwent a set of more specific siting criteria weighted by expert judgment to select preferable sites and alternatives using AHP method again.

Yemen is considered economically undeveloped with less than forty percent of the population having access to electric power and less than one quarter of the land area having grid coverage. Yemen's grid capacity is less than it should be to support greater access to power. It is currently at about 1,200 MW. A single or double reactor of 300 MWe nuclear power plant would provide enough power to dramatically improve access to electric power for the people of Yemen. It would in fact increase the available power to acceptable range.

But, to increase access to electric power, the government of Yemen should consider projects to enhance the grid capacity and reliability prior to construction of new power plants.

2. NPP Siting Study Method for Yemen

As it is the first siting study for NPP for Yemen, it was important to illustrate the process of this study using system engineering approach. In Fig (1) a flow chart diagram was created to clarify the process of the study that includes gathering input data, limits and constraints of IAEA and NRC for NPP siting studies, decision making method, and tools that generate input and output data.

As shown in Fig (1), potential regions have been identified along the coast of Yemen using fundamental and exclusionary criteria; cooling water supply, population distribution, and grid location. Then twelve sites were initially proposed based on the same exclusionary criteria. Preliminary site characterization data then were collected by literature review and characterization data for all sites were reviewed prior to performing the site selection analysis. The site selection was made by evaluation under site avoidance criteria; population number, seismicity, topography, natural hazards, land use, distance to grid, public acceptance, distance to airport, and security This resulted in six candidate sites being selected. Later, these candidate sites underwent more detailed studies collecting data related to some suitability criteria; population in emergency zones(EZs), Seismic Peak Ground acceleration (PGA), sea flooding, sea water temperature, wind direction, water supply for construction, distance to population centre, and access roads . All these suitability criteria were evaluated for the six candidate sites and resulted in three preferable sites and three alternative sites.

2.1. Regulation Limits:

Evaluation for both selection stages relied on IAEA & NRC limits and constraints as Yemen does not have its own NPP regulation rules yet.

Exclusion Area (EA) : is the nuclear power plant building and activities boundary, where no inhabitants are allowed, and all activities not related to the plant shall be terminated and compensated, that means the number of population in this area should be zero. This are is determined to be a zone of one mile radius (1.6 km) surrounding the NPP [1, 2].

Low Population Zone (LPZ): is the area that surrounds the pant of 1000 MWt with approximately 10 miles (16 km) where the maximum population number allowed is 25000 people or 500 person/km^2. LPZ areas were calculated by U.S. Atomic Energy Commission approach for a 1000 MWt light water reactor based on a ten miles (16 km) radius from the population centre. [2, 3]

To support the decision analysis method, both selection stages' criteria, in the study [4], were ordered and numbered from the most important (9) to least important (1) for using an Expert Judgment method [5], and then applied in the Analytical Hierarchy Process (AHP) [6], as a decision support method. Then, all evaluation results were input to a commercial decision making software tool, *Logical Decision* to perform stage 1 and stage 2 selections.

2.2. Potential Sites

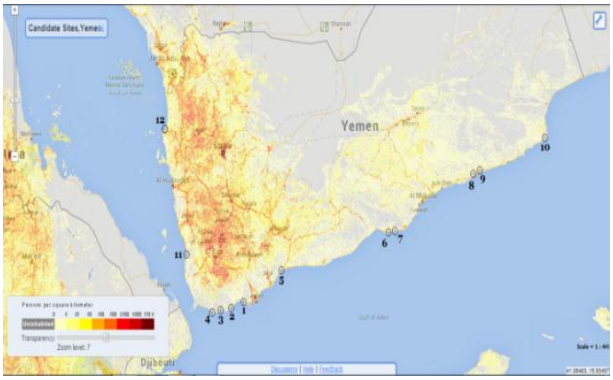

Figure 2. Candidate Sites as numbered from 1 to 12.

Under evaluation using Exclusion criteria, eight provinces were selected and from those provinces twelve sites were selected as potential sites using Google Earth and population explorer online applications. [7]

The twelve potential sites are shown in Fig (2) located on Yemen costal line while their latitude and longitude are stated in table (1).

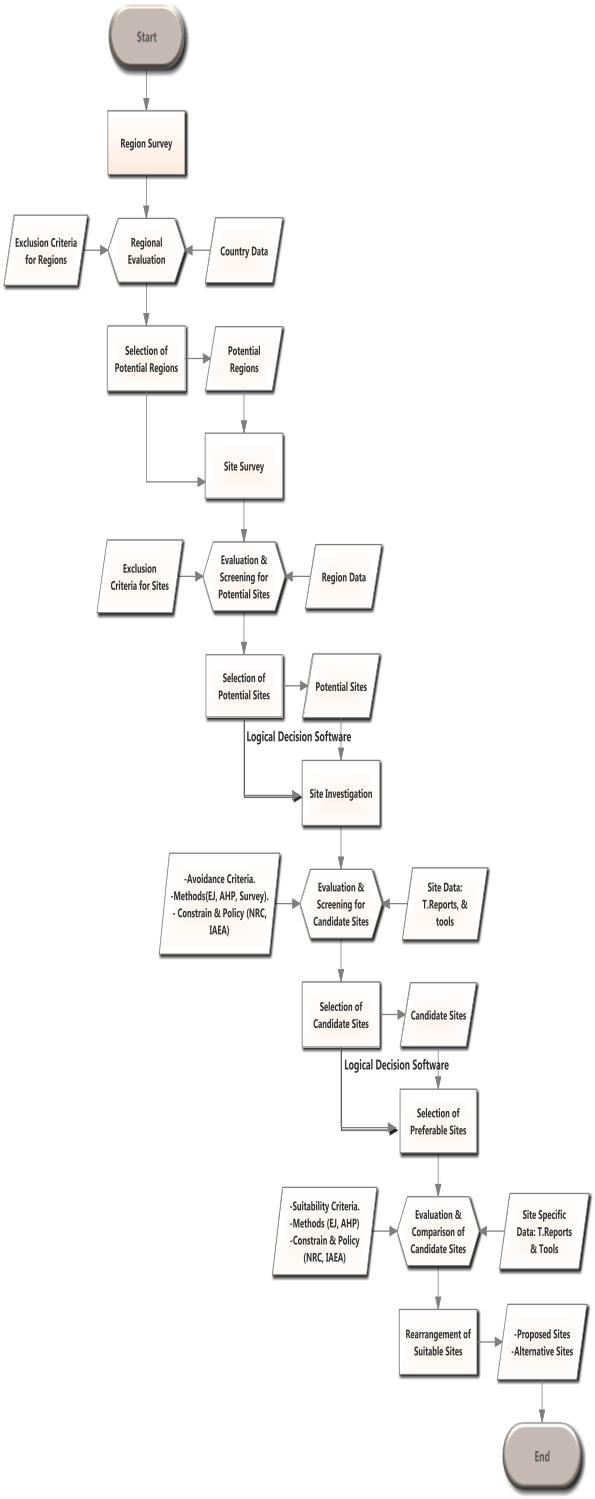

Figure 1. Site Evaluation and Selection Process for 1st NPP in Yemen.

Table 1. Latitude & longitude of each potential sites proposed for the 1st NPP in Yemen.

site	Name and address	Latitude	Longitude
Site 1	Emran area – Aden Assoghra-Aden	12,79468	44,69867
Site 2	Qa'awah – Lahij	12,68444	44,37777
Site 3	Omairah Gulf – Lahij	12,64995	44,13225
Site 4	Rass-Elarah – Lahij	12,61996	43,92579
Site 5	Shoqrah – Abyan	13,34174	45,64034
Site 6	Lazordi Beach – Bir Ali - Shabwah	13,99660	48,28148
Site 7	Qana – Bir Ali – Shabwah	14,02096	48,44007
Site 8	Moa'ber – East Raidah - Hadhramout	15,00400	50,37689
Site 9	East Raidah – Hadhramout	15,06874	50,53816
Site 10	Tarad – Haswayn - Almaharah	15,62160	52,13869
Site 11	Jirdan- Wadi Al-Mulk – Taiz	13,62210	43,29324
Site 12	Allohayyah area - Al-Hodaydah	15,77536	42,75293

3. Site Characterization

The study used site information from several online mapping applications including, Google Earth, Population Explorer Beta, Flood Map, and Gmap4, in addition to information that was gathered from official sources and some technical reports. Specifications of each site have been discussed in terms of each criterion, and supported by data and maps.

Population number and density distributions for each site are derived from census data. This data includes population counts and growth rates, average household sizes and administrative boundaries and estimated data are provided on the Population Explorer Beta application. [7]

To determine seismic hazard and the distance to major active faults, the United States Geological Survey (USGS) earth tectonic plate application were mapped in Google Earth and used to measure the distance from each site to the major fault (plates boundaries), then GPA of Yemen costal line areas were gathered and estimated from a reliable technical study done by researchers from Karlsruhe Institute of Technology (KIT), Germany [8].

Land topography was studied generally for each site. Topographical maps generated from the Gmap4 (www.mappingsupport.com/p/gmap4.html) and elevation data of the proposed sites and the sea flood risk was determined using Flood Map application [9].

Distance to active airports, water supply for construction, and access roads were measured for each site using Google Earth and other criteria. In addition electrical grid of Yemen was helpful to apply distance measurement on Google Earth [10].

Land use, sea surface temperature, wind direction, security alerts, rock and soil structure (land geology), and natural hazards input information were gathered from reliable technical reports, maps, and studies; respectively [11, 12, 13, 14, 15].

At this preliminary stage public acceptance was based on an informal survey conducted with social media (Facebook.com) gathering opinions from people of some affected areas and estimating the rest of unreachable places with potential land use concerns. Future work would include more detailed public acceptance investigations should a site be selected.

4. Sites Evaluation Criteria and Limits

The International Atomic Energy Agency (IAEA) and the U.S. Nuclear Regulatory Commission (NRC) criteria and guidelines for NPP siting were used in this study to elaborate and evaluate the site data [3] and [1]. Criteria are categorized in NPP Siting field to three types:

- Exclusion Criteria: which are the basic and fundamental criteria to choose the potential regions and potential sites out of the country land; mainly are water cooling supply, grid location, and in particular for Yemen, population distribution as it is varied from North to South.
- Avoidance Criteria: are a set of criteria that should be considered to avoid and minimize risks of the project. These criteria are to evaluate potential sites in order to select 6-8 candidate sites for further studies. [16] The avoidance evaluation criteria that were used in this study are: Seismicity, External Natural Hazards., Population No., Security, Distance to Grid, Land Use, Public acceptance, Land Elevation, and Distance to Airport.
- Suitability Criteria: which are used to choose the preferable sites based on detailed and comprehensive studies on the candidate sites. Some suitability criteria have been discussed in this study to approach the second stage of site selection; these criteria are: population in EZs (EPZ), distance to population centre, seismic PGA, water supply for construction, sea water temperature, wind direction, sea flooding, rocks and soil conditions, and access roads.

Except "Security Criterion" all criteria that have been chosen for this study are discussed in NRC and IAEA guidelines, and for this study not all NRC and IAEA criteria elected to be focused on due to technical reasons (lake of detailed information on each criterion from reliable resources, and AHP method which limits the weighting numbers between 1-9. For "Security Criterion" although such an important project (NPP project) would not approved in any country unless the security situation is very good, still security alerts should be considered based on Yemen's complex culture, political situation, and security alerts that can be considered long term problems.

Avoidance and Suitability criteria have been divided and categorized for this study into three groups of evaluation to enhance clarity of the study; these three groups were:

- Impact from the plant to the site
- Impacts from the site the plant
- Cost Impact criteria.

4.1. Evaluation Impact from the Plant to the site:

Criteria that relate to evaluation of radiation impacts of the plant to the site are:

- Population impacts (population distribution, population in LPZ, distance to population centre, and population in EPZs).
- Socioeconomic & environmental impact (land use).
- And environmental impact (sea water temperature and wind direction).

IAEA & NRC regulation limits were applied for population impact; Exclusion Area (EA)boundary radii, Low Population Zone (LPZ) boundary radii, and Distance to Population Centre(D.PC), are considered to be 0.67, 10.3,and 13.7 miles respectively for the proposed reactor of 1000MWt[2]. And as IAEA recommended, EZ/EPZs with in 50 km radii, population in EA should be zero, and in LPZ should be less than 25000 people/500 person per km^2[2]. As general evaluation was generated, decision was made based on: the lowest populated area is the best.

Fig.(3) and table(2) shows Site1, Aden, as an example of candidate site for the 1st NPP in Yemen. EA, LPZ, EZs, and D.PC parameters maps and data are generated from Population Explorer Beta application [7].

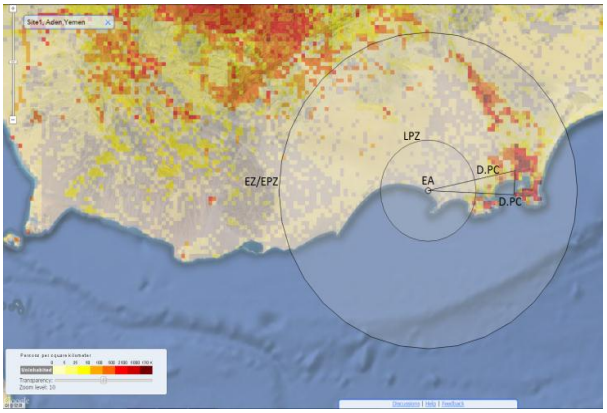

Figure 3. Population zones and distance to population centre for Site1, Aden.

Table 3. Site1, Aden, Yemen, population parameters.

Site Population parameter	Total Population/ person	Map Area/km^2	Population Density/ person/km^2
EA	0	3.14	0
LPZ	2258	804.57	3
EZ	905359	7857	116

Note: Distance to population center (D.PC) is 28 km from Aden city, and 28 km from Alhawtah city (capital of Lahij)

Land use criterion was evaluated based on the economic activities near the candidate site. Activities including fishing, farming, and economic activities were studied from maps [11] and economic reports. As it is stated in IAEA & NRC that no activities should be occurring inside the EA, and the less archeological sites, mining, fishing, farming activities in LPZ of the potential site is to be considered as Good in the evaluation measure the sites.

Table 4. The number of population in LPZ, and the land use activities measure

Sites	Population No.	Land Use
Site 1	2607	Low
Site 2	222	Low
Site 3	995	Medium
Site 4	933	Low
Site 5	4892	Medium
Site 6	7464	Low
Site 7	3118	Low
Site 8	26301	Medium
Site 9	15480	Medium
Site 10	7035	Medium
Site 11	5144	High
Site 12	27184	High

For environmental impact criteria; sea water temperature and wind direction, data have been

generated from a technical report of the National Institute of Oceanography, Goa, India [12]. And as they were studied in the second stage, a one year water sea temperature and monsoon wind directions evaluation of the candidate sites are shown in table(4).

Table 5. Evaluation of Sea Water Temperature and Wind Direction of 1year of candidates sites for NPP in Yemen

Site	Site1	Site2	Site3	Site4	Site6	Site7
SW.T Evaluation	G	M	M	G	N.B	N.B
W.D Evaluation	M	B	B	M	B	M

4.2. Evaluation Impacts from the site the plant:

Evaluation criteria for the impacts from the site to the plant are:

- Seismic; distance to near active fault and Peak Ground Acceleration (PGA).
- External natural hazards (volcanism, cyclones, and see flood).
- Man-induced event (Security, and distance to airport).
- Socioeconomic; Public acceptance.

- Seismic events for potential sites at 1st stage were evaluated by simply comparing the distances from each site to the nearest major active fault (plate boundary) as it was provided by USGS application attached to Google Earth. The evaluation was to grade the farthest site from major fault as Good.

Table 6. PGA of Aden, Lahij, and Al-Mukalla as stated in KIT report.

Major City	Sites nearby	100-year r.period PGA/g	475-year r.period PGA/g
Aden	Site 1	0.217	0.292
Al-Hawtah (Lahij)	Site1, Site 2, Site 3	0.146	0.227
Al-Mukalla (Hadheamout, near Shabwah costal line)	Site 6, Site 7	0.083	0.137

While PGA of candidate sites at the 2nd stage were estimated from a technical report of Karlsruhe Institute of Technology, Germany that shows the PGA in 100-year and 475-year returned. Then evaluation made based on the latest design of seismic system in nuclear power plants which is 0.3-0.4 g, so, each candidate sites has less than 0.3g was considered good; as it is shown in table (5).

Fig (4) shows the measuring method of the 1st stage from the potential sites to the major fault and to the nearest active volcanoes.

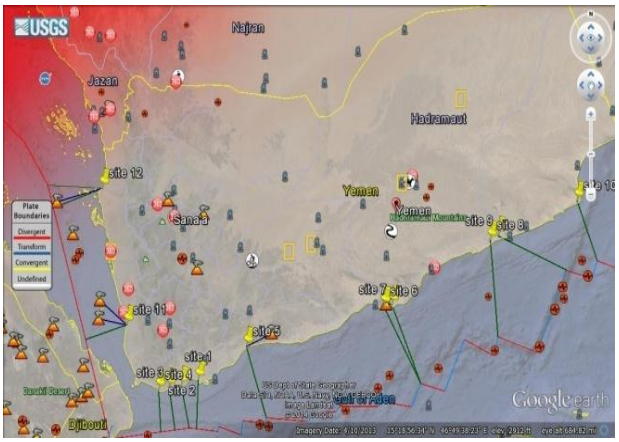

Figure 4. Distance measurements from potential sites to the seismic active faults and near volcanoes hazards.

- External natural hazards such as volcanic activity and cyclone likelihood are weighed as high, medium, and low for site evaluation relaying on the information and maps available from the internet and the land scan satellite information available on Google Earth; as is shown in Fig(4). For volcanoes measurement of the distance from the near active volcano was helpful to determine the weight of each site against volcano activity event (high, medium, or low). Table (6) providing evaluation of E.NH of Yemen.

Table 7. External Natural Hazard evaluation of potential sites for the 1st NPP in Yemen.

Site	Site1	Site2	Site3	Site4	Site5	Site6	Site7
C.	G	G	G	G	G	G	G
V.	G	G	M	M	B	B	B
F.E	**G**	**G**	**M**	**M**	**B**	**B**	**B**

Site	Site8	Site9	Site10	Site11	Site12
C.	B	B	B	G	G
V.	G	G	G	B	B
F.E	B	B	B	B	B

- Security is a fundamental issue for development of infrastructure in Yemen which has

unique complex problems. Although it is beyond the scope of the study to accurately evaluate the magnitude of security threats or how it would be expand within the country in few years. This study is based on the reasonable assumption that security issues will be sufficiently resolved by the government prior to the initiation of any significant infrastructure projects involving nuclear power. With this assumption in mind, technical reports about security in Yemen were used to estimate and evaluate the risks that may affect each site due to security issues[14]

As a man-induced event, airplanes crash is important to understand as the NRC Reg. Guide 4.7 has limited ten miles (16 km) to be the minimum distance from a nuclear site to a major airport. Google Earth land scan was used to measure the approximate distance between each site to the nearest active airport for the evaluation.

- In socioeconomic issues public acceptance considered an impact from the site to the plant as the nuclear power plants cannot operate safely while people in the country or nearby the site don't want it to continue. In subsequent studies this should be measured with public survey techniques in the country, in the province, and in the local area of the site, since this kind of survey is not feasible, study author preferred at this stage to conduct an informal survey using social media to gauge public acceptance. As ten sites have been chosen for an NPP in South area of Yemen, a group of people participated in this survey and the question was "Do we need a nuclear power plant in our country for generating electricity? "the answer to this was judged Good in Southern part of Yemen while it was Bad in Northern areas considering the farming activities and the tribal rules in that part of the country.

Table (3) shows sites data against five criteria; Distance to Active Fault (D.AF), Natural Hazards (NH), Security (S), Public Acceptance (PA), and Distance to Airport (D.A).

Table 8. Hazards evaluation data of potential sites for the 1st NPP in Yemen.

Site	D.AF	NH	S	PA	D.A
Site 1	86.4	Low	G	G	36
Site 2	75.9	Low	G	G	74
Site 3	75.2	M	G	G	99
Site 4	73.5	M	G	G	120
Site 5	131	M	B	G	87
Site 6	158	high	M	G	123
Site 7	152	M	M	G	138
Site 8	171	high	M	G	114
Site 9	161	high	M	G	134
Site 10	115	high	G	G	63
Site 11	94.4	high	B	B	92
Site 12	114	high	B	B	111

4.3. Cost Impact Evaluation

The cost of siting regarding building NPPS was compared in a relative sense using cost criteria which included distance to grid, water supply for construction, and Access roads, land elevation, and rocks & soil structures as surrogate indicators of cost.

The official electrical grid map provided by the ministry of electric and water in Yemen was used to estimate and weight the distance from each site to the electric grid. And the distance was then grouped as far, medium, and near, where the nearest distance is the best; Google Earth was used to confirm this estimated weight of distance. The distance from sites to access roads was measured carefully using Google Earth too.

As the water supply for construction is directly related to cost, it was important to study and analyze reliable technical reports [17, 18], it could be estimated from those reports the available water capacity near the provinces that have proposed or candidate sites, and this estimation was used to evaluate each site in term of the access water for construction.

In time of construction, civil engineers need to know the land soil and rocks structure in order to decide if this site can sustain operating NPP without any geological and land faults, that's why a geological map offered by the ministry of mineral and oil in Yemen was well defied and helpful to make the author estimate the strength of the land. In addition the elevation of each site was measured exactly using NASA flood application [9] and the decision made under the latest prevention action taken by many countries as lessons learned after the Fukushima disaster; a proposal made to sit a NPP in a land have elevation not less than 6m, and not more than 16m, this proposal also consider the height of discharged water of the plant that is usually about 10m; so, the best land elevation that approaches 10m, and the worst that is higher than 16m or lower than 5m.

Table 9. Sites data and evaluation against all cost impact criteria.

Site	D. to Grid	Land E. /m	Rocks type	Water for C.
Site 1	Near	2	Medium	Near
Site 2	Medium	16	Medium	Medium
Site 3	Medium	9	Good	Medium
Site 4	Far	3	Bad	Far
Site 5	Near	6	------	-----
Site 6	Far	8	Good	Medium
Site 7	Medium	4	Good	Medium
Site 8	Far	34	------	-----
Site 9	Far	22	------	-----
Site 10	Far	5	------	-----
Site 11	Near	3	------	-----
Site 12	Far	4	------	-----

5. Expert Judgment Ranking Method

An Expert Judgment is a method used to support any compliance application [5], a panel of experts whom are related to nuclear power plant project experts in construction, seismology, hazard analysis, waste management, system engineering, and project management, performed a kind of election to rank the 1st stage criteria and the 2nd stage criteria as their importance from 9 to 1(9= the most important, and 1= the least important); as it is shown in table (5).

Table 10. Avoidance & Suitability criteria ordered by Expert Judgment, from the most important to the least important.

1st Stage Criteria	2nd Stage Criteria	Weight
Seismicity	Seismic *PGA*	*9*
External Natural Hazards	Distance to population center	*8*
security	Rocks structure	*7*
Population No.	Population No. in *EPZs*	*6*
Distance to Grid	Sea flooding	*5*
Land Use	Sea water temperature	*4*
Public acceptance	Water supply for construction	*3*
Land Elevation	Wind direction	*2*
Distance to Airport	Access roads	*1*

6. AHP Selection Method

The analytic hierarchy process (AHP) is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. It has particular application in group decision making, and is used around the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education to quantifying elements, for relating those elements to overall goals, and for evaluating alternative solutions. [6]

Analytical Hierarchy Process method is one of the system engineering decision making methods that weight all factors, which to be considered in time of evaluation, against the global weight. All potential sites are weighted by making contribution of all criteria weights for each site. In AHP method for this study the first step was to show how are all criteria are related to the global weight, and to each other.

As an example of using this method in this study, 1st stage criteria were compared to each other and to the global weight; as it is shown in table (6).

7. Results

Using the Logical Decision software as a tool for the purpose of getting accurate selection results, all input data and criteria ranking weights were saved in the software, and then, the output results were generated.

Logical Decision software calculated all sites weights against all criteria and the result shows each site weight.

As a result of 1st stage selection, six sites out of twelve were ranked against avoidance criteria as the best in first to be the candidate sites for 1000 MWt NPP in Yemen. Sites: 1, 2, 3, 4, 7, and 6 respectively were selected to undergo some suitability criteria in the 2nd stage for detailed study.

For the 2nd stage selection, process followed the same methods and input data and suitability criteria' weights were saved then output results were generated ordering the candidate site as three preferable sites (Site6, Site7, Site2) and three alternative sites (Site3, Site1, Site4).

Table 11. Relation between all 1st stage criteria and global weight in AHP method.

C	D.F	NH	S	P.no	DG	LU	PA	LE	DA
D.F	0.2	9/8	9/7	9/6	9/5	9/4	9/3	9/2	9/1
NH	8/9	0.178	8/7	8/6	8/5	8/4	8/3	8/2	8/1
S	7/9	7/8	0.156	7/6	7/5	7/4	7/3	7/2	7/1
PD	6/9	6/8	6/7	0.133	6/5	6/4	6/3	6/2	6/1
DG	5/9	5/8	5/7	5/6	0.111	5/4	5/3	5/2	5/1
L.U	4/9	4/8	4/7	4/6	4/5	0.089	4/3	4/2	4/1
P.A	3/9	3/8	3/7	3/6	3/5	3/4	0.067	3/2	3/1
LE	2/9	2/8	2/7	2/6	2/5	2/4	2/3	0.044	2/1
DA	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	0.022

: Data are showing the relation with global weigh

Fig (5) and Fig (6) shows the final selection results of 1st stage & 2nd stage respectively.

Figure 5. Selection ranking results; 1st stage

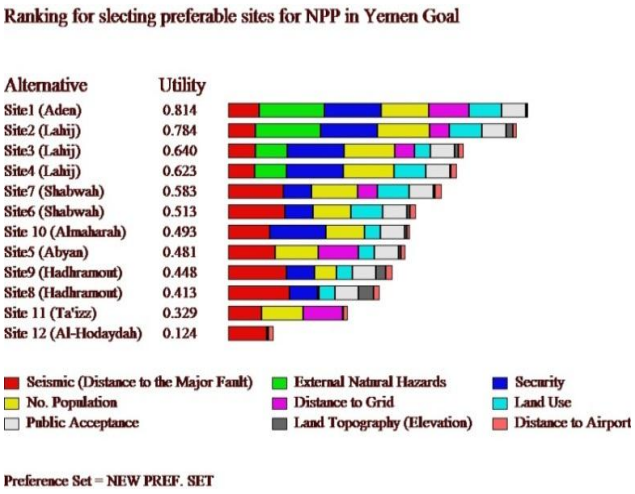

Figure 6. Selection ranking results; 2nd stage

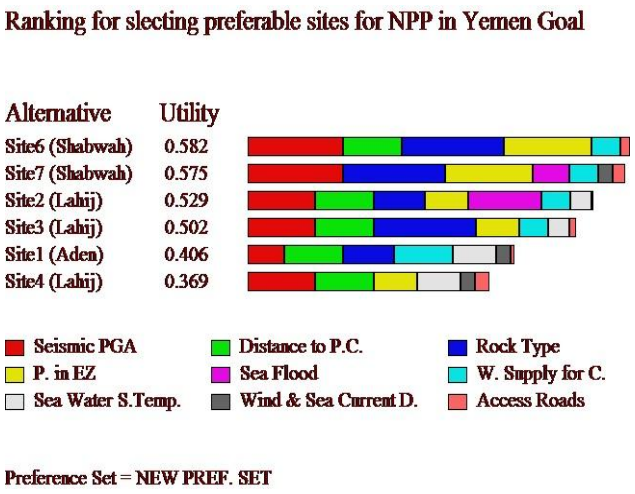

Table 12. Sites weight results (Ranking Result Matrix) 1st stage.

	Selecting preferable sites for NPP in Yemen	Seismic; D.MF measure	Natural Hazards measure	Security measure	No. of population measure	Distance to grid measure	Land use measure	Public acceptance measure	Land elevation measure	Distance to airport measure
Weight	1	0.2	0.178	0.156	0.133	0.111	0.089	0.067	0.044	0.022
Site1	0.814	0.432	1	1	0.896	1	1	1	0.057	0.235
Site2	0.784	0.38	1	1	0.991	0.5	1	1	0.457	0.49
Site3	0.64	0.376	0.5	1	0.96	0.5	0.5	1	0.257	0.658
Site4	0.623	0.367	0.5	1	0.963	0	1	1	0.086	0.799
Site7	0.583	0.76	0	0.5	0.875	0.5	1	1	0.114	0.919
Site6	0.513	0.79	0	0.5	0.701	0	1	1	0.229	0.819
Site10	0.493	0.575	0	1	0.719	0	0.5	1	0.143	0.416
Site5	0.481	0.655	0	0	0.804	1	0.5	1	0.171	0.577
Site9	0.448	0.805	0	0.5	0.381	0	0.5	1	0.629	0.893
Site8	0.413	0.855	0	0.5	-0.052	0	0.5	1	0.971	0.758
Site11	0.329	0.472	0	0	0.794	1	0	0	0.086	0.611
Site12	0.124	0.57	0	0	-0.087	0	0	0	0.114	0.738

Table 13. Sites weight results (Ranking Result Matrix), 2nd stage.

	Selecting preferable sites for NPP in Yemen	Seismic; PGA measure	Distance to P.C. measure	Rocks type measure	Population in EPZs measure	Sea flooding measure	Water S. for Construction measure	Sea water Temperature measure	Wind & Sea current direction measure	Access roads measure
Weight	1	0.2	0.178	0.156	0.133	0.111	0.089	0.067	0.044	0.022
Site6	0.582	0.723	0.5	1	1	0	0.5	0	0	0.695
Site7	0.575	0.723	0	1	1	0.5	0.5	0	0.5	0.867
Site2	0.529	0.513	0.5	0.5	0.5	1	0.5	0.5	0	0.167
Site3	0.502	0.513	0.5	1	0.5	0	0.5	0.5	0	0.467
Site1	0.406	0.277	0.5	0.5	0	0	1	1	0.5	0.3
Site4	0.369	0.513	0.5	0	0.5	0	0	1	0.5	0.983

8. Discussion & Conclusions

The study of Site Selection for the 1st NPP in Yemen was divided to two stages:

- 1st stage was the site survey study and selection of candidate sites; country survey was performed to choose potential regions, regional survey was performed to get potential sites, and then evaluation analysis and selection methodology based on three exclusionary criteria and nine avoidance criteria were performed to end up this stage with six candidate sites.
- 2nd stage done by performing site investigation, selection and comparison methodologies, to reach the final step of the study objective which is selecting three preferable sites, and three alternative sites; in case of unsuitability of all preferable sites after field investigation or regulation restrictions and decision. The six candidate sites were evaluated under nine suitability criteria the reordered as Site6, Site7, Site2, Site3, Site1, and Site4 respectively.

Expert Judgment method was used to rank and weight the importance of each criteria, then AHP method used to evaluate and weight the relation between criterion to criterion and between all criteria against the global weight. Then logical decision software was used to rank sites upon their weighting value.

The whole process of this siting study for the first NPP in Yemen is explained in Fig (7).

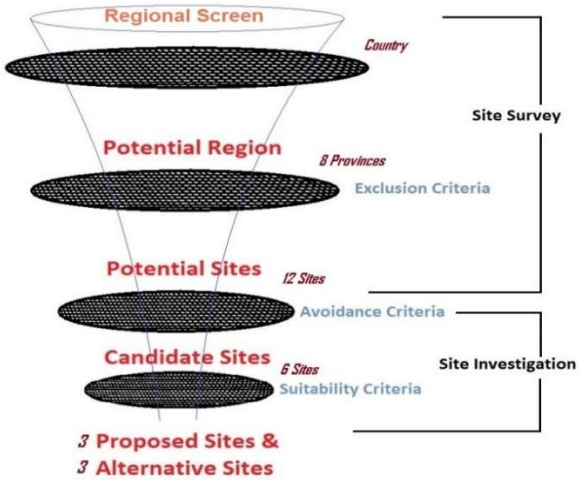

Figure 7. Site Screening Process for 1st NPP in Yemen

After screening six candidate sites out of twelve potential sites, results show that all six candidate site are in the southern costal line (*Sit6-Lazordi Beach-Bir Ali-Shabwah, Site7-Qana-Bir Ali-Shabwah, Site2-Qa'awah-Lahij, Sites3-Omairah Gulf-Lahij, Site1-Emran region-Aden, then Site4-Rass-Elarah- Lahij*) where the hazards are less; low seismicity, zero cyclones events, low volcanism activity, low, low airlines activity, low land use activities, good land elevation, good public opinion of a nuclear power plant, and the first four candidate sites are near to the electric power grid.

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