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Decision Analysis in a Fishing Port Project Using Multi-attribute Utility Theory†

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Decision Analysis in a Fishing Port Project Using Multi-attribute Utility Theory†

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Abstract

In order to attain the goal of an overall project evaluation of a fishing port project, a conceptual approach has been established in this paper, using a multi-attribute utility theory. As a first step, the multiple attributes relevant to a fishing port project have been formulated. Based on these attributes, a basic approach to the overall evaluation of a fishing port project has further been sought through developing an evaluation model in the form of a flow chart.

It is pointed out that an application of such methodology can only be made a concrete and detailed proposal which is quite often the case presented by the concerned authority for the consideration of a financial institution. In the past, many researchers in this field contributed their efforts to the approach and methodology for the preparation of a feasibility study through presenting and examining various alternative proposals. However, the evaluation of the detailed proposal based on an already completed feasibility study which was carried out by the other party, was hardly given consideration. In order to actually test the methodology and approach, an actual project proposal case has been taken from the Seo Geo Cha fishing port project in Korea, through which presented steps were examined.

1. Introduction

To attain the ultimate goal of an overall project evaluation of a fishing port project, it is necessary to define the multiple attributes relevant to a fishing port project. Based on the established multiple attributes, an approach was sought through introducing a flow chart by which an investor will be able to form a judgment as to the viability of the project. The flow chart describes each step by step procedure to be followed for testing the viability of the project. It is also pointed out that the application of such methodology can only be made to a concrete and detailed proposal which is quite often the case presented by the concerned authority for the consideration of a financial institution. In the past,

† This report doesn't necessarily reflect the views of Asian Development Bank.

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** Asian Development Bank

many researchers in this field contributed their efforts to the approach and methodology for the preparation of a feasibility study through presenting and examining various alternative proposals. However, the evaluation of the detailed proposal based on an already completed feasibility study which was carried out by the other party, was hardly given consideration. If the feasibility study is such that it examined all possible alternatives, this approach will not take place. However, quite often, the project proposal is merely presented as just a proposal.

To judge the established methodology and procedure, a case study was selected from a fishing port project proposal located in Seo Geo Cha, Korea. In September 1978, an Asian Development Bank* Project Appraisal Mission visited Korea and appraised a fisheries development project which included the Seo Geo Cha fishing port project. Using this project as a case study, the established flow chart was examined in depth. Particular attention was given in the course of following step by step procedures, to the present overall quantitative evaluation through an introduction of the multi-attribute utility theory.

2. Determination of Multiple Attributes

With a view to determining multiple attributes for the purpose of evaluating a fishing port project, consideration was given as to what should be the most appropriate methodology to define the multiple attributes. As the fishing operation is on the whole vested within an entire chain of operations from fish catching up to transportation and marketing of the catch, it was decided to apply the matrix method within the entire flow of correlations between the objectives among possible attributes. As it is not the aim of presenting the means of defining such attributes in this paper, we have curtailed the methodology. The following 24 attributes are relevant for the evaluation of any fishing port project.

Attribute 1 Priority in the Government development plan.

Attribute 2 Regional conflict - location of fishing ground and probable export species.

Attribute 3 Project site availability.

Attribute 4 Other possible financing sources for the project and/or for a similar project in an adjacent site.

Attribute 5 Availability of fisheries resources.

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* An international financial institution located in Manila with 43 member countries inside and outside of the region with an aim to extend financial and technical aid to foster the economic development of its member countries within Asia and the South Pacific region. It started operations in December 1966.

Attribute 6	Prevailing fishing activities - number of mechanized fishing vessels.
Attribute 7	Engineering data availability - soil test, hydraulic survey, laboratory model test, etc.
Attribute 8	Fishing port in the project area - appropriateness of siting.
Attribute 9	Benefits to the existing vessels attached to the proposed fishing port.
Attribute 10	Benefits from the newly constructed vessels to be attached to the proposed fishing port.
Attribute 11	Storm sheltering benefits of the proposed fishing port.
Attribute 12	Public utilities (power and water supply) in the project site.
Attribute 13	Boatbuilding and repair yard - technical skill and production capacity.
Attribute 14	Refrigeration and processing industry - cold storage, ice, freezer and processing capacity.
Attribute 15	Transportation facilities.
Attribute 16	Strength of markets.
Attribute 17	Soundness of executing agency.
Attribute 18	Need of consultants.
Attribute 19	Economic internal rate of retun.
Attribute 20	Sensitivity analysis of economic rate of return.
Attribute 21	The amount of Government revenue generation.
Attribute 22	Project beneficiaries.
Attribute 23	Number of consumers benefitted.
Attribute 24	Environmental impact due to probable pollution.

3. An Evaluation Model To Test Project Viability

There can be two different approaches for evaluating a fishing port project concerning simply the initial formulation of such projects. In the event that the scope of a fishing port project is broadly presented, namely, an exact siting of the project, scope, determined relevant costs etc., it is necessary to evaluate such a proposal in comparison with possible or similar alternative projects. This methodology would quite often be used when the detailed feasibility study will have to be conducted, since the concerned authorities' proposal is simply a request to construct a fishing port in an area to be determined. Various conceivable approaches and methodologies have to be introduced from absolute comparative viewpoints. This also applies to several engineering projects as well as agriculture projects. For instance, if there is a request to develop a country's certain rural area for industrial and agricultural purposes, the feasibility study would have to certainly examine the need for such a port, shore facilities, industrial activities, housing, hospital, schools and other necessary supporting facilities. It would also include a selection of appropriate crops for the area's agricultural land and its supporting irrigation system, which would have to have a necessary power and water supply.

However, in the event of a fishing port project, the case is often proposed as a concrete fishing port project in a decided site with a detailed breakdown of capital and operating costs, as well as the possible generation of revenue from

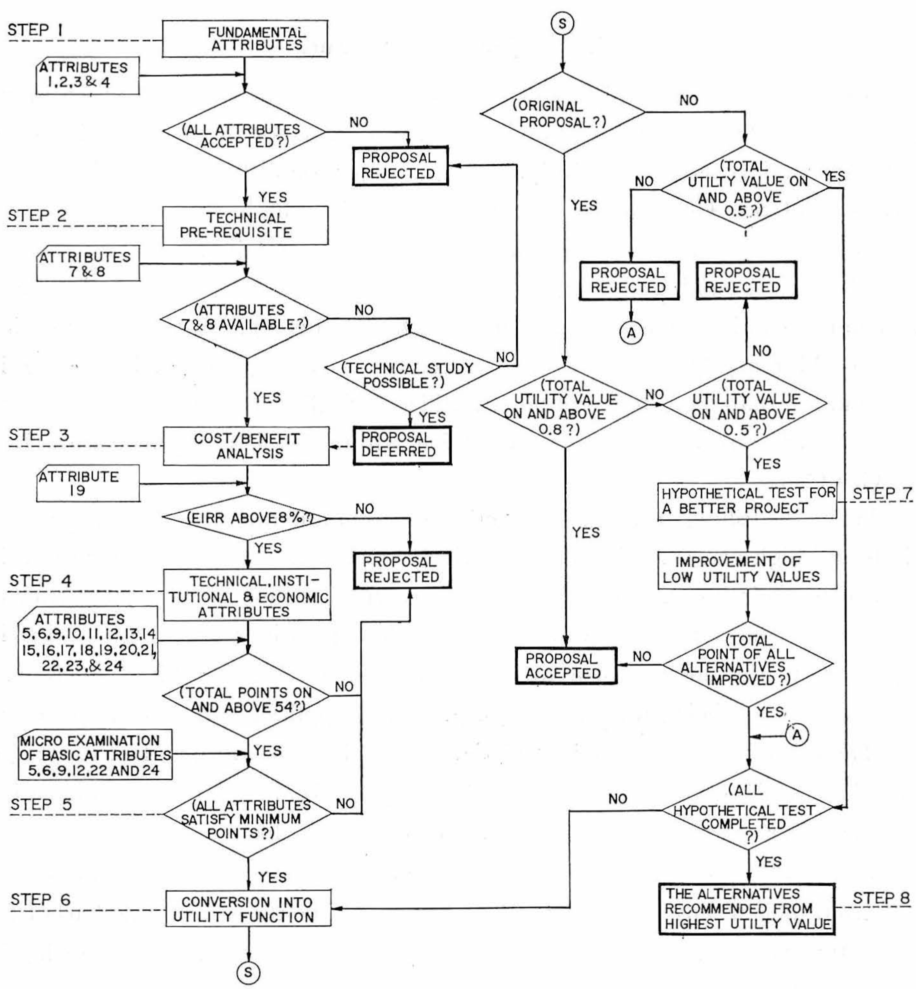


Fig. 1. Flow Chart of the Model (Approach to Overall Project Evaluation a Fishing Port Project)

the port. It should also be mentioned that such a project proposal is in some cases derived from other reasons, whereas technical and economic considerations unfortunately draw secondary concern. As pointed out, since a presentation of a concrete proposal to construct a fishing port is frequently a common case, we wish to give emphasis to substantially modify previous approaches made by various researchers into a new concept which could be applied immediately upon receipt of such a concrete proposal. An evaluation model describing the flow of this approach has already been developed, as shown in Fig. 1. For the purpose of establishing actual utilization of the evaluation model, we would like to present a case project taken from the Seo Geo Cha fishing port project in Korea.

4. Project Background

The proposed port project is for Seo Geo Cha which is located on an island approximately 90 km. southwest and 80 km. west of major mainland fishing ports at Mogpo and Wando respectively. Also, a major island fishing port lies 70 km. northwest of Seo Geo Cha at Daehuksando, and a small coastal fishing vessel port is situated on an island 55 km. to the southeast at Jejua.

The area around Geo Cha Island off the southwest coast of Korea is one of the country's richest coastal fishing areas. During this region's two major fishing seasons (March-July and September-December), over 1,000 vessels ranging in size from less than 5 g.t. to about 50 g.t. utilize drift gill nets and small stow nets to catch fish and crustanceans in waters lying within 3–4 hours (40–60 km.) from Seo Geo Cha.

While the fishing ground is productive, the area is frequently affected by strong winds and high waves forcing these relatively small vessels to seek shelter to avoid damage to their boats. Occasionally, fish carriers anchor at designated sites in the area to collect fish. However, such carrier operations are irregular due in large part to the absence of a well protected harbor where fishing vessels may collect to market their catches, and also purchase supplies for their next operation.

The offshore fishing activities in the East China Sea are based at the major coastal ports of Incheon, Mogpo, Yeosu and Busan. While there is little indication that the larger vessels engaged in this offshore fishing are likely to shift their operating base to an island port such as Seo Geo Cha, when storms force these vessels back from their fishing grounds, Seo Geo Cha would be the nearest safe harbor for up to 50 per cent or more of the offshore fleet of about 1,000 vessels operating in the East China Sea. Since there are plans to construct a new port at Seohuksando, 66 km. southwest of Seo Geo Cha to support this offshore fishery, it has been assumed that only a minimal number of offshore fishing vessels will utilize the Seo Geo Cha Port. If the Seohuksando port is not built, or if its completion is delayed for a number of years beyond the completion of Seo Geo Cha Port, the benefits of the Project port will be substantially higher as a larger number of offshore fishing vessels will utilize Seo Geo Cha.

5. Project Scope

The proposed project will involve the construction of a fishing port at Seo Geo Cha, located at the western part of Geo Cha Island, about 90 km. south west of Mogpo off the South West coast of the Korean Peninsula (Fig. 2). Seo

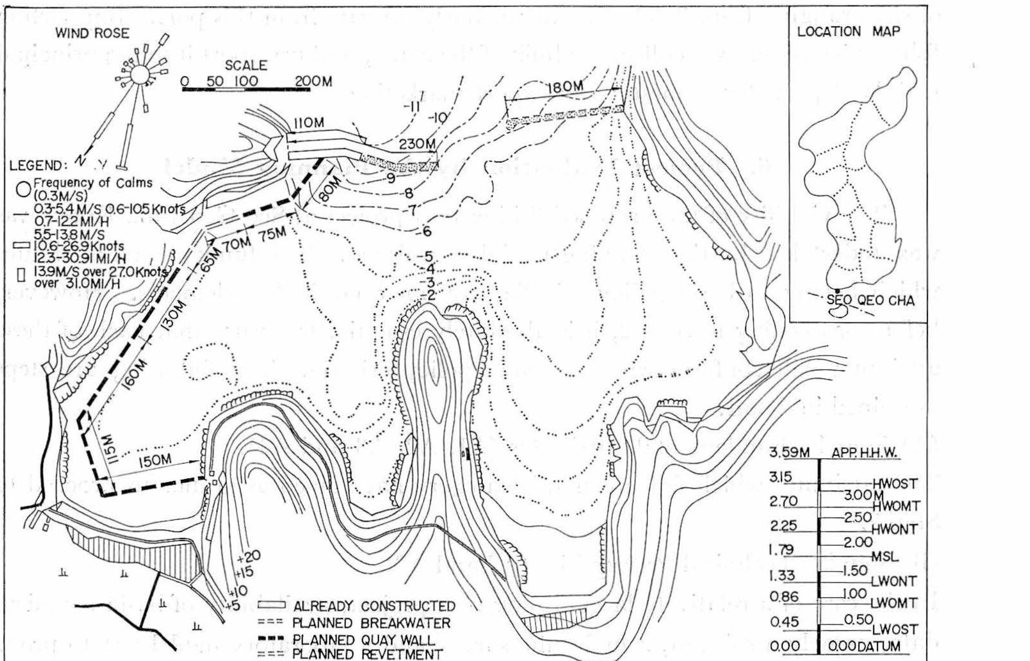


Fig. 2. Master Plan of Seo Geo Cha Port.

Geo Cha is well located with respect to fishery resources. The port will provide additional operational facilities for fishing vessels resulting in reduced vessel operating costs, increased fishing periods, imporved fish processing and marketing facilities, and shelter from rough seas and storms.

The major works to be undertaken are - a) Two rubble mound breakwaters with a cover layer of concrete, the eastern breakwater being 230 m in length (of which 110 m have already been completed), and the western breakwater being

180 m long. These breakwaters are necessary to protect the harbor area against waves caused by typhoons and other storms coming from the south. b) A gravity retaining quay wall of concrete blocks with a vertical front-side and with a length of 710 m of which 155 m will have a water depth of 4.00 m below LLW (for general cargo, passenger and carrier vessels) and 555 m will have a water depth of 2.00 m below LLW (for fishing vessels). c) A simple rock stone revetment with a total length of 130 m. The master plan of Seo Geo Cha Port is given in Fig. 2.

The availability of adequate facilities, including fresh water, electric power and fuel supply, sufficient to serve the port town and all vessels using the Seo Geo Cha Port, within a reasonable period after completion of the construction of Seo Geo Cha Port has been ascertained. It is assumed that about 400 fishing vessels of sizes ranging from 2–50 g.t. will regularly operate from this port. Supporting fish carrier vessels will collect the bulk of the catch, and transport it to the principal mainland ports for domestic and export marketing.

6. Project Evaluation by the Planning Model

The viability of the proposed fishing port project at Seo Geo Cha, Korea was was undertaken by the planning model established. The fundamental attributes which belong to basic policy criteria, are not quantifiable elements. However, before proceeding to Step 2, it is absolutely essential to ensure that each of these attributes will conform with the basic policy criteria. The following are steps examined in detail:

(A) Step 1 Fundamental Attributes (A1, A2, A3 and A4).
The attributes which fall under this category have given assurance to proceed to Step 2.

(B) Step 2 Technical Prerequisite (A7 and A8).
In the case of a relatively large fishing port project, availability of basic technical data, namely a soil test, a hydraulic survey and a laboratory model test to prove the technical soundness of a port construction, would also be the next important factor to be clearly examined. Another important attribute which falls under this step is the appropriateness of the proposed project site, viz., current utilization of any nearby fishing port will have to be studied so as to insure the anticipated utilization of the proposed port. In the event the proposed project fails to meet with these criteria, the project will have to be either rejected or deferred.

As mentioned in the preceding chapter, consideration was given as to the possible future planning of constructing another fishing port at Seohuksando, 66 km. southwest of the proposed Seo Geo Cha fishing port. It was decided to proceed to Step 3, bearing in mind this future planning which should be incorporated in the cost benefit analysis.

(C) Step 3 Cost Benefit Analysis (A19).

Before proceeding to the overall project evaluation, it is necessary to test the viability of the project based on a cost/benefit analysis. This is simply for the reason that it is meaningless to further pursue a project of which the economic internal rate of return will be negative or very low even though positive. The required minimum economic internal rate of return is set at 8 per cent in the flow chart, which generally complies with the lending interest rate of the Government to banking institutions involved in various activities. In other words, from an overall economy point of view, if the economic internal rate of return is less than 8 per cent, the proposed project will have to be rejected on economic grounds.

The principal economic benefits from the construction of the project port at Seo Geo Cha will accrue to the coastal fishermen operating 2–50 g.t. class fishing vessels.

Summary of Annual Benefits

- annual net benefits to existing 5–50 g.t. class fishing vessels	$308,000
- annual net benefits to existing 2–5 g.t. class fishing vessels	$247,500
- storm sheltering benefits	$231,000
Total	$786,500

- Additional Benefits from Sales of Land for Port Related Development ($371,000 divided evenly over 3 years, 1982, 1983 and 1984)

The economic rate of return for Seo Geo Cha Port is conservatively estimated

Table 1. Calculation of Economic Rate of Return for Seo Geo Cha Fishing Port

Year	Investment Cost	Maintenance Cost[a]	Benefits[b]	Net Benefits
0	690	—		(690)
1	2,414	—		(2,414)
2	2,759	—	79	(2,680)
3	1,034	—	281	(753)
4		69	517	448
5		69	713	644
6–40		69	786	717

EIRR=9.0 per cent

a) Calculated as 1 per cent of total investment cost.

b) Benefits in Year 2 are 10 per cent of full benefit, benefits in Years 3–5 are 20 per cent, 50 per cent and 75 per cent of full annual benefits plus $124,000 in each of these three years for the value of land sold for port related development. Benefits in Years 6–40 remain constant.

(Table. 1). Nine per cent is considered marginally satisfactory for an infrastructure investment of this type in Korea.

Sensitivity tests were carried out by varying the number of fishing vessels regularly using the port, by reducing the storm sheltering benefits and by delaying the use of the port. As shown in Table 2, the port remains economically viable over a range of less than favorable assumptions.

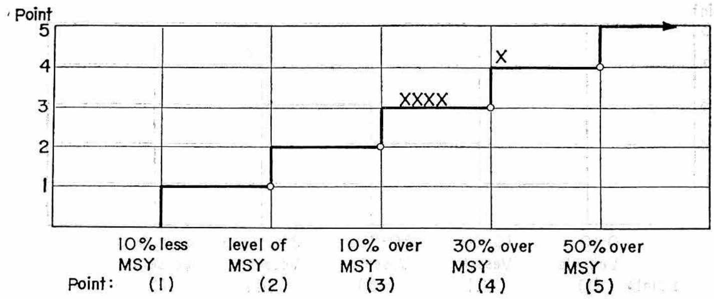
Table 2. Sensitivity Tests on Seo Geo Cha Port

	EIRR (%)
A. Base Case	9.0
B. Only 56 large and 264 smaller existing vessels use the port (20% below base case)	7.6
C. Storm sheltering benefits reduced by 20 per cent	8.4
D. Target use of port delayed until four years after completion (1986)	8.1
E. Seohuksando port is not built and therefore 250 90 g.t. class offshore vessels use the project port during 5 storms each year	14.1

(D) Step 4 Technical, Institutional and Economic Attributes (A5, A6, A9, A10, A11, A12, A13, A14, A15, A16, A17, A18, A19, A20, A21, A22, A23 and A24)

Various project proposals have generally been evaluated through the process of the above Steps 1, 2 and 3. It is considered that the above steps are primarily the prerequisites before proceeding to Step 4, wherein and thereafter the essence of the overall quantification of the project evaluation is vested. The number of attributes which falls under this Step 4 is 18. The maximum points given to the total attribute is 5. Another assumption introduced is that point 3 indicates the average position of each attribute, and an attribute which is less than 3 points is considered unfavorable and draws special attention. Therefore, a total less than 54 will have to be rejected, since it failed to attain, on an average, more than 3 points for each attribute. As illustrated in the flow chart, the technical, institutional and economic attributes relevant for evaluating a fishing port project proposal were selected. The following Figures from 3 to 20, indicate the relative value of each attribute on the y axis using 5 points as maximum. The x axis shows the absolute value of each attribute corresponding to the relative value on the y axis. The amounts on the x axis and the points on the y axis for the Seo Geo Cha fishing port Project in Korea are plotted as X on each Figure. The points gained for each attribute are shown in the following table for the Seo Geo Cha fishing port Project.

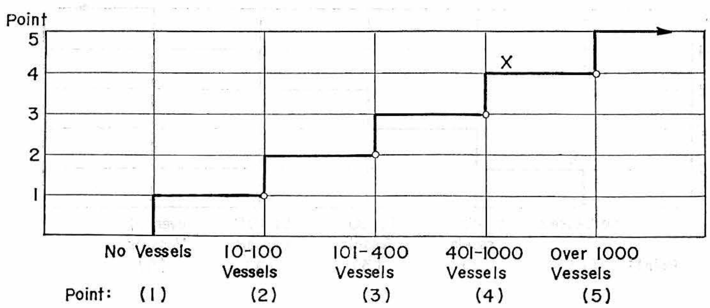
In this context, it should be mentioned that in most cases, many financing institutions in the past undertook the viability test of a project up to Step 3 in the presented flow chart. From the standpoint of an overall project evaluation,



Note: χ axis shows possible additional fish catch which exceed maximum sustainable yield. (MSY) Point 3 indicates possibility of catching additional 10% catch vis-a-vis current catch. Points 2 is fully exploited. Point 1 is over-exploited. χ appears predominantly on Point 3 and also on Point 4 due to the fluctuation of resources assessment by various sources.

Relative value: Points 3 for Seo Geo Cha fishing port project.

Fig. 3. Fisheries resources (attribute 5.)



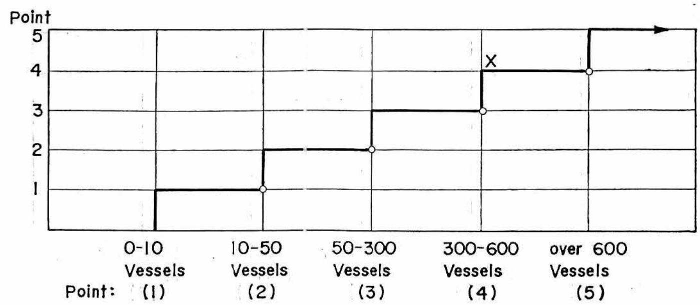
Note: Alteration of this atribute 9 from the original attribute 9 is required as in the case of a fishing port project, it concerns with only number of fishing vessels in the project area.

The vessels do not necessarily use the proposed fishing port. χ axis shows the total number of fishing vessels operating in and around the proposed fishing port site.

Point 3 indicates average preferable number of vessels operating in the area to justify a fishing port project of over 2nd Grade Class fishing port.

Relative value: Point 4 for Seo Geo Cha fishing port project.

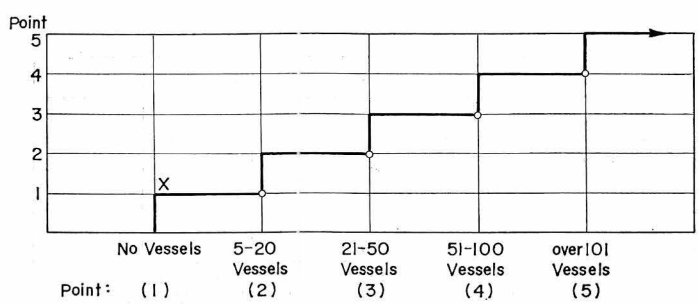
Fig. 4. Prevailing fishing activities (attribute 6).



Note: This figure has direct relationship from previous Fig. 2 χ axis shows number of vessels which will actually receive benefit from the proposed fishing port. This benefit can be converted into monetary terms which was used in the cost/benefit analysis. Therefore, number of vessel alone was presented in this figure. Point 3 indicates range of minimum requirement of vessel usage of over 2nd grade fishing port.

Relative Value: Point 4 for Seo Geo Cha fishing port project.

Fig. 5. Benefit to the existing vessels (attribute 9).

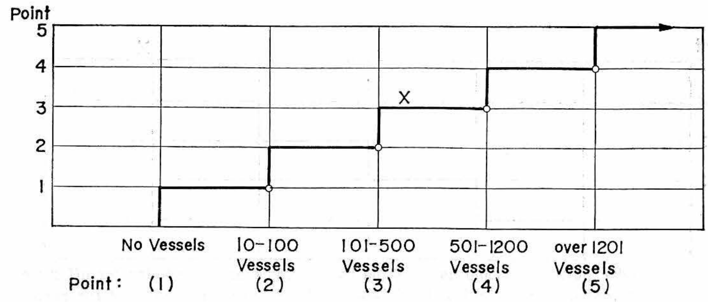


Note: It is difficult to estimate possible number of vessels to be constructed which will operate from the Fishing Port. Unless construction of new vessels be included as a part of package of a proposed project or possible new vessel construction be clearly identified, this benefit should not be included in the project evaluation. χ axis shows possible number of new vessels to be constructed which will operate from the proposed fishing port. Point 3 indicates range of minimum prefered number of new vessels which will operate from the port.

Relative value: Point 1 for Seo Geo Cha fishing port project

No new vessel construction was envisaged for the project due to the reasons mentioned in the above Note.

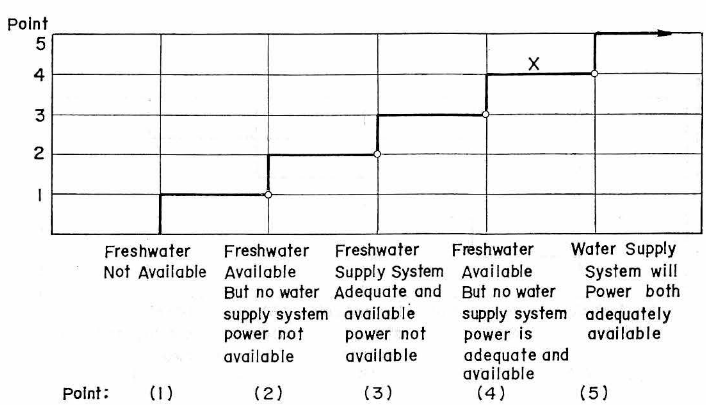
Fig. 6. Benefit from the newly constructed vessels.



Note: Storm sheltering benefit will be derived from number of vessels operating in the project area. χ axis shows number of vessels including fish carriers cargo vessels, passenger vessels and off-shore fishing vessels which will have storm sheltering benefit. As it includes all type of vessels number shown on χ axis will be higher than that of number of fishing vessels in the project area as shown on Fig. 2. Point 3 indicates average preferable number of vessels which will have storm sheltering benefit from the proposed fishing port of over 2nd grade class fishing port.

Relative Value: Point 3 for Seo Geo Cha fishing port project.

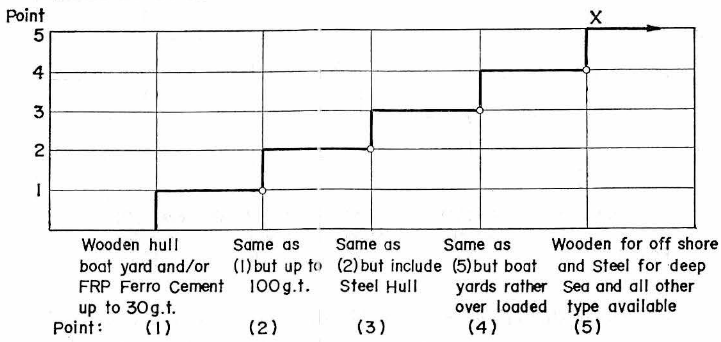
Fig. 7. Storm sheltering benefit. (attribbute 11)



Note: χ axis shows availability of power and water supply which a basin need to construct and operate a fishing port. In the case of point 2 water supply system must be established through (a) extension of existing city water pipingline or (b) pumping from a deep well. Also power generator which have to be attached. Point 3 is considered as minimum basic requirements.

Relative Value: Point 4 for Seo Geo Cha fishing port project.

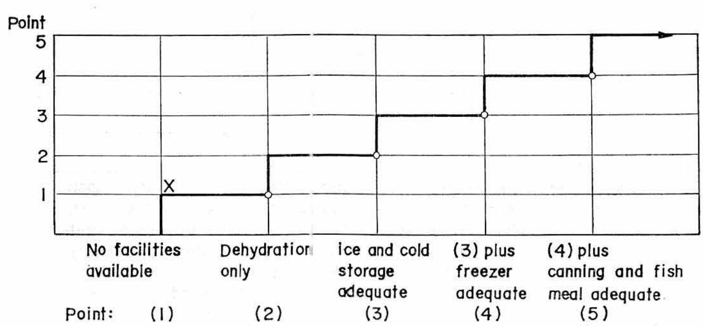
Fig. 8. Public utliity. (attribute 12)



Note: This attribute is relatively less important for a fishing port project as it correlates indirectly only. However, if the facilities are over-loaded, construction of a boat yard and necessary shipway is rarely included in the fishing port project. χ axis shows state of existing boat buildng and repair yard. Point 3 indicates minimum desired requirements for the type of a fishing port.

Relative Value: Point 5 for Seo Geo Cha fishing port project.

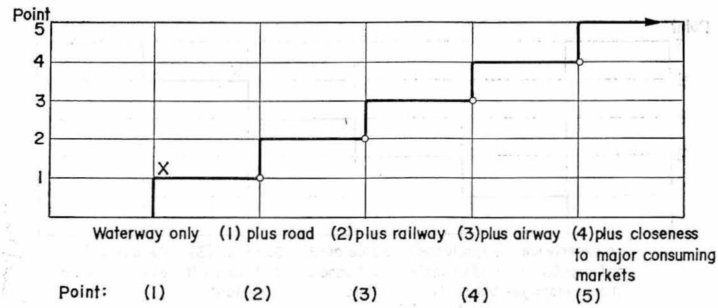
Fig. 9. Boatbuilding and repair yard. (attribute 13)



Note: It is preferable to have refrigeration and processing facilities in the project area. If such facilities are not adequately available, it is necessary to include the facilities depending on type of fishing activities expected from the proposed fishing port. χ axis shows type of refrigeration and processing facilities available in the project area, Point 3 indicates minimum desired requirement for the type of a fishing port.

Relative Value: Point 1 for Seo Geo Cha fishing port project.

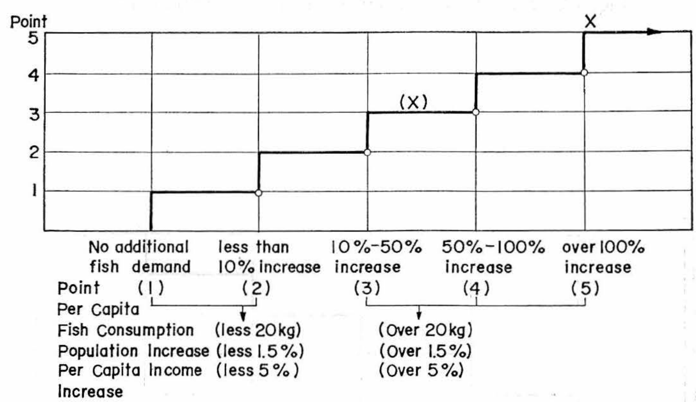
Fig. 10. Refrigeration and processing. (attribute 14)



Note: In the case of a fishing port project on an island, often waterway is the only means of transportation. χ axis shows mode of transportation. Point 3 indicates minimum desired availability of transportation facilities that is waterway, road and railway.

Relative Value: Point 1 for Seo Geo Cha fishing port project.

Fig. 11. Transportation facilities. (attribute 15)

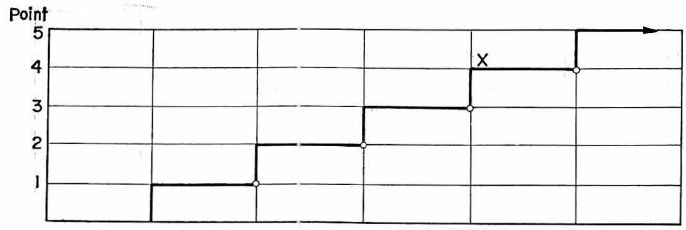


Note: Strength of foreign market was excluded. Strength of domestic market is generally determined by a most important factor ie, additional fish demand vis-a-vis available fish supply. This is further affected by other three factors ie, per capita fish consumption level, population increase and per capita income increase. These three factors shown above indicates as another factors to determine the strength of market. χ axis shows extent of additional fish demand vis-a-vis avaliable fish supply. Point 3 indicates minimum desired strength of market.

Relative Value: Point 5 for Seo Geo Cha fishing port project.

1) Additional fish demand in Korea is about 21% vis-a-vis available fish supply. Therefore it lies on the Point 3. However other 3 factors are all satisfied in Korea, the point was increased to 5.

Fig. 12. Strength of market. (attribute 16)



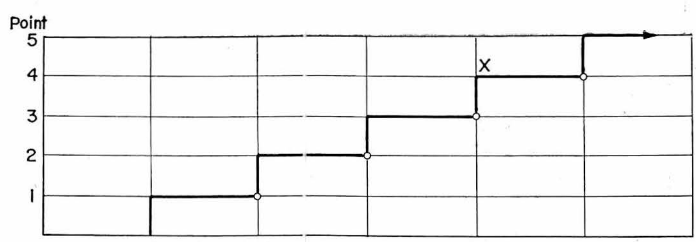
No experience and capability in port management | Experienced and capable but staff and financial constraints | Same as(2) by financially sound | Same as (3) but No staff constant | Excellent in every aspects

Point: (1) (2) (3) (4) (5)

Note: Executing Agency arrangements differ from country to country and type of a fishing port. It is undertaken either by Department of Fisheries under (usually) Ministry of Agriculture or Port Authority under (usually) Ministry of Transport. It can be managed either by Central Government or Provincial Government. χ axis shows degree of experience, capability, financial and staffing position. Point 3 indicates minimum desired soundness of an executing agency.

Relative Value: Point 4 for Seo Geo Cha fishing port project.

Fig. 13. Soundnes of executing agency. (attribute 17)



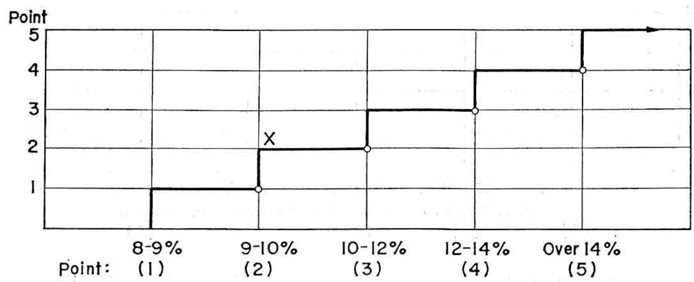
Over 10% of total cost | 5-10% of total cost | 2-5% of total cost | less than 2% of total cost | Not required

Point: (1) (2) (3) (4) (5)

Note: Usually consultant is required to draw detailed designs, tender documents and specifications. If major preparatory works are conducted by executing agency and consultants are locally available the relative cost will be cheaper. χ axis shows amount of consultant fee in the total cost of a Fishing Port Project. Point 3 indicates minimum unavailable consultant fee.

Relative Value: Point 4 for Seo Geo Cha fishing port project.

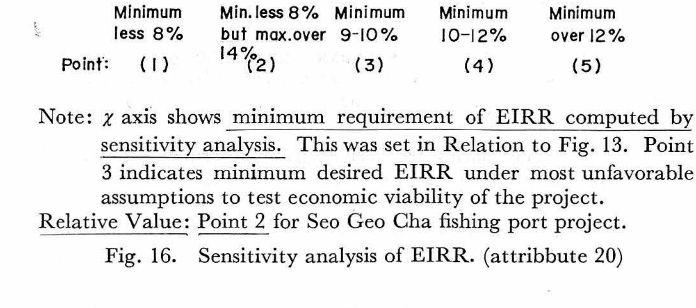
Fig. 14. Need of consultant. (attribute 18)



Note: χ axis shows economic internal rate of return (EIRR) Point 1 was set as less 9% since the project evaluated at this step has passed minimum requirement of 8% EIRR. Point 3 indicates minimum desired EIRR.

Relative Value: Point 2 for Seo Geo Cha fishing project.

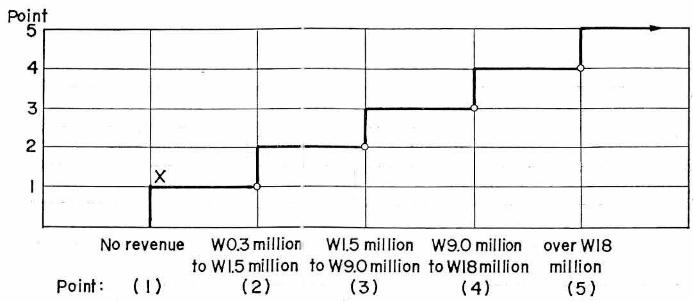
Fig. 15. Economic internal rate of return. (attribute 19)



Note: χ axis shows minimum requirement of EIRR computed by sensitivity analysis. This was set in Relation to Fig. 13. Point 3 indicates minimum desired EIRR under most unfavorable assumptions to test economic viability of the project.

Relative Value: Point 2 for Seo Geo Cha fishing port project.

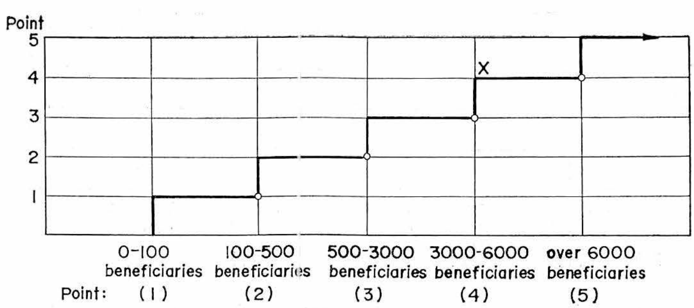
Fig. 16. Sensitivity analysis of EIRR. (attribbute 20)



Note: The Port dues are concerned generally as the only direct source of Government Revenue Generation in the case of Fishing Port Operation unlike Commercial Cargo Port. The Port dues are calculated based on 30 Korean won (w) per gross tonnage of a boat. The number of vessels which utilize the port has taken from Fig. B. The size of a boat is estimated as, on average, 50 gross ton which makes 20 visits to the port annually. χ axis therefore shows Government Revenue through collection of port dues. Point 3 indicates minimum desired port dues to be collected. It should be mentioned that quite often port dues are not charged to fishing vessels, therefore, this attribute is not regarded as an important attribute.

Relative Value: Point 1 for Seo Geo Cha fishing port project.

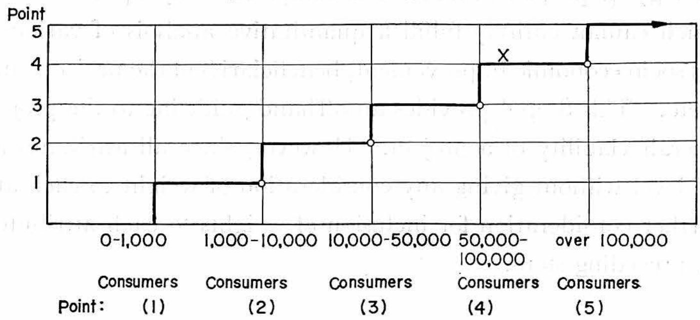
Fig. 17. Government revenue. (attribute 21)



Note: No. of beneficiaries are derived from fishermen, other vessels crew using the port and employment created at port shore facitities. No. of beneficiaries are estimasted based on 10 fishermen per boat taken from Fig. 3. χ axis shows no. of Beneficiaries. Point 3 indicates minimum desired no. of beneficiaries.

Relative Value: Point 4 for Seo Geo Cha fishing port projects.

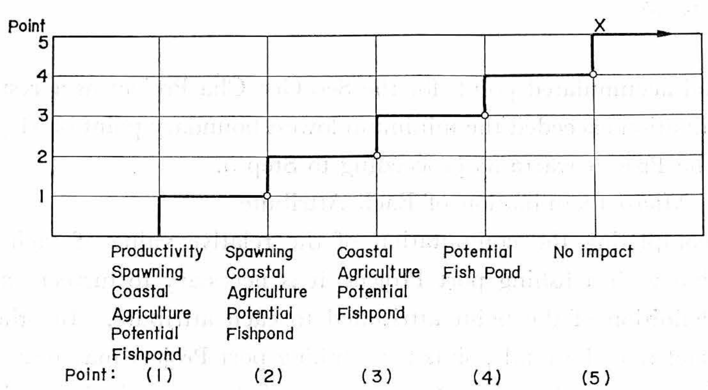
Fig. 18. Project beneficiaries. (attribute 22)



Note: χ axis shows number of consumers benefited from the project. The fishing port project is not direct production oriented project. Therefore the level of no. of consumers will be lower versus the Points. Also, this is depending on total population and per capita fish consumption of a concerned country. This figure gives broad of consumers benefitted by a fishing port project. Point 3 indicated minimum desired no. of consumers to be benefitted.

Relative Value: Point 4 for Seo Geo Cha fishing port project.

Fig. 19. Consumers benefitted. (attribute 23)



Note: χ axis shows environmental impact which will be created due to construction of a fishing port. Generally fishing port construction does not cause serious problem unlike commercial cargo port as the scale of reclamation and oil leakage is relatively small. Point 3 indicates usual influence caused. If the port will create all type of adverse impact as shown in point, the construction of the port draws serious attention.

Relative Value: Point 5 for Seo Geo Cha fishing port project.

Fig. 20. Environmental impact. (attribute 24)

this methodology of project evaluation encompasses only up to the cost benefit analysis, which cannot entirely fulfill a quantitative analysis of various other aspects such as socio economic improvement, beneficiaries of the project, environmental impact, etc. This Step 4 provides an offhand guideline to the project assessor as to the overall viability of a project. However, since all attributes are placed on an equal level without giving any consideration of weight to each attribute in this step, further consideration for inclusion of weights to each attribute has been made in the preceding steps.

Table 3. Total Cumulated Points (Seo Geo Cha Fishing Port Project)

Fig.	Attribute	Points	Fig.	Attribute	Points
3	5	3	12	16	5
4	6	4	13	17	4
5	9	4	14	18	4
6	10	1	15	19	2
7	11	3	16	20	2
8	12	4	17	21	1
9	13	5	18	22	4
10	14	1	19	23	4
11	15	1	20	24	5

Total Points=57

The total accumulated points for the Seo Geo Cha Project as a result of the Step 4 examination exceeded the minimum lowest boundary point of 54 (Table 3). Therefore, the Project warrants proceeding to Step 5.

(E) Step 5 Micro Examination of Each Attribute

Upon completing the computation of the relative value of each attribute in conjunction with a fishing port Project, it is necessary to further examine in depth the definition of the point attributed to each attribute. In other words, despite the fact that the total points for a fishing port Project may have exceeded 54, the Project may yet be rejected on the ground that a particular attribute, if it had very low points, could be judged to be a serious impediment for the success of the Project. In that case, the entire Project would have to be rejected due to the particular attribute which would cause a serious adverse influence for the Project. Such a low point attribute was noted in an accepted Project due to the reason that the other points were high enough to offset this low point. Hence, the total project score showed over 54 points. The following table shows the results of a micro examination of each attribute. Those attributes, which do not provide significant reason for a rejection of the entire Project even when the attribute has low points, were excluded. Table 4.

Table 4. Micro Examination of Relevant Attributes

Fig.	Attribute	Project Rejected	Fig.	Attribute	Project Rejected
3	5	below Point 1	8	12	below Point 2
4	6	below Point 2	18	22	below Point 2
5	9	below Point 2	20	24	below Point 2

Attribute 5- Fisheries' Resources

The degree of utilization of Fisheries' Resources is an essential element for any fisheries' project, including a fishing port project. Even if an additional potential fish catch is 10 per cent less than the maximum sustainable yield (MSY), the fishing operation can be carried out with caution. However, if it falls below that level, a strict resource management law should be enforced to reduce the fishing efforts. Thus, the need for constructing a fishing port would be reduced, and consideration of such a proposal should at least be deferred.

Attribute 6- Prevailing Fishing Activities

The number of vessels operating in the Project area is an important factor to justify a fishing port Project, as a majority of those vessels are expected to utilize the port. If the number of vessels is, say less than 10 in the area, and yet the proposal is to construct a port exceeding the second grade class, it should be considered as a politically motivated project and should be rejected on economic grounds.

Attribute 9- Benefit to Existing Vessels

The largest economic benefit for a fishing port project is derived from the number of existing vessels which will utilize the Port. Likewise, as the case of Attribute 6, if the benefit from the existing vessels is too small the Project should be rejected.

Attribute 12- Public Utility

The availability of power and water supply is a basic need for the construction and operation of a fishing port. As for power, if it is not available, a power generator can be installed. Likewise, water supply facilities can also be provided if there is a source of such water supply. However, if fresh water is insufficient or not available the proposed Project should be rejected.

Attribute 22- Project Beneficiaries

If the Project beneficiaries are very minimal, say, less than 100 beneficiaries, although the proposal can be justified on economic grounds, it will not serve the socio-economic objective of the fishing port. Therefore, the proposal should be rejected.

Attribute 24- Environmental Impact

The problem of pollution and environmental destruction has become a serious issue recently for every type of Project. In the case of a fishing port Project, such impact will be relatively less compared to industrial or large scale civil work projects. However, if the construction of a fishing port should result in (i) the reduced productivity of the fish catch, (ii) the destruction of a spawning ground including its nursery, (iii) the prohibition of coastal aquaculture and (iv) the prevention of potential fishpond development, the adverse impact is of a dual nature. The proposal should be rejected.

The following table shows the results of the micro examination of these attributes, relative to the Seo Geo Cha fishing port project (Table 5).

Table 5. Application of the Attributes to Seo Geo Cha Fishing Port Project

Fig.	Attribute	Point	Fig.	Attribute	Point
3	5	3	8	12	4
4	6	4	18	12	4
5	9	4	20	24	5

All attributes for the Seo Geo Cha Project show satisfactory results, much over the lowest ceiling point indicated in Table 4. Therefore, the project warrants proceeding to Step 5.

(F) Step 6 Conversion into Utility Function

(a) The Methodology of the Utility Function

For the last 30 years, the theory of Utility Function has been applied in various practical fields. This development started with the comprehensive work of N.M. Smith, Jr. (1956),[13] in which he presented an historical summary of the utility theory. This was further refined by P. Fishburn (1964),[3] J.W. Pratt et al. (1965)[11].

In 1972, R.L. Keeney[6] made a remarkable contribution in establishing appropriate terms of multi-attribute utility functions. He has indicated two essential independence properties. The detailed definitions of these properties were further discussed by R.L. Keeney (1973)[7]. The independence properties are called "value independence" and "utility independence" (UI). The value independence is often referred to as preferential independence (PI). The PI is the more restrictive of the two and is a sufficient condition for the UI. The UI is only a necessary condition for the PI.

It would be convenient to use $x_1, x_2 \cdots x_n$ to designate a special level of attributes $x_1, x_2 \cdots x_n$ in a simple function form of U which would be shown in the following equation

$$U(x_{,1}\ x_2, \cdots, x_n) = f((u_1(x_1), u_2(x_2), \cdots, u_n(x_n)) \qquad (1)$$

where $i=1, 2, \cdots, n$, and u_i is a preference function over x_i.

Based on various PI and UI conditions, different forms of utility functions u consistent with the above equation (1) can be obtained. U can be expressed either in an additive form or a multiplicative form.

$$\left.\begin{aligned} &\text{Additive form- if } \textstyle\sum k_i = 1 \\ &U(x_1, x_2, \cdots, x_n) = \sum_{i=1}^{n} k_i u_i(x_i) \\ &= k_1 u_1(x_1) + k_2 u_2(x_2) + \cdots + k_n u_n(x_n) \end{aligned}\right\} \qquad (2)$$

The computation of u contains a certain degree of error, since whatever we do measure accurately still reflects individual preference, resulting in a degree of uncertainty. To avoid as much as possible a cumbersome mathematical computation, it is therefore felt that equation (2) would be sufficient for selecting an appropriate utility function for both PI and UI.

Table 6. Attributes for the Seo Geo Cha Problem

	Attributes	Measure	Worst	Best
1	Fisheries Resources	% over MSY	−10	50
2	Fishing Activities	No. of vessels	0	1,000
3	Benefit (Existing Vessels)	No. of vessels	0	600
4	Benefit (New Vessels)	No. of vessels	0	100
5	Benefit (Storm Sheltering)	No. of vessels	0	1,200
6	Public Utility	Subjective	0	100
7	Boatyard	Subjective	0	100
8	Shore Facilities	Subjective	0	100
9	Transportation	Subjective	0	100
10	Market	Subjective	0	100
11	Executing Agency	Subjective	0	100
12	Consultant	% of total cost	10	0
13	EIRR	%	8	14
14	Sensitivity Analysis	Subjective	0	100
15	Government Revenue	Korean Won	0	18 million
16	Beneficiaries	Number	0	6,000
17	Consumers	Number	0	100,000
18	Environmental Impact	Subjective	0	100

Note– (The technical, institutional and economic attributes defined under Step 4 were renumbered for convenience).

(b) Attributes for the Seo Geo Cha Problem

Before proceeding the theory of lottery it is necessary to assess the utility function over the individual attributes. Each attribute has been analyzed to draw the worst and best case, using a respective measure relevant to the particular attribute. The following table 6 is a summary describing the attributes for the Seo Geo Cha situation.

(c) Assessment of Utility Functions

The project assessor should prepare these figures before determining appropriate lottery for each attribute. This will provide more confidence, although in some attributes the mid-points of figures do not necessarily provide the point distribution of 0.5. For example, the following Figure 23, showing the curve drawn from 3 points, represents the utility function for attribute 3, namely the benefit from existing vessels.

Following the above approaches described in (a) and (b), the utility functions for each attribute of the Seo Geo Cha fishing port project are illustrated in the Figures from 21 to 38 below.

(d) Assessment of the Scaling Factors k_i

The scaling factor (k_i) shown in equation (2) will have to be assessed in a descending order in terms of magnitude. In establishing the relative scaling factors, k_i, it is necessary to examine tradeoffs between the two attributes. The Project assessor is asked to indicate his priority among attributes which should first be swung from the worst to the best. In the case of a fishing port project, since the 18 attributes are of a diversified nature, the following steps to determine the scaling factors are suggested, utilizing the evaluation factors.

(1) Technical Factors:

(a) Fishing ground and resources - x_1, x_2

(b) Fishing port - x_3, x_4, x_5

(c) Shore facilities - x_6, x_7, x_8

(d) Transportation and marketing - x_9, x_{10}

(2) Institutional Factors:

x_{11}, x_{12}

(3) Financial and Economic Factors:

x_{13}, x_{14}, x_{15}, x_{16}, x_{17}, x_{18}

Initially, six different sets of attributes are considered -

(Set)		(Attributes)	(Set)		(Attributes)	
1	(1)(a)	x_1, x_2	4	(1)(d)	x_9, x_{10}	
2	(1)(b)	x_3, x_4, x_5	5	(2)	x_{11}, x_{12}	
3	(1)(c)	x_6, x_7, x_8	6	(3)	x_{13}, x_{14}, x_{15}, x_{16}, x_{17}, x_{18},	(3)

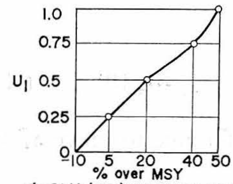


Fig.21 X_1(AT1) FISHERIES RESOURCES

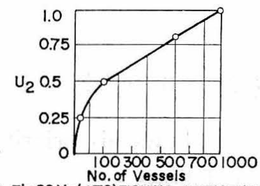


Fig.22 X_2(AT2) FISHING ACTIVITIES

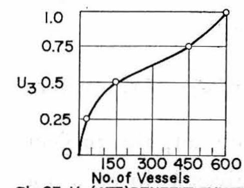


Fig.23 X_3(AT3) BENEFIT EXISTING VESSELS

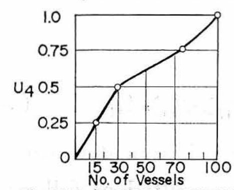


Fig.24 X_4(AT4) BENEFIT NEW VESSEIS

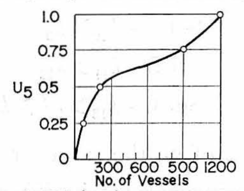


Fig.25 X_5(AT5) BENEFIT STORM SHELTERING

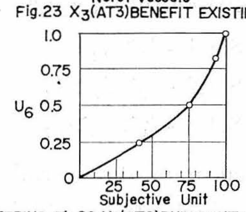


Fig.26 X_6(AT6) PUBLIC UTILITY

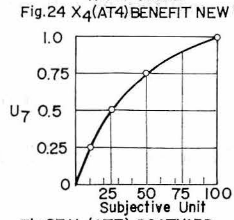


Fig.27 X_7(AT7) BOATYARD

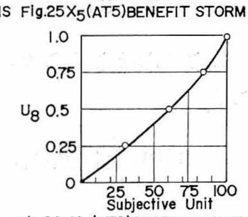


Fig.28 X_8(AT8) SHORE FACILITIES

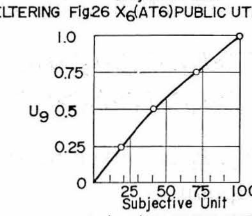


Fig.29 X_9(AT9) TRANSPORTATION

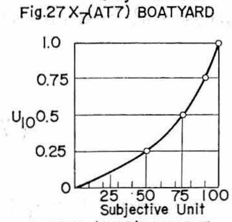


Fig.30 X_{10}(AT10) MARKET

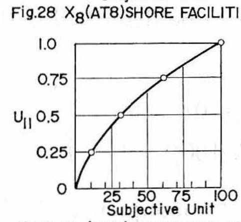


Fig.31 X_{11}(AT11) EXECUTING AGENCY

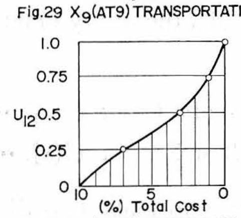


Fig.32 X_{12}(AT12) CONSULTANT

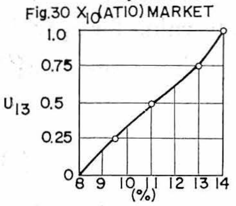


Fig.33 X_{13}(AT13) EIRR

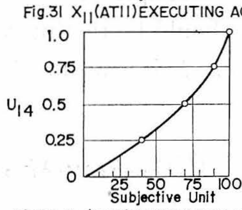


Fig.34 X_{14}(AT14) SENSITIVITY ANALYSIS

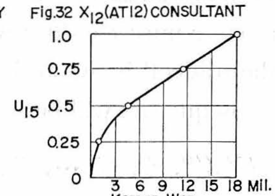


Fig.35 X_{15}(AT15) GOV'T. REVENUE

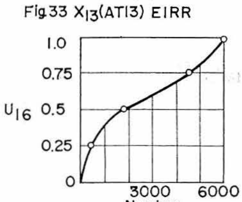


Fig.36 X_{16}(AT16) BENEFICIARIES

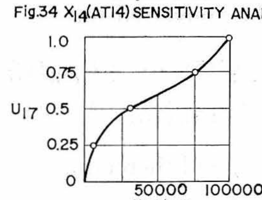


Fig.37 X_{17}(AT17) CONSUMERS

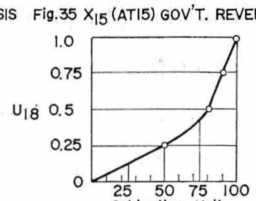


Fig.38 X_{18}(AT18) ENVIRONMENTAL IMPACT

The project assessor has to state which one he prefers to swing from the worst to the best as his priority attribute. To do this, the following assupmtions are to be introduced.

$$x_i^w \leqslant x_i \leqslant x_i^b \quad \text{where} \quad u_i(x_i^w) = 0 \quad u_i(x_i^b) = 1 \qquad (i=1, \cdots, 18) \tag{4}$$

At each set, the project assessor shows his priority preference to move x_i^w to x_i^b which gives k_i in equation (2) as follows -

$$\begin{array}{ll} \text{Set 1 - } k_1 > k_2 & \text{Set 4 - } k_{10} > k_9 \\ \text{Set 2 - } k_3 > k_5 > k_4 & \text{Set 5 - } k_{11} > k_{12} \\ \text{Set 3 - } k_6 > k_8 > k_7 & \text{Set 6 - } k_{13} > {}_{18}k > k_{16} > k_{17} > k_{15} > k_{14} \end{array} \tag{5}$$

To determine the overall order of k_i, the same procedure is repeated among attributes which attain a higher k_i in each set in (5) which resulted as follows -

$$\begin{array}{l} k_1 > k_{13} > k_{18} > k_6 > k_{16} > k_8 > k_{10} > k_3 > k_2 > k_5 > k_{17} \\ k_9 > k_{11} > k_4 > k_{15} > k_{14} > k_{12} > k_7 \end{array} \tag{6}$$

Since, in (6), k_1 has taken maximum weight, $\sum_{i=1}^{n} k_i u_i(x_i)$ should be considered from the x_1 standpoint.

From (4), the utility function can be described both in worst and best cases as follows -

$$\left.\begin{array}{l} \text{Worst Case: } U(x_1^w, \cdots, x_{17}^w, 0) = 0 \\ \text{Best Case : } U(x_1^b, \cdots, x_1^b, 100) = 1 \end{array}\right\} \tag{7}$$

In order to make two different consequences in (7) into an equal term, the project assessor must consider what should be the intermediate value for x_1 which will be the tradeoff between the two. If it is assumed that such a value is $x_1''^w$, the two consequences will be -

$$U(x_1''^w, x_2^w, x_3^w, \cdots, x_{17}^w, 0) == U(x_1^w, x_2^w, \cdots, x_{17}^w, 100) \tag{8}$$

From equation (2), (8) will be converted to,

$$\begin{array}{l} k_1 u_1(x_1''^w) + k_2 u_2(x_2^w) + k_3 u_3(x_3^w), \cdots, + k_{17} u_{17}(x_{17}^w) + k_{18} u_{18}(0) \\ = k_1 u_1(x_1^w) + k_2 u_2(x_2^w), \cdots, + k_{17} u_{17}(x_{17}^w) + k_{18} u_{18}(100) \end{array} \tag{9}$$

$U_{18}(100)$ is defined as 1, and therefore,

$$k_1 u_1(x_1''^w) = k_{18} \tag{10}$$

Considering the order of scaling factors as shown in (6), the tradeoffs between X_{13}, X_{18}, X_6'''' and X_1 will be considered, using the same procedures one after another.

(e) Application of Utility Function for Seo Geo Cha Project

The scaling factor k_i, which actually provides weights to each attribute, will have to be determined. In order to assess the equation $k_1u_1(x_1^{\prime\prime\prime w})=k_{13}$ the determination of the intermediate value of $x^{\prime\prime\prime w}$ is required. The utility for the right and left sides will be equal in the following equation. (See also Table 6.).

$$u(x_1^{\prime\prime\prime w}, 8, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 10, 0)$$
$$= u(0, 14, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 10, 0) \quad (11)$$

The project assessor will give consideration as to what value of $x_1^{\prime\prime\prime w}$ will be most appropriate to best balance the utility u on the right side of the equation (11).

It is assumed that

$$k_1u_1(45) = k_{13} \quad (12)$$

From Fig. 21, the corresponding value of 45 is taken as 0.85. Therefore,

$$0.85k_1 = k_{13} \quad (13)$$

The result of tradeoffs for k_i is shown in Table 7.

Table 7. Scaling Factor k_i

$k_i=k_1u_1(x_1{}^{\prime\cdots w})$	$k_i=k_1u_1(x_1{}^{\prime\cdots w})$	$k_i\equiv k_1u_1(x_1{}^{\prime\cdots w})$	$k_i=k_1u_1(x_1{}^{\prime\cdots w})$
$k_2=0.53k_1$	$k_7=0.13k_1$	$k_{12}=0.16k_1$	$k_{17}=0.44k_1$
$k_3=0.55k_1$	$k_8=0.62k_1$	$k_{13}=0.86k_1$	$k_{18}=0.83k_1$
$k_4=0.31k_1$	$k_9=0.37k_1$	$k_{14}=0.22k_1$	
$k_5=0.50k_1$	$k_{10}=0.59k_1$	$k_{15}=0.25k_1$	
$k_7=0.72k_1$	$k_{11}=0.35k_1$	$k_{16}=0.67k_1$	

From equation (2), k_1 is computed as

$$k_1 = \frac{1}{9.09} = 0.110 \quad (14)$$

From the above table the value of k_i is determined as follows (Table 8):

Table 8. Value of k_i

$k_1=0.110$	$k_6=0.079$	$k_{11}=0.038$	$k_{16}=0.074$
$k_2=0.058$	$k_7=0.014$	$k_{12}=0.018$	$k_{17}=0.048$
$k_3=0.061$	$k_8=0.068$	$k_{13}=0.093$	$k_{18}=0.091$
$k_4=0.034$	$k_9=0.041$	$k_{14}=0.024$	
$k_5=0.055$	$k_{10}=0.065$	$k_{15}=0.028$	

The total utility value $\sum_{i=1}^{18} k_iu^i(x_i)$ of the Seo Geo Cha fishing port project was calculated from Table 9. The actual value of each attribute X_i was taken

Table 9. Summary$-\sum_{i=1}^{18} k_i u_i(x_i)$

Actual Value (Seo Geo Cha Project)		$u_i(x_i)$	k_i	$k_i u_i(x_i)$
X_1	25 per cent over MSY	0.55	0.110	0.061
X_2	620 vessels	0.77	0.058	0.045
X_3	400 vessels	0.70	0.061	0.043
X_4	0 vessels	0	0.034	0
X_5	290 vessels	0.54	0.055	0.030
X_6	Point 4	0.47	0.079	0.037
X_7	Point 5	0.97	0.014	0.014
X_8	Point 1	0.08	0.068	0.005
X_9	Point 1	0.13	0.041	0.005
X_{10}	Point 5	0.75	0.065	0.409
X_{11}	Point 4	0.82	0.038	0.031
X_{12}	1.5 per cent of total cost	0.66	0.018	0.012
X_{13}	9.0 per cent	0.19	0.093	0.018
X_{14}	Point 2	0.19	0.024	0.005
X_{15}	No revenue	0	0.028	0
X_{16}	3,310 beneficiaries	0.68	0.074	0.050
X_{17}	50,000 consumers	0.60	0.048	0.029
X_{18}	Point 5	0.75	0.091	0.068

$\sum_{i=1}^{18} u_i(x_i)=8.76$ $\sum_{i=1}^{18} k_i=0.999$ $\sum_{i=1}^{18} k_i u_i(x_i)=0.502$

Note– (The correlation between the points in Figs. 3–Figs. 20 and the subjective units in Figs. 21–Fig. 38 was defined as–Point 1=10, Point 2=30, Point 3=50, Point 4=70 and Point 5=90)

from Fig. 3 to Fig. 20; and its corresponding value of $u_i(x_i)$ was taken from Fig. 21 to Fig. 38.

The total utility was assessed at 0.502. This value is located between 0.5 and 0.8. Therefore, according to the Flow Chart, the proposal is neither accepted nor rejected. It is necessary to proceed to Step 7.

(F) Step 7 Hypothetical Test for a Better Project

Under this Step 7, the lowest point attributes will be selected as variables with a view to improving the particular attributes by way of swinging them to the fullest scale of 5 points. The remaining attributes, which will be affected through this process will have to be adjusted accordingly. Depending on the nature of the project proposal, several variables could be taken to make a hypothetical test to search for a better project. Upon completion of such exercises, the project which gained a maximum improvement in terms of total points would be selected as the best possible project, and that project should be counter proposed to the concerned authority.

In this step, therefore, it is necessary to reexamine the possible alternative proposals from Step 4 once again. The attributes which had less than 3 points were extracted from Table 3 and tabulated as follows (Table 10):

Table 10. Attributes Below Point 3

Fig.	Attribute	Point
6	(10) Benefit from Newly Constructed Vessels	1
10	(14) Shore Facilities (Refrigeration and Processing)	1
11	(15) Transportation	1
15	(19) Economic Internal Rate of Return	2
16	(20) Sensitivity Analysis of Economic Internal Rate of Return	2
17	(21) Government Revenue	1

Notwithstanding the aim of paying maximum efforts in improving such low point attributes, it should be pointed out that due to the prevailing circumstances, many of the attributes cannot be hypothetically swung up the full scale point 5 or even to an improved scale point 4. Therefore, it is necessary to give careful consideration to each attribute.

(a) Attributes Impractical for Improvement

Attribute 14 - Shore Facilities (Refrigeration and Processing)

The port is mainly used as a fish transition point to mainland Korea. Ice is required but not other facilities. Needless to say, if such facilities are available, it would be better for the area development. Since ice is sufficiently brought from mainland Korea by fish carriers, it would be an unrealistic assumption to consider inclusion of such facilities at this site.

Attribute 15 - Transportation

Since the site is located at an outer small island, this aspect cannot be improved.

Attribute 21 - Government Revenue

Since port dues and other charges cannot be charged under the current practice, this aspect cannot be improved.

(b) Alternative 1 Proposal - Improvement of Attribute 10
(Benefit from the Newly Constructed Vessels)

For the purpose of a conservative estimate, the new vessel construction aspect was not considered in the Seo Geo Cha fishing port project. If new vessels are to be constructed, because of the new fishing port, how this aspect will affect any other pertinent attributes will be a matter to be examined. The following assumptions can be introduced.

(i) Fisheries' resources are not affected by 60 vessels to be newly constructed.

(ii) 60 vessels are approximately 10 per cent of the existing vessels (620), which would be a reasonable increase.

(iii) Government will take strong initiative and promotional activities for local fishermen's cooperative societies to encourage them to expand their activities.

(iv) Government or other alternate financial sources will make funds available through appropriate financial institutions for vessel construction purposes if so required.

Assuming that the above conditions are fulfilled, the next aspect to be considered is what would be the attributes affected by the change of this attribute. The following attributes will be affected, some of which were suitably adjusted.

Attribute 11 - Benefit from Storm Sheltering

As these vessels are to operate from Seo Geo Cha port, it is assumed that 60 vessels will also benefit from storm sheltering. The total number of vessels will thus be increased from 290 vessels to 350 vessels.

Attribute 16 - Market

A very slight fish catch increase will not affect the overall marketing situation in the country.

Attribute 19 - EIRR

New annual revenue added to the Project:

(i) Fish catch - $\$500 \times 100$ (m.t.) $\times 60$ (vessels)$=\$3,000,000$

(ii) Storm sheltering - 10 (storms annually) $\times 7$ hours round trip travel time to safe anchorage $\times$ 40 kg. fish/hour $\times$ \$0.5/kg. $\times 60$ (vessels=)\$84,000

The total benefit is estimated at \$3,084,000. The capital costs and operating costs are also calculated and added to the original costs accordingly. The EIRR is estimated at 26.5 per cent.

Attribute 20 - Sensitivity Analysis

The most unfavorable situation was considered, viz., capital and operating cost increases by 20 per cent, and revenue decreases by 20 per cent. The EIRR was 16.8 per cent.

Attribute 22 - Beneficiaries

6 fishermen $\times 60$ (vessels)$=360$ fishermen to be added to 3,310 beneficiaries. Therefore, 3,670 beneficiaries will benefit from the project.

Attribute 23 - Consumers

A very slight fish catch increase will not affect the overall marketing situation in the country.

(c) Alternative 2 Proposal - Improvement of Attributes 19 (EIRR) and 20 (Sensitivity Analysis)

From the sensitivity analysis, if Shokokusando port is not buit in the future, the EIRR for Seo Geo Cha fishing port would increase to 14 per cent. (See Table 2.) Conversely, the minimum sensitivity shows 9 per cent.

Attribute 11 - Benefit from Stom Sheltering

It is assumed that 250 90 g.t. class offshore vessels operating in the East China Sea will use the port for storm sheltering purposes since Shokokusando port is not built. The size of the vessels is more than double that of the existing vessels in the Seo Geo Cha area. Thus, the actual addition was estimated at 500 vessels.

Attribute 22 - Beneficiaries

12 fishermen × 250 vessels=3,000 fishermen to be added to 3,310 beneficiaries. Therefore, 6,310 beneficiaries will benefit from the Project.

(d) Alternative 3 Proposal

The above two alternative proposals are indifferent to each other, and therefore can be combined into one proposal. The integration of the above two alternative proposals should be considered as Alternative 3 Proposal. The following table 11 indicates $\sum_{i=1}^{18} k_i u_i(x_i)$ for three. Alternative Proposals (Table 11).

Table 11. Summary (Alternative Proposals)—$\sum_{i=1}^{18} k_i u_i(x^i)$

Proposals		Actual Value (Seo Geo Cha Project)	$u_i(x_i)$	k_i	$k_i u_i(x_i)$
X_4	Alternative 1	60 vessels	0.65	0.034	0.022
	Alternative 3	60 vessels	0.65		0.022
	Alternative 1	350 vessels	0.55		0.032
X_5	Alternative 2	500 vessels	0.61	0.055	0.034
	Alternative 3	850 vessels	0.72		0.040
	Alternative 1	Point 5 (26.5%)	1.0		0.093
X_{13}	Alternative 2	Point 5 (14%)	1.0	0.093	0.093
	Alternative 3	Point 5 (27.8%)	1.0		0.093
	Alternative 1	Point 5 (16.8%)	0.75		0.018
X_{14}	Alternative 2	Point 3 (9.0%)	0.31	0.024	0.007
	Alternative 3	Point 5 (18.2%)	0.75		0.018
	Alternative 1	3,670 beneficiaries	0.69		0.051
X_{16}	Alternative 2	6,310 beneficiaries	1.0	0.074	0.074
	Alternative 3	6,670 beneficiaries	1.0		0.074

Note– Apart from the above X_4, X_5, X_{13}, X_{14}, and X_{16}, other X_i remain unchanged which are to be taken from Table 9 for the computation of $\sum_{i=1}^{18} k_i u_i(x_i)$.

In this context, it should be noted that in the event each alternative proposal is indifferent to the other, allowing integration of the proposals, the alternative proposal which comprises the maximum possible integration of the different proposals should apparently indicate the highest total utility value. In this case too, therefore, this last alternative proposal is expected to show the highest total utility value.

The results of the total utility for the three alternative proposals are presented in Table 12.

Table 12. Total Utility for Three Proposals

Proposal	$\sum_{i=1}^{18} k_i u_i(x_i)$
Original Proposal	0.502
Alternative 1	0.615
Alternative 2	0.607
Alternative 3	0.646

(H) Step 8 Examination of Alternatives

From Table 12, it is noted the three alternative proposals have shown considerable improvement with regard to the total utility value. The project assessor, considering the above series of analysis, should make a clear cut decision as to what direction the project should proceed. The first priority alternative proposal clearly shows that the integrated Alternative 3 proposal of Alternative 1 - construction of an additional 60 vessels and Alternative 2 - cancellation of the Government plan to construct the Shohokusando fishing port, should be given first consideration. In the event that because of policy issues of the Government or certain other unavoidable reasons, if one of the two proposals is not accepted, the project assessor should recommend Alternative 1 and then Alternative 2 in accordance with the total utility value gained by the respective proposals. The responsibility of the final decision will, however, be vested in the decision power of the concerned authorities.

7. Conclusions

In the course of formulation and subsequent evaluation of a project proposed by a concerned authority, the project assessor will come across essential subjects as to what decision analysis has to be used in order to recommend the most suitable project for the consideration of the authority. The dilemma can be relieved depending upon the state of the project formulation. This means that the state of the proposed project can be categorized as:

Case (a): the project assessor received a caption of a project proposal but no detailed feasibility study available.

Case (b): the project assessor received a proposal which contains a detailed project proposal analyzed from all possible angles including alternative proposals.

Case (c): the project assessor received a proposal which is sufficiently detailed, but merely presents only the proposal alone, without alternative proposals.

In the case of (a), it is necessary for the project assessor to work out all possible project alternatives. Upon completion of the study, the project assessor will be able to make recommendations to the authority as to what detailed project should be selected. Quite often, project preparatory feasibility study work falls in this category. In the case of (b), since it is assumed that all necessary data, information, and analysis for all possible alternative proposals are available, it is the project assessor who should evaluate the best proposal among them. This type of proposal is generally found in the completed project feasibility study. In the case of (c) which is actually quite often the case, the concerned authority presents a project with a rather simple format containing a brief description of the project, with a break down of cost estimates, financial and economic justifications of the project. However, it lacks comparative assessment of the viability of the project.

In addition to the above, it should also be mentioned that so far the project assessor contemplated a viability test of the project up to the extent of cost benefit analysis. The other benefits, or so to say other important factors are quite often dealt with as unquantifiable benefits or side effects of the project. In order to attain on overall evaluation of a project in a more concrete manner, or in quantitative analysis rather than qualitative analysis, it became necessary to introduce such a methodology as the project in most cases has manifold components within the projects. In this regard, attempts have been made to introduce a multiple utility theory with a view to defining, evaluating and recommending the project in a more quantitative manner.

In view of the foregoing reasons, consideration has been given in this paper to establish detailed procedures for undertaking the most appropriate evaluation applicable to the above (c) case. A detailed evaluation model in the form of a flow chart has been developed to deal with the subject.

The evaluation model established describes every necessary step to be followed by a project assessor who will ultimately attain the initial objective of the project evaluation through the correct guidance envisaged in this paper.

In order to actually test the practical introduction of the planning model as well as to present a clear cut concept of the approach, a case study was taken from the Seo Geo Cha fishing port project, Korea. It so happens that through this exercise the proposed project was acceptable. However, it revealed that there was possible room to improve the scope of the project as the alternative proposals had shown higher total utility value.

In addition to the above concept and approaches introduced in this paper, the following are newly improved aspects established so as to facilitate and present a more accurate analysis:

(i) establishment of a project evaluation model

(ii) selection and weighting of scaling factor (k_i) utilizing evaluation factors

(iii) utilization of Figures on Relative Points of each attribute for estimation of subjective units of $u_i(x_i)$

(iv) recommendation of improved alternative project proposals.

We wish to mention herewith that an application of the study presented in this paper can be made elsewhere in other project undertakings, which the fall under category (c) mentioned above. Also, we would be quite happy if we could make a humble contribution as to the concept, approach and methodology, which can further be proven through a more diversified application of the concept envisaged in this paper. Finally, we would like to express our grateful appreciation to Assistant I. Wakai of the Department of Transportation Engineering for his useful comments extended to us in the course of the preparation of this paper.

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