Planning Large Engineering Project in high risk country areas: the Evaluation of Local Content strategies in the Oil & Gas industry through a robust planning technique

M. De Falco, M. Gallo, L.C. Santillo, E. PM Troncone and P. Viecelli

***Abstract*—** The paper propose a different approach to evaluate the local content investments: starting from defining what is meant by local content, and considering investment in local content as a real economic strategies that generate opportunities for the area and for the project (including the mitigation of exposure to certain types of risks), we propose their evaluation in a scenario analysis model. The Local content of a complex project is an important variable to create value and increase the overall sustainability of large engineering projects in the Oil & Gas industry, especially in the developing countries. The evaluation methodology is applied to a case study carried out in collaboration with Saipem (ENI group), one of the major international contractor in the oil industry, specialized in developing complex projects in remote areas.

***Keywords*—**Local content, scenario analysis, causal knowledge map, large engineering projects.

I. Introduction

THE term “Local content” refers to use of local labour, supplies and services in large engineering projects. In general, this can be seen as investments made on site, linked to the project or not, to achieve certain goals for the project or simply for the generation of externalities to benefit the territory [1]. In Large engineering projects, local content can be a powerful lever for strategic development of the territory and for the involved company [2]. In fact the territory sees a large induced economic rise, and companies, achieve their performance improving the ability of negotiation, especially in those countries where the importance of the National Oil Company is increasing. In fact, often projects of E&C companies, especially in the energy sector, are based in those countries of the developing world, where the creation of jobs, the growth of human capital and the ability to create business can be an effective tool for poverty reduction and for the achievement of the Millennium Development Goals set by the United Nation (MDGs) [3]. In fact, many international organizations like WTO and United Nations organizations recognize the need to increase the use of local manpower and supplies to promote development in poor countries. In addition, Oil&Gas projects are often conducted in areas with different risks, this is partly due to the concentration of energy resources in the world, located in areas with medium to high-risk country as shown in Figure 1.

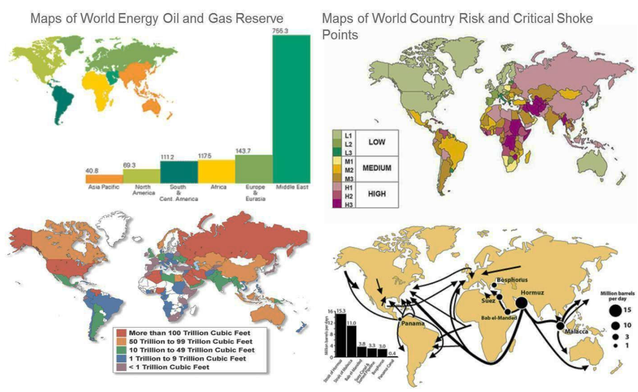

Figure 1 Comparison of the maps with the concentration of resources in the world (source: British Petroleum), the map of the world country risk of SACE and the map of oil transit through the four critical chokepoints of the World.

Moreover, many international organizations like Engineer Against Poverty and the Overseas Development Institute recognize that supporting local economic development by engaging local enterprises in the project

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supply chain can significantly reduce project social risk. In general, the strategies of local content can be divided into three types, ON-Project, LINK-Project and OFF-Project (not mutually exclusive), depending on how they are related or not to the project, as shown in the table 1.

Table 1 – Examples of Local Content Strategies: On, Off and Link-project [4]

On-Project	
Employment	Local Recruitment
Training	Prior training, on-the-job training, apprenticeships
Supplier support	Support to community suppliers to meet project quality standards
Local infrastructure	Project infrastructure utilised by local population
Institution strengthening	Project-driven interaction with local government agencies (e.g. for licences and permits) resulting in capacity strengthening
Project Link	
Employment	Inward-linkage – outreach recruitment programmes
	Outward linkage – enhancing post-project employment prospects, e.g. assisted job seeking
Training	Inward-linkage – outreach training programmes
	Outward linkage – training specifically to enhance post-project employment prospects
Supplier support	Inward-linkage – outreach enterprise support
	Outward linkage – supporting existing supplier's to access external markets, e.g. business plans, marketing surveys, interface with financial institutions, direct financial support, regulatory navigation, etc.
Local infrastructure	Aligning project infrastructure with government infrastructure development plans/policies and other investments
Institution strengthening	Project-driven interaction with local government agencies aligned with government or donor institutional capacity strengthening programmes
Off-project	
Employment	Job seeker service
Training	Technical and vocational training, alternative incomes training
Supplier support	Micro-enterprise business support and finance
Local infrastructure	Unilateral or PPP infrastructure projects unrelated to contract needs, but builds reputation of contractor with future clients and government
Institution strengthening	Support to local institutions to develop competencies and capacity

All of these strategies emphasize a feature of planning a complex project: the link between the development of the project and the development of the area and the local community [16], [17]. The development of the system formed by the project and the territory depends on company characteristics (i.e. know-how financial strength and operational capabilities), characteristics of the project (i.e. resources, time, complexity, environmental sustainability and characteristics of the area: availability of resources compatible with the project, social risk, fragile ecosystems, political risk, financial risk, etc) [5]. Figure 2 shows a kind of "osmosis" between the project and the territory, explicable in the confluence of the Project Development Plan and Territory Development Plan in a process of negotiation between the company and stakeholders to determine what actions will be taken to ensure a sustainable development of the project and the area. It is important to note that the result of this process will be a series of contracts between the company and the stakeholders involved, expression of ON, LINK and OFF-Project strategies.

Furthermore, by analysing those success factors for a project, also included by Project Management Institute in the PMBOK manual, alongside the traditional *success in the project management, success in achieving results, success in the contribution to business,* also *the success in the long term impact on the area,* a further demonstration of the link between the project development and the area where it is made [6].

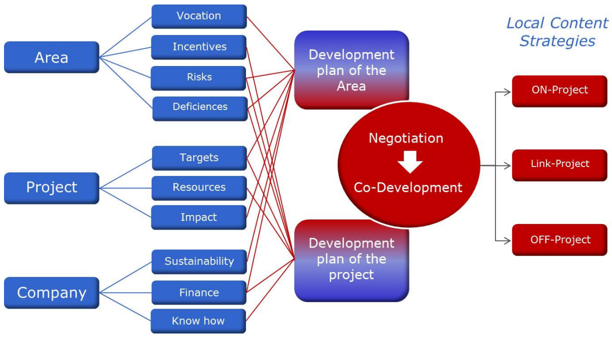

Figure 2 Link between the development of a project and that the Territory: CO-Development Strategies [E.Troncone]

It should be noted that these dimensions, however, are themselves interconnected, as will be explained in later sections, illustrating the causal knowledge map of the case study. It has to be pointed out that there are inhibiting factors in use of local resources [18]. While on the one hand, costs are often reduced, there are various other risks including the fact of not being able to find resources in line with company's standards, or enough competent and productive staff for the tasks required when compared to the standard company hours (or in terms of hours/kg) as shown in table 2.

Table 2 – Examples of Inhibiting factors [4]

Inhibiting Factors	Description
Policies and incentives	■ Existing procurement policies and procedures may be generally 'fit for purpose' for conventional project procurement but not be readily suitable for facilitating local enterprise contributions. ■ The benefits of maximizing the contribution of local enterprises may be realized at the corporate or strategic level e.g. through improved relations with the host government. However the immediate costs, effort and risks (see below) may be borne by those responsible for procuring goods and services at the project level.
Knowledge and skills	■ Personnel procuring goods and services may not necessarily be fully familiar with the local business environment and/or have experience with engaging local enterprises in low income country environments.
Cost	■ Initial transaction costs may be higher when engaging local enterprises. This may be perceived as a prohibitive barrier despite potential opportunities to realise cost savings in the longer term.
Time and management effort	■ Engaging local enterprises may require additional management time and effort in the initial instance.
Quality	■ Local enterprises may not readily meet the required quality standards or have the requisite quality management systems in place.
Risk management	■ Engage local enterprises may result in an increase in the actual or perceived risk associated with contracts – on cost, time and quality issues – as well as occupational health and safety (OHS) and environmental performance.
Established supplier relationships	■ Utilising established suppliers may be more attractive when faced with the additional initial effort and costs of identifying new local suppliers.

So, the problem appears to be strongly multidisciplinary and requires an approach capable of shedding light on the relationship between different aspects of the decision problem, namely: environmental sustainability, financial aspects, engineering aspects, and local management aspects (social, environmental, etc.). In order to properly balance a strategy it is necessary to study the effects of the project on the environment and of local variables on the project itself, and clearly highlight all items affecting in some way the financial results in order to successfully "design" a negotiation process and contracts.

This paper is further organized as follows. In the next paragraph the scenario analysis technique will be presented. Later the case study description will be presented. In the last paragraph some conclusions and future development of the study will be traced.

II. The Scenario Analysis as a Tool for Assessment and Support Planning and Decisions

Under the name of "Scenario Analysis" there are a series of analytical techniques for decision support, developed mainly after World War II. The Scenario Analysis supports the decision-making process under uncertainty, determining the possible futures, through the calculation of probabilities, and eventually studying the effect of alternative strategies and determining the best set of actions. So, the problem usually comes down to the calculation of the probability and eventually to an optimization problem of a suitably defined objective function[7].

In this context, a technique of considerable interest to strategic planning is the cross-impact analysis that considers the effects of actions available to decision makers and external events on the a priori probability given to a set of events. In general, the analysis starts by considering a scenario as a set of events, each of which presents some initial probability of occurrence. Then a strategy is defined i.e. a certain set of "set of actions", chosen among all those possible, each characterized by a cost or effort. In the cross-impact analysis both the effects of actions on events that events over other events are considered. Moreover, some variables are considered to check their value and effects (on events and other variables) and external events, which impact on the system but are not affected by any of the entities considered in the model. In particular for the case study we used a simulation software based on Cross-impact analysis developed by the Laboratory for Analysis and Models for Planning (LAMP), University of Sassari [8]. The software works according to the mechanism described in Figure 3.

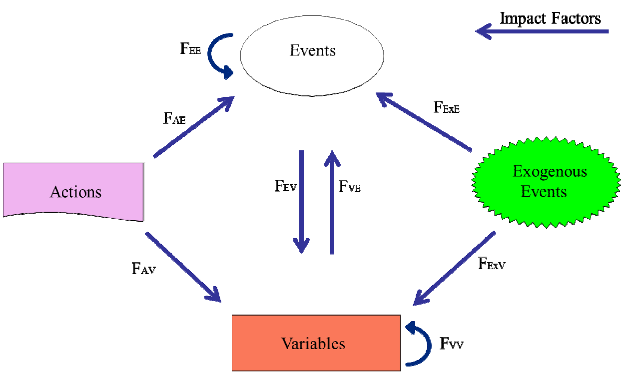

Figure 3: Relations between the entities of a model built with The Time Machine software based on Cross-Impact Analysis [9]

By splitting the system considered in actions, events, causal factors (i.e. variables) and exogenous events (i.e. external events and contingencies) it is first possible to build a causal knowledge map (or diagram of influence), expression of cause-effect relationships between the constituent entities of the system. Subsequently, given appropriate values to the entities, it is possible to perform the simulations using Monte Carlo method and then start an optimization algorithm. In particular, after building a plan for the various simulation runs, it is possible to verify variations of the initial probability of events with respect to the experimental probabilities, and changes of variables values. Clearly, if a strategy is effective with respect to a desirable event, it can be expected an increase in its experimental probability and vice versa for undesirable event. In the case study we will clarify the method to build the causal knowledge map. For a complete discussion on the operation of the simulation software, please refer to [9].

III. Case Study

The Karimun yard on the island which brings the same name in the Strait of Malacca in Indonesia, is one of the largest production site ever made by Saipem. Karimun yard is devoted to build products for the oil & gas industry, the FPSO integration, and, being this area chosen by Saipem as marine base, it gives a logistical support to Saipem vessels in service in the Far-east (see Figure 4).

Figure 4 Image of Karimun yard

Table 3 Key data of Karimun yard

YARD GENERAL INFORMATION KARIMUN ISLAND BASE		
Total area	sq.m	920,000
Fabrication area covered	sq.m	62,000
Fabrication area open	sq.m	200,000
Warehousing covered	sq.m	3,000
Warehousing open	sq.m	40,000
Blasting/painting area	sq.m	9,600
Assembly area	sq.m	200,000
Office area	sq.m	12,800
Skid ways	number	2
Closest port distance	km	0
Main international airport (Singapore)	hrs (road + ferry)	2
Freezone		yes

The construction of the facility began in 2008 and was completed in May 2011. It will be fully operational between 2013 and 2014. It is expected, which will operate Karimun between 2000 and 4000 local worker (Table 3).

The objective of the case study is to evaluate the investments in the local content in order to maximize the probability of all four dimensions of success (and off course of all desirable events) of a project and then generate the maximum benefit also on the territory. In particular, which strategy as mix of investments (ON, OFF or LINK to the project) to prefer, depending on the local context and the type of project considered. In our acceptation, an ON strategy is focused more on the project target, an OFF strategy is focused more on a territory development target and a LINK strategy is a mix of particular actions (i.e. investments) that has a strong connection with the project but at the same time it also meets the specific needs of the area (e.g. the construction of a road to improve the connection of the plant to the port that also connect a local village to the same port).

A. Application of the model using the software "The Time Machine"

The Saipem case study has some critical features:

1) The shipyard is located in an area characterized by different types of natural hazards, social and environmental factors, such as piracy in the strait, the occurrence of extreme natural phenomena, the risk of a medical emergency, etc.;

2) The Shipyard is a strategic production facility;

3) The construction of the shipyard and its subsequent implementation will help improve the economic and social aspirations of the area, generating a significant turnover, creating jobs and building a new local economy;

4) A critical issue is the management of sustainability policies;

5) An economic and financial perspective are desirable because of the importance of the investment [10].

To evaluate those optimal strategies and to test the organizational system's response to the effects of different types of scenarios a simulation model for scenario analysis was built following these steps:

1. Construction of Causal Knowledge Map;
2. Determination of value to be given to the model entities and relations of cause effect identified through online questionnaires and Knowledge Assessment;
3. Simulations using Monte Carlo method through a plan of the simulations for the scenarios should be constructed;
4. Starting an of optimization process through genetic algorithm, to seek the suboptimal best solutions (i.e. strategies) among the eligible ones;
5. Analysis of results and conclusions.

B. Causal-Knowledge Map development and building of the model for scenarios analysis

A Causal Knowledge Map has been developed as a point of convergence of corporate knowledge through several rounds of Knowledge Assessment (KA) with the departments involved in the project: QHSE, Sustainability, Logistics, Security, Legal, Fabrication Yard IROKM and Project Management of Karimun's yard. The map involves all actions to be taken by the company, including those related to local content (on, off and Links), events of interest (favourable or unfavourable), the variables to be monitored and the external events that affect the system, in a time interval of 5 years.

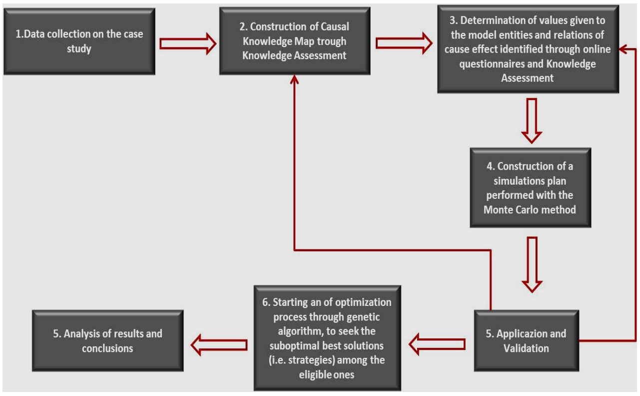

Figure 5 Phases of model identification and application

As shown in Figure 6, basing on unambiguous experts' judgement a map has been constructed starting from the known cause-effect relationships, and then the indirect ones were obtained. The starting point for this map is the four dimensions of project success as defined in the PMBOK [6].

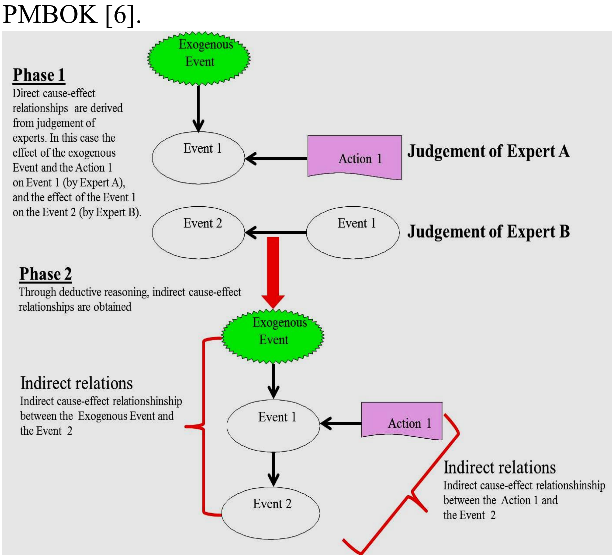

Figure 6 Construction of Causal Knowledge Map

Starting from the diagram in Figure 6 were derived those events (and exogenous events) variables and those actions that directly or indirectly influence the four dimensions of project's success, considered in as *desirable events*. The impact could be either positive or negative, depending on the effect they have on the event or variable. The result of this process is the complex map in Figure 8, consisting of 47 elements and over 130 cause-effect relations.

The cause-effect relationships between the entities and their numerical values were determined by direct knowledge of the problem by technical experts (experts' judgment) in various sessions of KA, or were derived from corporate materials, such as the "Sustainability Report" available on the company's website.

The graphical shape of the map is a circular chart, similar to a "causal loop diagram" used in system dynamics [12,13]. In fact, a complex project is a dynamic complex and adaptive system. It is important to note that all events converges to the "4 core events" defined by the four success dimensions shown in Figure 7. This point is of considerable interest since it facilitates the reading and evaluation of the final results obtained with the simulations.

To estimate the impact of factors that characterize the values of the cause-effect relationships, an online questionnaire has been used, where each question corresponds to the impact of a cause-effect relation [14].

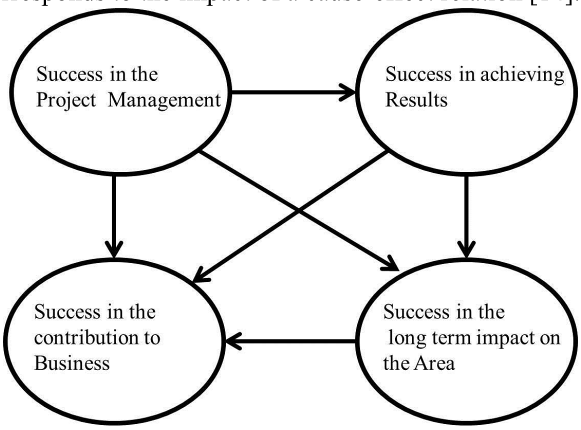

Figure 7 "Core Events": The four project success dimensions [11]

C. Simulation settings and results

Use To test the system response with respect to critical scenarios and evaluate different types of strategies (on, off, link), a table has been developed with different combinations of external events to perform simulations using Monte Carlo method [15].

Seven scenarios have been simulated (Table 4):

- Scenario 1: Exposure to local and national risk factors;
- Scenario 2: international risk factors;
- Scenario 3: risk factors related to the external supply chain
- Scenario 4: scenario 3 plus change in specifications by the client;
- Scenario 5: risk factors related to the occurrence of natural phenomena;
- Scenario 6: scenario 5 plus Epidemic event;
- Scenario 7: international embargo.

It should be noted that simulation results from scenario 7 have been used also as a validation procedure of the simulation model, being well-known the effects produced by such an event. Anyhow it could be necessary to go deeply in this aspect with further studies.

Table 4: Scenarios Setting

EXOGENOUS EVENTS	SCENARIO 1 Exposure to local and national risk factors	SCENARIO 2 Exposure to international risk factors	SCENARIO 3 Exposure to risk factors related to the external supply chain	SCENARIO 4 sc.3 plus change in specifications by the client	SCENARIO 5 risk factors related to the occurrence of natural phenomena	SCENARIO 6 sc.5 plus Epidemic event	SCENARIO 7 international embargo	All Ex.Ev. except embargo	No actions and OFAT simulations
.Pol.Count.ris	x							x	x
Fin.Count.Risk	x							x	x
Fin.Crisis		x						x	x
€:$		x						x	x
Oil.Dem Inc.		x						x	x
Mark.Dem.Dec.		x						x	x
Commitent.				x				x	x
Int.Transp			x	x				x	x
Piracy			x	x				x	x
Earthquake			x	x	x	x		x	x
Tsunami			x	x	x	x		x	x
Epidemic Event.						x		x	x
ExtremeWeather condition					x	x		x	x
Embar.							x		

Moreover, others simulation runs have been performed, in particular an OFAT (One Factor at Time) simulation plan to test the sensitivity of the system to any single factor; a free evolution of the system and one with all the factors not active. In the following, for the sake of brevity we report the results only for the free evolution of the system.

By setting an optimization problem is then possible to determine which sub-optimal strategies (combinations of actions) best meet the set criteria.

The free simulation was carried out by letting the system evolve in a free manner (all the factors active with their initial probability). From the graph in Figure 9, it can be argued that the system is fairly robust under the effect of exogenous factors. This is confirmed by observing the "4 core events" probabilities that are all increased if contrasted with the initial values.

It also must be noted an increase in the probability of failure to comply with budget and the likelihood of increased cost of materials.

The values of variables measuring sustainability are increased, because over a period of 5 years the site should be completed and the production started, leading to an increase of land use, emissions of pollutants, etc. (Figure 10).

Nevertheless, with respect to the given objectives, this did not significantly compromise the overall sustainability of the project. Also because this effect is mitigated by investing in QHSE as shown in figure 10 where the direct effect of actions on events and variables is depicted.

It should be noted that an increase in probability of health emergencies could be observed, so a further study of this issue in relation to the area considered could be suggested. In the scenario analysed, changes in economic and financial events could occur and a lowering of time compliance probability. This is due to the strict relation between work on time, quality standard respect and financial effect in this kind of business. After analysing all scenarios, the system shows to be stable to external events. After the simulations it was set a optimization procedure based on a genetic algorithm.

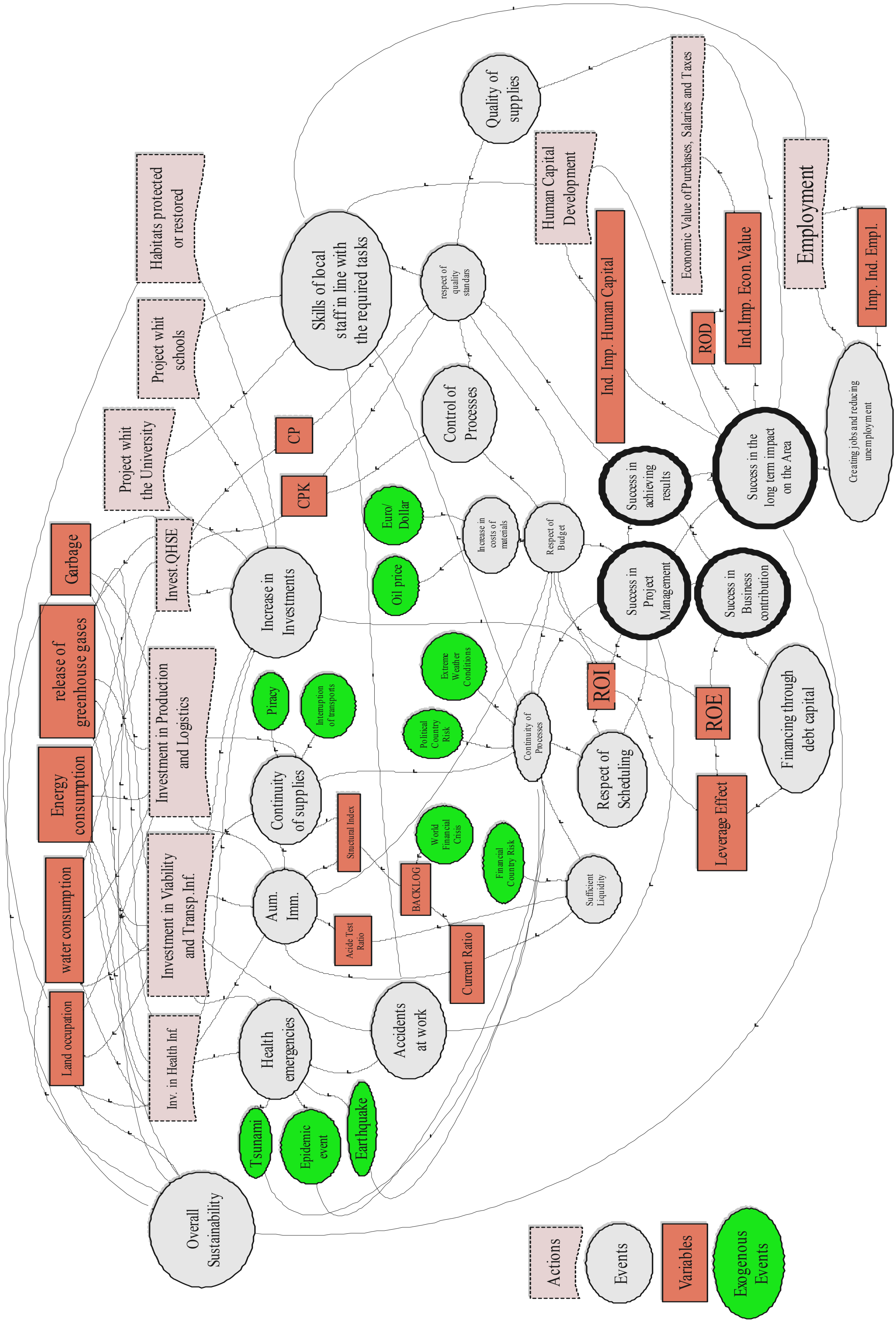

Figure 8 Causal Knowledge Map of Karimun's Project

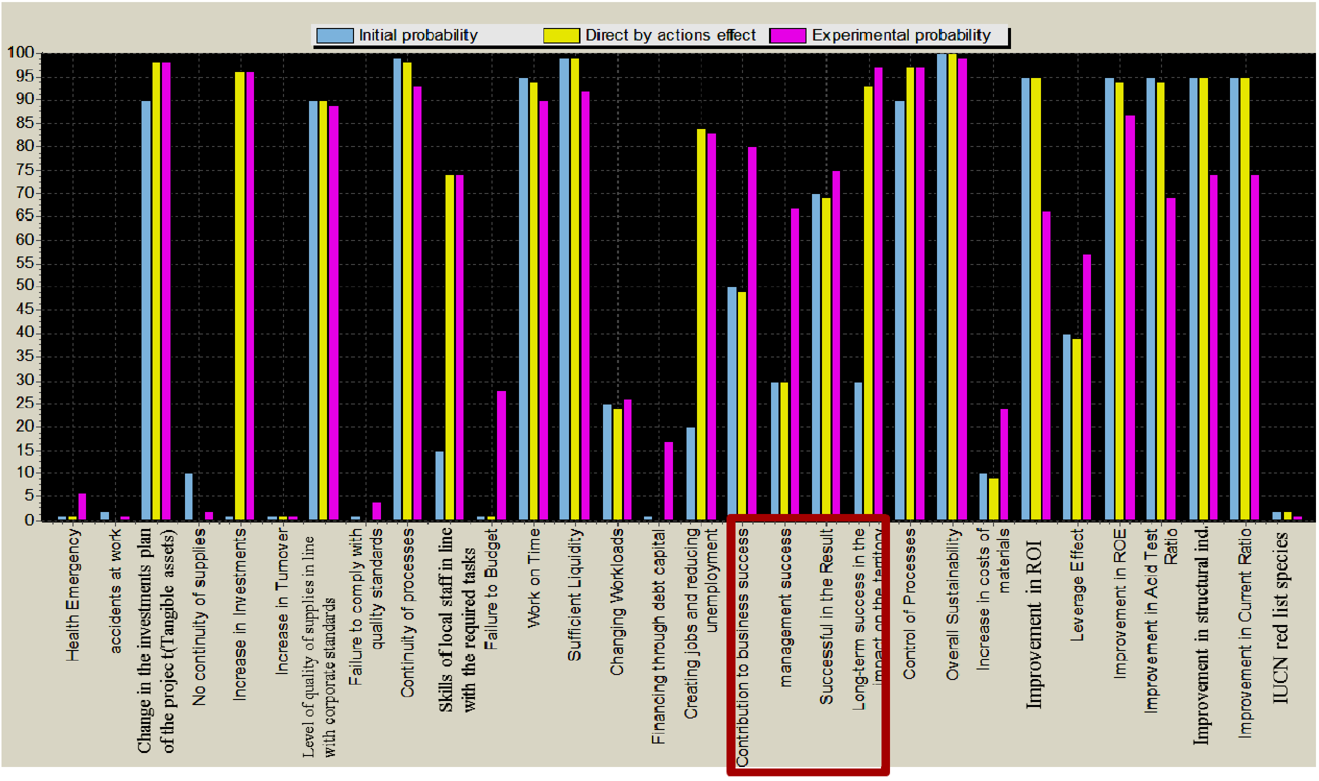

Figure 9 Simulation results for the free evolution of the system

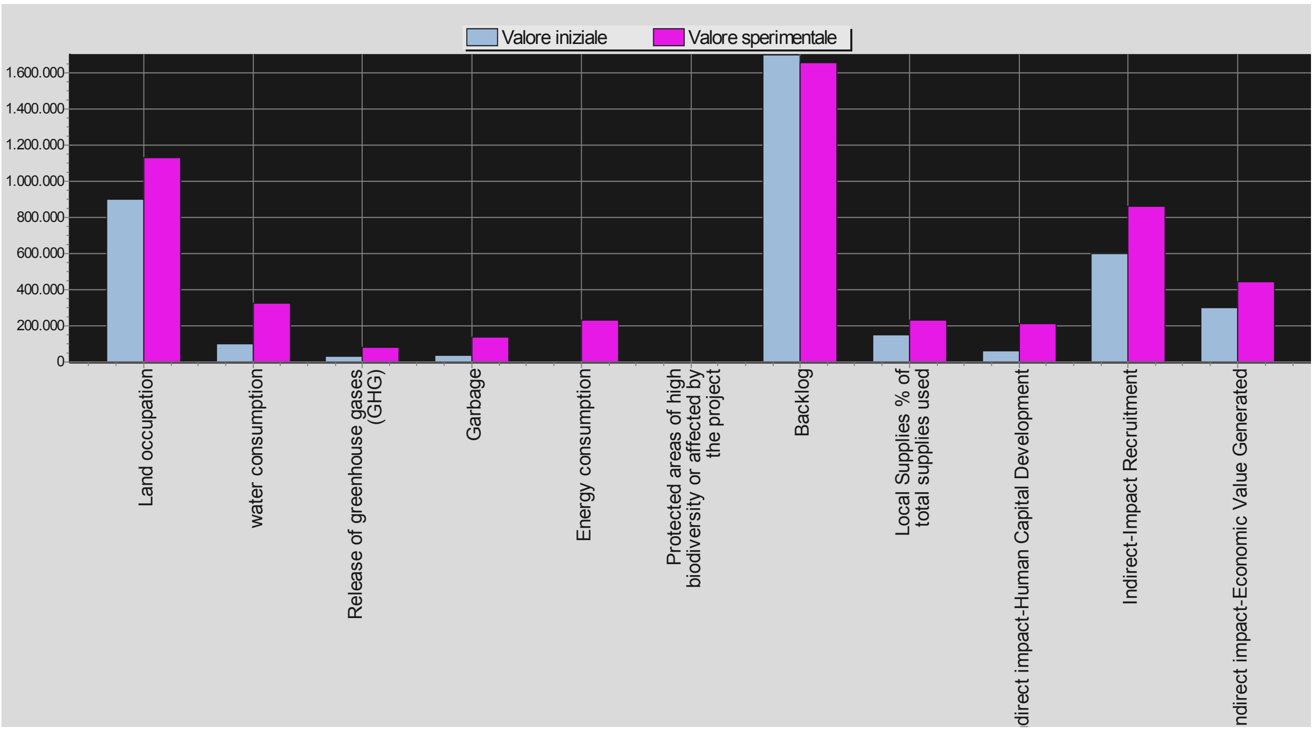

Figure 10 Variable Values in the free evolution simulation (blue: Initial Value, violet: Experimental Value)

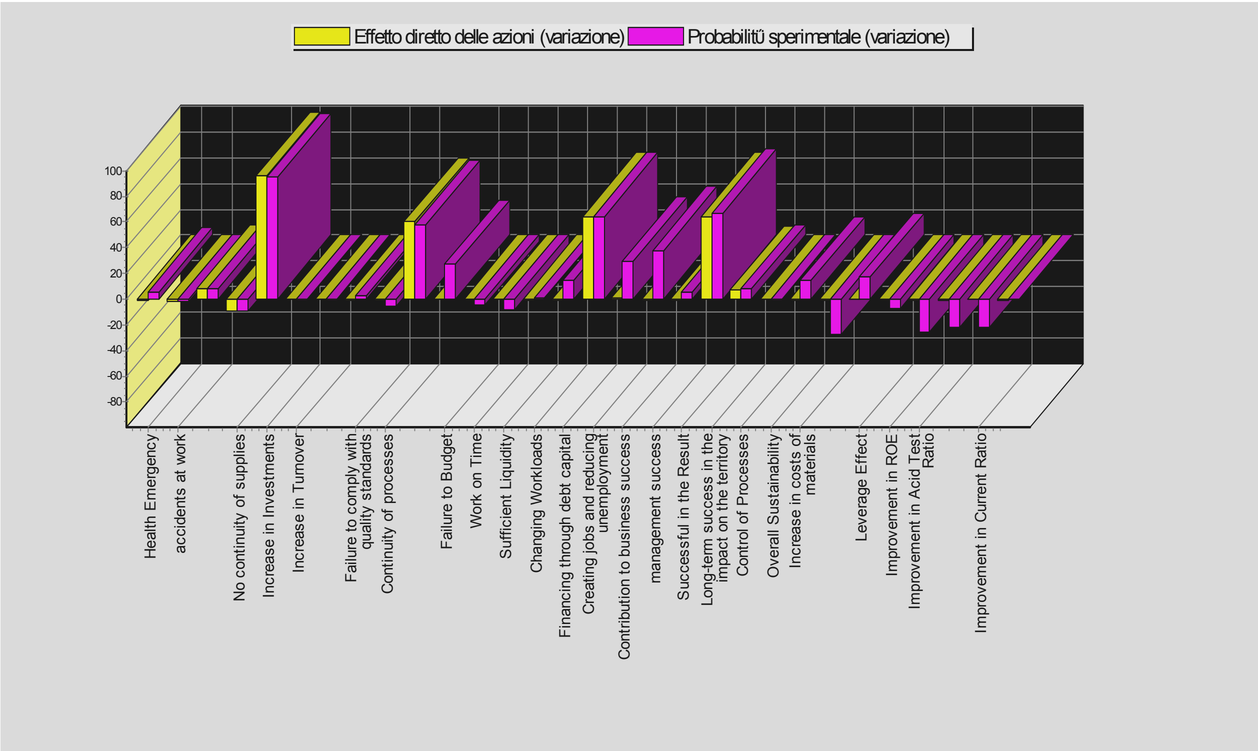

Figure 11 Effect of actions on events to the free evolution simulation (yellow: direct actions effect, violet: probability

IV. Conclusion and Future Development

This study shows a strong potential capacity for the company to complete successfully a complex project in a critical scenario, exploiting and properly balancing the levers of local content.

Moreover, a decision support system as the one considered, through a classification of the events in "desirable" and "undesirable", allows to set a optimization procedure considering a minimization of experimental probability of undesirable events, a maximizing of the experimental probability of desirable events, a minimizing of total cost.

The research of solutions through the sub-optimal genetic algorithm, produced a predominance of ON and LINK strategies, compared to those with predominance of actions related to the growth of human capital through training, accompanied by habitat restoration as shown in Table 5.

So, such evaluation leads to prefer a long-term and business-oriented vision choosing those strategies intended to create benefits for the area and for the project: an efficient managing of the project, avoiding environmental and safety issues and generating an induced economy. Organization and territory should establish a partnership for mutual development.

Moreover such a tool could offer suggestions about critical issue to analyse deeply. In particular, despite the company's effort in efficiently managing a complex project, the simulation runs suggest to investigate some aspects related to local risk factors emerged, such as piracy or risk of health emergencies and the need for careful and continuously monitoring of project's sustainability.

Moreover, a decision support tool in the negotiation process for the understanding and definition of mutual requirements and the elaboration of joint LC strategies, facilitates the negotiation process itself. A further application of Cross-Impact Analysis could affect specific aspects of QHSE and sustainability in general.

Table 5: Best Suboptimal Strategies

BEST SUB-OBTIMAL STRATEGIES	ACTIVE ACTONS
1°	Employment (Recruiting of local workers) Increase in purchases, taxes and salaries
2°	Employment (Recruiting of local workers) Human Capital Development
3°	Employment (Recruiting of local workers) Human Capital Development Increase in purchases, salaries and taxes
4°	Employment (Recruiting of local workers); Investments for the quality of life of workers; Human Capital Development
5°	Employment (recruiting of local workers) Habitat protected or restored
6°	Projects whit school; Projects whit University; Habitat protected or restored; Increase in purchases, salaries and taxes;
7°	QHSE actions Human Capital Development Employment

An interesting observation is about the causal knowledge diagram obtained, because is similar to a causal loop diagram of system dynamic: this suggest to compare a Large Engineering Project and its relation with a territory as a Complex System. In particular, considering events and variables, we could transform the diagram in a stock and flow system and laying the foundation for a control system which allows to calibrate the actions (and therefore the strategies) over time, in consideration of the effects achieved through a feedback mechanism as shown in figure 12.

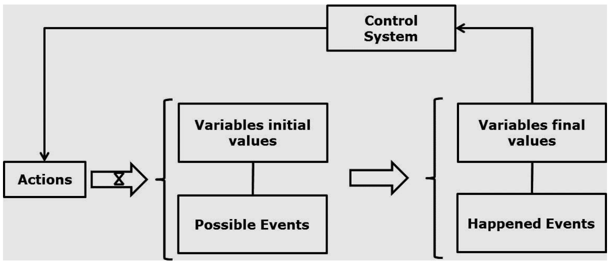

Figure 12 Complex Project as Dynamic System

It should be emphasized that decision support techniques are useful in planning a complex technological system, where low understanding of reality or errors, even apparently minimal, could cause massive damage, especially considering issues related to QHSE. On the other hand the "design" of decision-making process supported by tools like The Time Machine, may allow the identification of organizational synergies that benefit both the company and the territory involved in the project.

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