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Abstract: Extractive companies have dramatic impacts on the host countries in which they operate. Those impacts can affect their image. Consequently, concerns about sustainability and local industrial development have been growing up. Companies developed sustainable strategies in order to enhance the positive effects of their presence. Nevertheless, a problem arises in regards to the evaluation of those effects. Indeed, the complexity induced by the interrelationship and interrelation of the different elements of the host countries makes difficult an overall understanding of the impacts. We propose a Domain Mapping Matrix (DMM) approach to better understand the effects of strategies on the host countries and build their assessment. An implementation on several scenarios is proposed. It allows to deduce implications and perspectives within the decision aiding process for choosing among strategies.

Keywords: Sustainable Development. Domain Mapping Matrix, Decision-aiding Process, Value Modeling, Project Management

1 Introduction

Extractive industries usually generated risks of negative impacts on their operation areas (Hennchen 2014; Frankel 2012). As a consequence, local governments have put more and more pressure on them by drastically increase their objectives in terms of local development (Tordo et al. 2013). These companies reacted by trying to align their strategies with host countries requirements (Ngoasong 2014), with actions not directly related to the development project. A strategy is characterized as a set of actions that generate impacts, on all dimensions of sustainable development, respectively economic, societal and environmental, positive or negative, temporary or sustainable, with immediate or long term effects. The selection of such a strategy is thus a negotiation between two main stakeholders, the host country (through one or more representatives) and the International Oil & Gas Company (IOC). They may have common or antinomic objectives, with different weights and satisfaction thresholds.

Nevertheless, experience showed that results were not as good as expected (Hammann 2016; Ovadia 2013). Thus, actors tried to understand how to make better decisions, for instance by structuring the decision-making process, or by developing value modeling techniques, with an extensive literature on sustainable indicators (e.g Anglo American 2012; Uhlmann et al. 2014; Horsley et al. 2015; Azapagic 2004). Under this perspective, this paper provides a decision-aiding process based on a capital-based approach, for modeling value and impacts of strategies, and a DMM-based approach, for connecting strategies alternatives and stakeholders' satisfaction.

The remainder of the paper is as follows. Section 2 introduces some work related to these topics. Section 3 describes the DMM-based approach to assess sustainable strategies. Section 4 describes an example of assessment of different scenarios in the Oil & Gas context. Finally, Section 5 outlines the contributions of the methodology and some perspectives for further work.

2 Related work and proposed approach

Since we aim at assisting selection of a strategy for bringing sustainable value to host countries, this Section starts with literature about decision-aiding processes. Then, DMM-based literature is briefly introduced since it is our choice for modeling the impacts of strategies on stakeholders' satisfaction.

2.1 Selecting a decision-aiding process

The objectives are to estimate the values brought to the host country by different sustainable strategies and make a recommendation for a decision board. Those recommendations ought to be aligned with the long term vision of the International Oil & Gas Company (IOC) and the local government. Nevertheless, our observations on the field showed the shortcomings of past projects concerning the choice of a strategy. (Ovadia 2013) confirms those observations. He explains that the choices undertaken did not take into account all the objectives of the host country - the selected strategies favored a minority share of the population. Similarly, (Hammann 2016) stresses the need for a better coherence of the strategies formulated with regard to increasing social expectations. There is therefore a mismatch between strategies formulated and initial objectives. This can be explained by inadequacies in the formulation of the problem (Bouyssou & al.; Simon 1960). To fill this gap, many decision-making processes have been elaborated in the literature (Schwenk 1984).

Our proposal is inspired by (Tsoukiàs 2007). The following 4-step decision-aiding process is presented hereunder:

- Formulate the decision problem;
- Identify and characterize criteria;
- Identify and estimate alternatives;
- Evaluate alternatives among criteria to make a choice.

This article focuses on the first 3 steps of the process, in which we estimate the impacts of strategies alternatives on stakeholders' satisfaction. Evaluation and final selection are out of the scope of this paper. The next paragraph describes the methodological choice of DMM for connecting alternatives and criteria.

2.2 The modeling approach: using DMMs for modeling impacts of strategies on stakeholders' satisfaction

Creating value in a host country turns out to be difficult. Objectives, capitals, stakeholders, values exchanged and actions are diverse and interrelated. Then, extractive industries face a complex problem. They have difficulties to overcome major hurdles as mastering the amount of information in order to assess their impact and improve their contribution to the host country.

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In order to address these complexity-related issues, many areas have used the Dependency and Structure Modeling (DSM) approach (Eppinger & Browning 2012). It gives a clear picture of the complexity of a system and have the advantages of simplicity and operability. More precisely, Domain Mapping Matrices (DMM) have been used to characterize relationship between heterogeneous elements (e.g Jankovic et al. 2012; Siyam et al. 2012; Tehrani et al. 2014; Browning 2016). They are particularly suited in our context where relationships between different elements have to be modeled. The aim is to establish link between *strategies* alternatives, made of *actions*, which have *impacts* on *capitals*. These *capitals* contribute more or less to *objectives* which are more or less important to *stakeholders*. As a consequence we propose the following process (Figure 1).
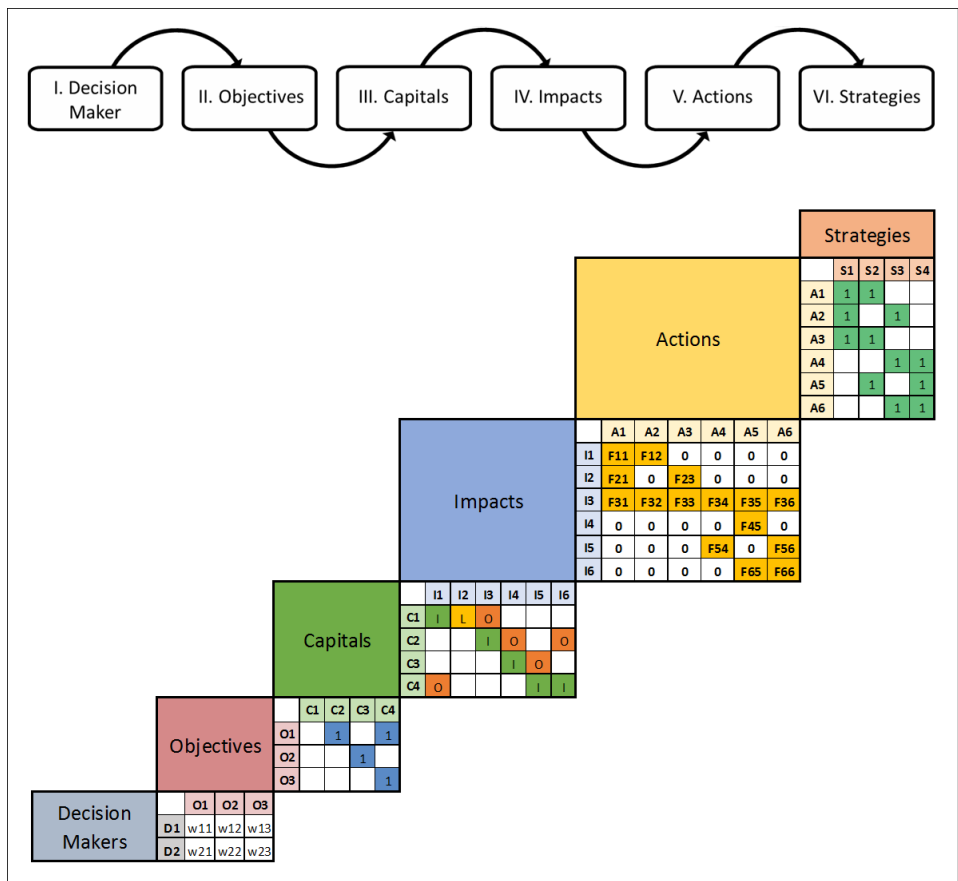

Figure 1: Using DMM matrices to link strategies.to stakeholders' satisfaction

The construction of the DMM is realized in two parts. Firstly, it links stakeholders' interest with the desired impacts. Secondly, it models the impacts realized by a strategy. These parts will be respectively detailed in Sections 3 and 4.

3 Modeling stakeholders' satisfaction through a capital-based approach

To estimate the impacts of a strategy on stakeholders' satisfaction, the sustainable value brought by a project to a host country has been defined in (Dernis et al. 2017). A list of attributes of sustainable value has been developed. From this, a systemic vision was adopted. The host country was considered as a system of interdependent elements whose interactions must be taken into account. The concept of capitals (Kulig et al. 2010) has been chosen in order to connect stakeholders' objectives and strategies impacts. Some references use modeling of values as multi-criteria flows between capitals (Meadows 1998; Feng et al. 2010; Cameron 2007). Finally, the value created to a host country can be modelled with flows between capitals.

A frequency analysis proved the consistency of the approach. It consisted in classifying 8130 sustainable indicators from 293 articles selected among 1734 references from the Web of Science. We extracted all the articles that had a capital approach in addition to those from our exploratory literature review (among them (Ekins & Medhurst 2006; Meadows 1998; Maack & Davidsdottir 2015; Freebairn & King 2003)). A list of standard capitals has thus been drawn up grouped under five major families: natural, social, human, industrial and financial capital. The classification aimed at sorting the 8130 indicators as flows between capitals or as stock of capitals. Only a 7.08% of the sample of indicators could not be classified. Given the low percentage of indicators rejected, the modeling of created value with flow between capitals was considered consistent.

The strategies create or modify value flows between capitals. Three matrices can be used to model the relationship between strategies impacts and stakeholders' satisfaction (figure 2).
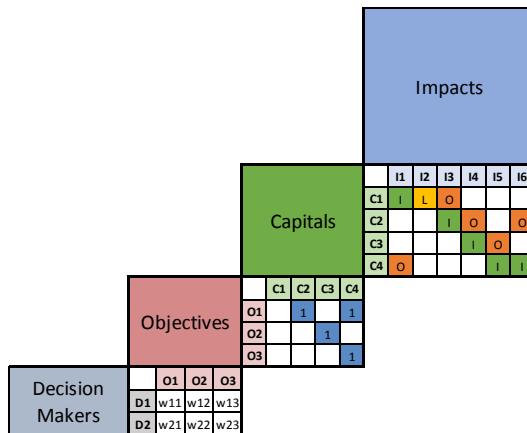

Figure 2: Impacts of a strategy in terms of stakeholders' satisfaction

Decision-makers put weights on objectives (Matrix Decision-Makers / Objectives). Those are represented with coefficients w_{ij}. The coefficient OC_{ij} of the Matrix Objectives / Capitals are binary numbers. $OC_{ij}=1$ means that contributions to capital j respond to objective i. Matrix Impact/ Capitals (IC_{ij}) aims at modeling the flows between capitals. This is done through an incidence matrix. $IC_{ij}= O$ ($/IC_{ij}= I$) means that

the impact i is an output (/ input) flow of (/to) the capital j. If an impact i is a loop flow from a capital j to itself then $IC_{ij} = L$

However, it is difficult to link strategies alternatives to final satisfaction of stakeholders involved in the decision-making process. The next paragraph proposes to use a DMM-based approach to assist identification and estimation of alternatives and their impacts on capitals, objectives and thus stakeholders' satisfaction.

4 Modeling the impacts of strategies

A strategy is a set of actions that generate multiple impacts, which can be displayed and managed using two matrices, with the representation advantage of matrix format compared to graph when things become complex (Figures 3 and 4). The first matrix actions/strategies represents the membership or not of an action to a strategy, while the second matrix, impacts/actions, quantifies the degree of impact of a given action.
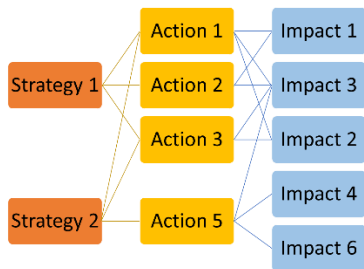

Figure 3: Impacts of a strategy

Figure 4: Matrices Actions/Impacts and Strategies/Action

The coefficient SA_{ij} of the Matrix Strategies / Actions are binary numbers. $SA_{ij} = 1$ means that the action j belongs to the strategy i. The matrix Impact / Actions (IA_{ij}) is filled with the quantification of the impacts i generated by the action j. Scales are numerical to measure impacts. These scales vary according to the type of impact. The aggregations of values depend on the latter. They can be a sum, a max function or something else.

Once the matrices has been built, they can be used to model the impacts of a sustainable strategy (Figure 5).
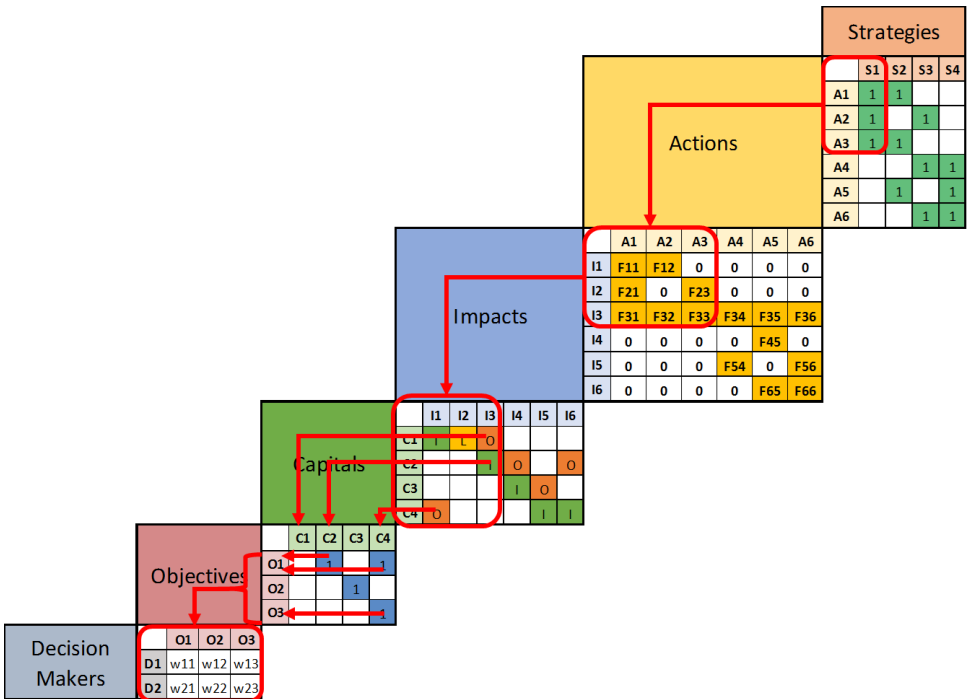
Figure 5: Estimation of the effect of strategy 1 (left), using the DMMs (right)

The example shows that the approach allows to estimate the impacts of a strategy alternative, by highlighting impacts of the actions this strategy is made of, then relating these impacts to capitals, objectives and finally stakeholders. For example, the figure 5 illustrates the effects of strategy 1. This strategy is composed of actions A1, A2 and A3 (matrix Strategies/Actions). Those actions have three impacts I1, I2 and I3 (matrix Actions/Impacts). Matrix Impacts/Capital shows the capitals affected by the impacts. For example, the impact I1 affects a flow from the capital C4 to the capital C1. Impact I2 have an effect on a loop flow on capital C1. As the impacts I1, I2 and I3 do not affect capital C3, the strategy does not have effect on objective O2 (as shown in the matrix Capitals/Objectives). This have the consequence that the strategy will have no effect on the satisfaction of decision makers D1 and D2 on preference components respectively weighted w12 and w22 (matrix Deciders/Objectives).

In order to test the operability of the model, a case study is proposed in the next paragraph.

5 An illustrative example

To illustrate our proposal, we use a fictitious example. We were not able to use real cases due to the lack of full data availability. In this way we have used project data and extrapolated them.

5.1 Data

The case study consists in the estimation of different sustainable strategies in the Oil & Gas sector during the development of the installations. These strategies are composed of training actions, the use of local labor as well as the local development of power generation. A description of the different strategies is given in Table 1.

Table 1: Description of the strategies;

	Local production		Human Capital Enhancement			Power supply
	Adapted to the local capacity	Above the local capacity	Minimum Case	Medium Case	Maximum Case	
Strategy 1	Yes		Yes			
Strategy 2	Yes			Yes		
Strategy 3	Yes		Yes			Yes
Strategy 4	Yes			Yes		Yes
Strategy 5		Yes	Yes			
Strategy 6		Yes		Yes		
Strategy 7		Yes			Yes	

5.2 Results

sThe application of the methodology to the different scenario was realized. The matrices are given below:
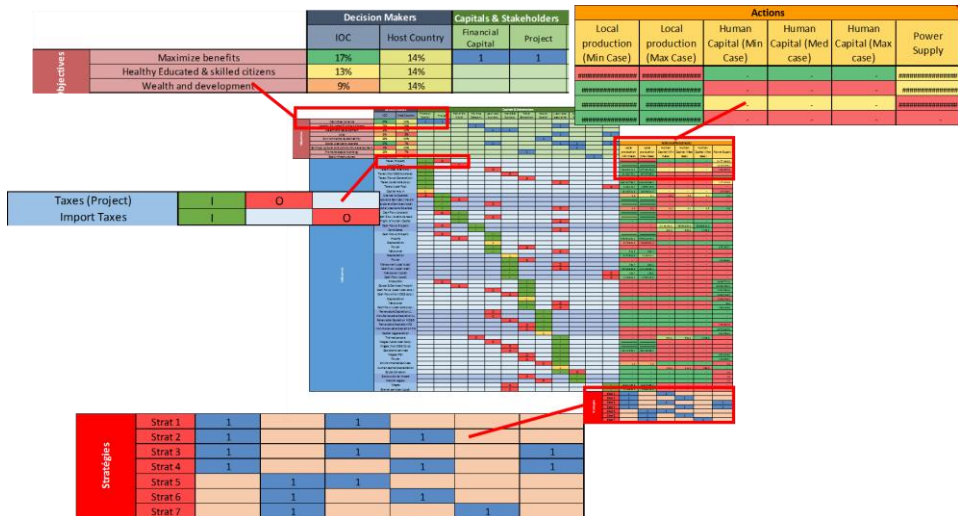

Figure 6: Application on the case study

The construction of the matrices allowed to model the exchanged values in the host country (on the top left hand corner of figure 7). We then have the opportunity to have an estimation of different strategies. We give 3 examples of them in figure 7.

On the bottom left hand corner strategy 4 is estimated. On the right hand-side strategies 2 and 7 are estimated. Flows are modelled with arrows. Their thickness is correlated with the magnitude of the impact. Negative (/positive) flows are shown in red (/green).
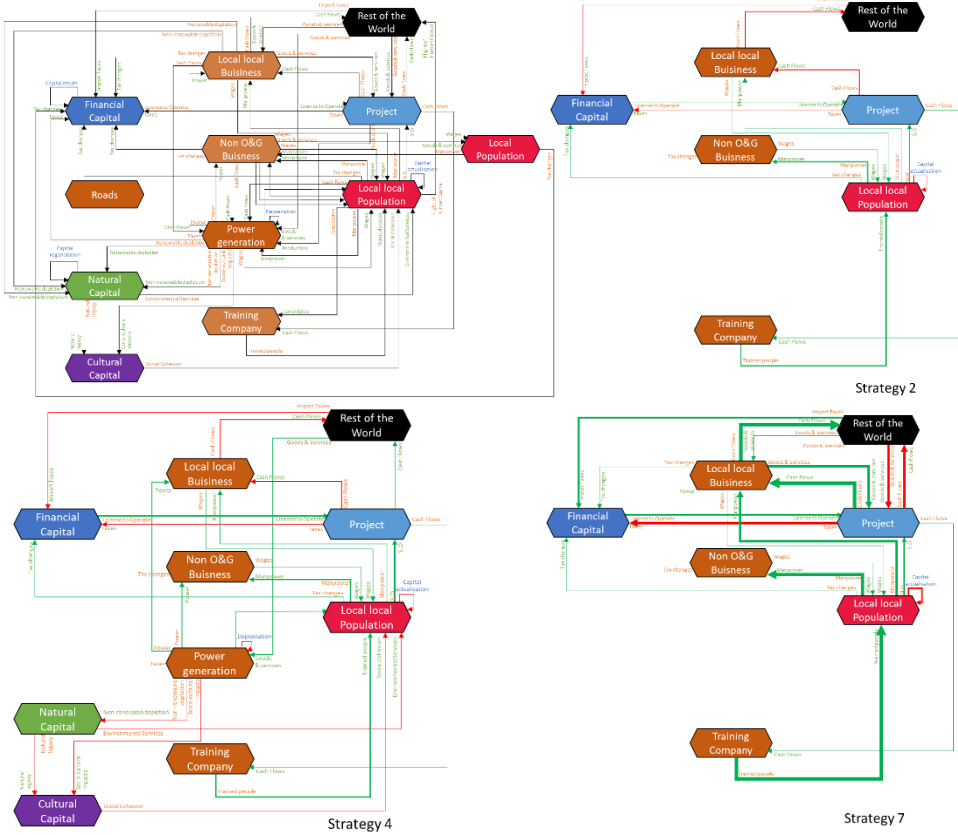

Figure 7: Modelling and estimation of the values brought to the host country.

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5.3 Discussion

Using our approach, we spotted some operational benefits. First, our approach helps to better understand and identify key components in value creation, which are flows between capitals in order to hopefully make them better for local beneficiaries. Second, by linking objectives to strategies through a chain of DMMs, an alignment with stakeholders' expectations is foreseeable. For example, our approach showed that some alternatives of strategies were forgetting some of the host country's objectives. Third, using an indicators database with a capital-based approach, we succeeded to take into account different scales for the decision problem (local development of the neighborhood of the installation versus global development of the country, short term versus long term). Moreover, it showed that usual KPIs in the O&G industry do not allow to account for the whole problem.

6 Conclusion and perspectives

Two theoretical proposals were presented in this paper: a decision-aiding process and a modeling of sustainable values brought to host countries. The use of DMM approach allowed to link the different elements involved in this decision. Moreover, it contributed to an industrial operationalization, through the user-friendliness of spreadsheet-based tools.

This article only concerned the first parts of the decision-making process. Further developments are required. Indeed, as the different estimates of the strategies in figure 7 show, making recommendations on different strategies is not an easy task. Estimations are given in the form of networks. This moves away from usual paradigms in multi-criteria decision aid. This have implications for the fourth part of the decision process. Many methodologies exist in the literature (Pahl et Beitz 1996; Bouyssou et al. 2005). An on-going development, not in the scope of this paper, proposes the use of two multicriteria aggregation methods to solve this problem.

Two limitations call for further development. Firstly, our approach does not take into account the dynamic aspects and relationships between the impacts. Secondly, the database stem from the literature. However, some aspects of the literature about indicators are still moving. For example, a lot of social aspects are currently in development (Stiglitz et al. 2008), which means that a regular update of this database will have to be done while the literature gets richer.

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