Decision-making process and feasibility study

Economic evaluation of industrial projects

Typical industrial projects

- Development and production of products/services
- Substantial modification of a process (improvement measures)
- Acquisition of a *capital asset* (*capital equipment*).
- A capital asset (or *fixed asset*) is an asset that
  - contributes (directly or indirectly) to the production
  - has a *useful life* of more than one year
  - has medium- to long-term effects
  - absorbs many resources.

- The acquisition of a capital asset must consider:
  - the investment costs (or *Capital Expenditures* – CAPEX)
  - the operating (≅ running) costs (or *Operational Expenditures* – OPEX)
  - the effects (positive and negative) on the system in which it is embedded (e.g., increased capacity).
- Asset acquisition and management includes several stages:
  - preliminary analysis and evaluation (for example, *feasibility study*)
  - selection, negotiation and contract definition
  - supply, installation and testing
  - operation, management, in-service support.

Types of energy efficiency measures

- Projects for energy management can include the following measures:
  - management measures (supervision, awareness, training, information...)
  - methods of energy generation and conversion (e.g. photovoltaic systems, cogeneration plants)
  - improvement measures on the distribution network (application of transformers, automatic switching on and off devices, etc.)
  - interventions on the way energy is used by processes (e.g. reusing waste heat from ovens, exhaust gases, or hot process streams to preheat air, water, or materials elsewhere in the plant)
  - replacement of energy users within the system with more efficient users
  - maintenance methods that reduce energy consumption.

Actors in the decision-making process

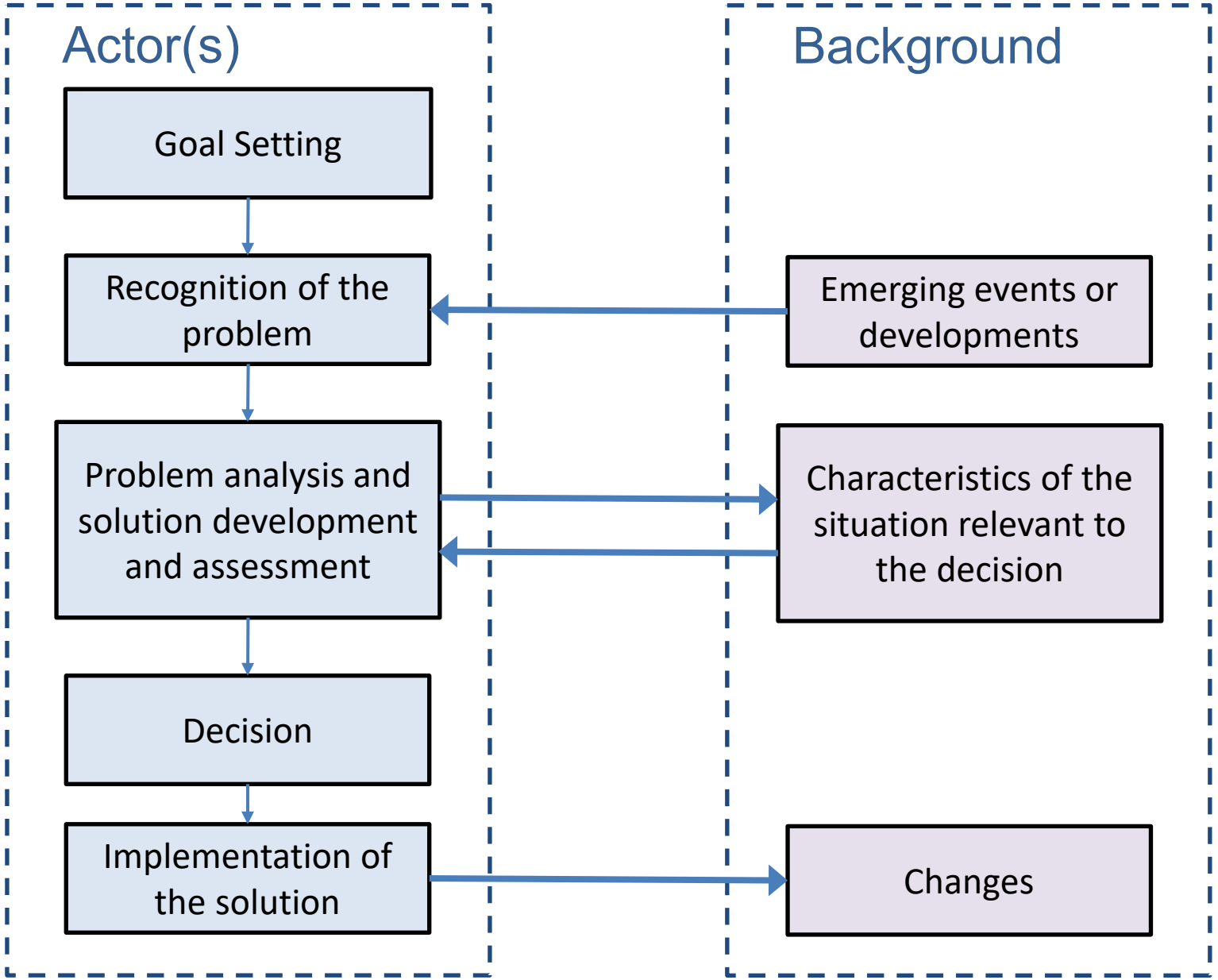
- Actor (of the process):

  a subject who directly or indirectly influences the decision process.
- Each actor is characterized by three classes of systems:
  - value system (underlies *value judgments*)
  - information system
  - relational system.

- Categories of actors:
  - decision maker (DM)
  - client (of the evaluation study)
  - *stakeholder*
  - analyst
  - facilitator/negotiator
  - source of information
  - expert.
- A real actor can belong to more than one category.

Problem ↔ project

- A project is activated in response to a *threat* or to seize *an opportunity*.
- A *problem* requires a response when a significant difference is perceived between the *current* and the *desired state*.
- In an organization, such conditions may arise:
  - from the perception of a decline in performance, even potential, due to internal or external factors (*threats*); this may result in failure to achieve objectives
  - by the perception that goals could be achieved more effectively (*opportunity*).


Actor(s)
Goal Setting
Recognition of the problem
Problem analysis and solution development and assessment
Decision
Implementation of the solution
Background
Emerging events or developments
Characteristics of the situation relevant to the decision
Changes

Rational decisions

- *Rational choice theory* makes the hypothesis that an individual or community has the ability to
  - search for different ways of acting (actions or solutions) on the problem
  - express preferences with respect to them.
- An action is then rational if it produces effects that benefit the well-being of the stakeholders.

- The actions analysed and discussed in the decision-making process are identified and evaluated based on their expected effects.
- The effects are evaluated in terms of the DM's preferences.
- Therefore, alternative actions are evaluated by comparing how effectively their outcomes align with the DM's preferences*.

(*March, J. G. 1994. Primer on decision making: How decisions happen. Free Press)

Used terminology

- A *decision problem* arises if
  - there is an intent to address the problem
  - there are *several ways* to deal with it.
- The *definition* (formulation) of the decision problem is an initial construct of the decision-making process.

- The term “attribute” is used to indicate a characteristic of actions or alternatives.
- That is, it indicates a *property* of the action that is considered in the evaluation: there may be other features of an action which are not judged useful or noteworthy in the context of the specific decision problem.
- An attribute could be associated with a *measure* (or *metric*) or *indicator*.

- Unlike objectives or goals, attributes are not generic but require a clear operational definition.
- Some examples:

Objective	Attribute
minimize maintenance costs	average hourly cost of the intervention (€)
reduce energy consumption in the production facility	yearly average of used energy (MWh/y)
increase staff training on the technologies employed	training hours per year devoted to technology training

- The term “criterion” will be used to link the characteristics of actions to the DM’s preferences.

Decision-making process

- In a simplified view, the decision-making process consists of a series of activities performed in a linear sequence.
- The very logic of setting up the process in a “planned” way derives from *normative* rational choice theories.
- The *normative* approach studies what rules and procedures a rational decision maker must follow to make the best decision in a context of rational agents.

- The idea behind the normative approach is related to the concept of the “optimal” decision:
  the solution that *maximizes the advantage* or *minimizes the disadvantage* will be adopted.
- This assumes that:
  - the decision maker acts *rationally*
  - access to information is *complete*
  - the solutions can be fully defined with respect to the effects of interest
  - uncertainty can be modelled by quantitative methods.

- From the study of the actual behaviour that actors (individually or collectively) enact in practice to make decisions, several *descriptive theories* of decision-making processes have developed.
- Based on the results of these studies, Herbert Simon introduced the concept of *bounded rationality** in contrast to the concept of perfect rationality of normative theories.

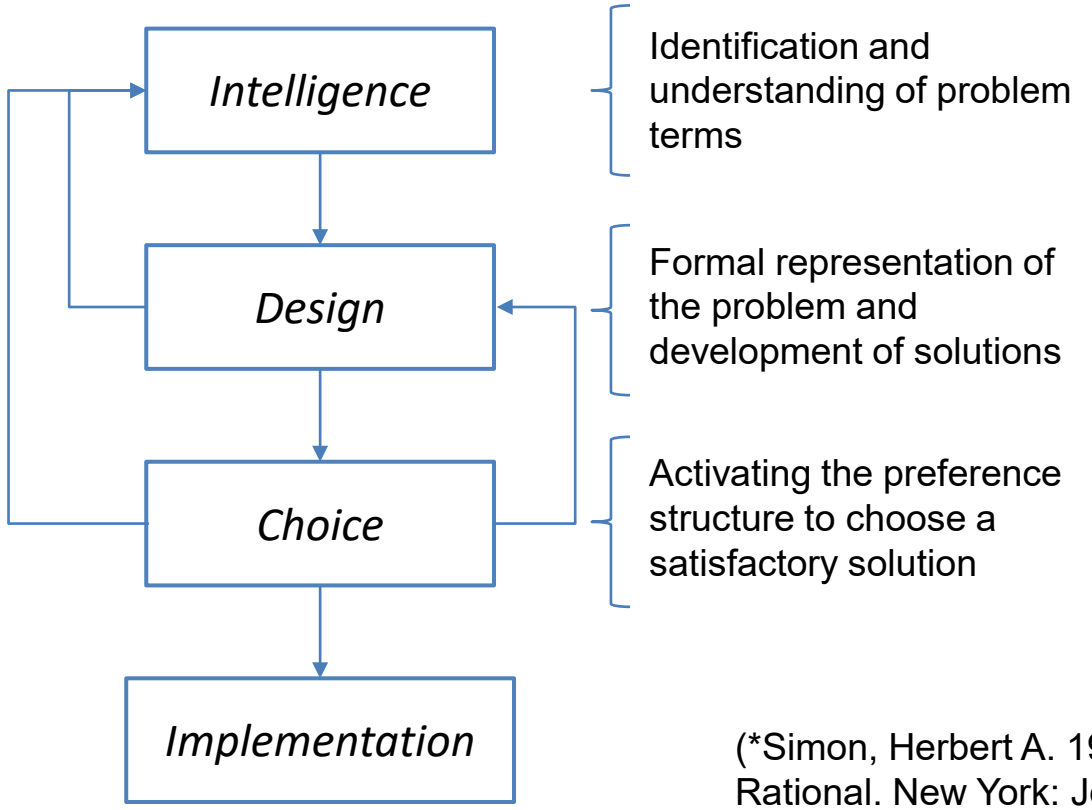
(* Simon, Herbert A. 1947. Administrative Behavior: A Study of Decision-Making Processes in Administrative Organization. New York: Macmillan Company.)

- Simon notes that actors' actions do not meet the requirements of classical normative theory because:
  - information is always incomplete and fragmented
  - time to decide is limited
  - they prefer to evaluate only a very limited number of solutions and in successive steps.
- Therefore, the indications of normative theory *cannot be absolute*, but constraints and conditioning that emerge in real processes must be taken into consideration.

- The *specific* process is at the centre of the analysis, and some aspects should be considered:
  - often the problem is not well defined
  - the objectives are multiple
  - choices are often developed and sought during the process
  - information is incomplete and often ambiguous
  - the DM is generally not looking for an optimal solution, but one that best meets a main objective and considers a number of secondary needs (*satisficing* solution).
- It has also been noted that decisions are often collective: thus, the need to choose a *compromise decision* arises.

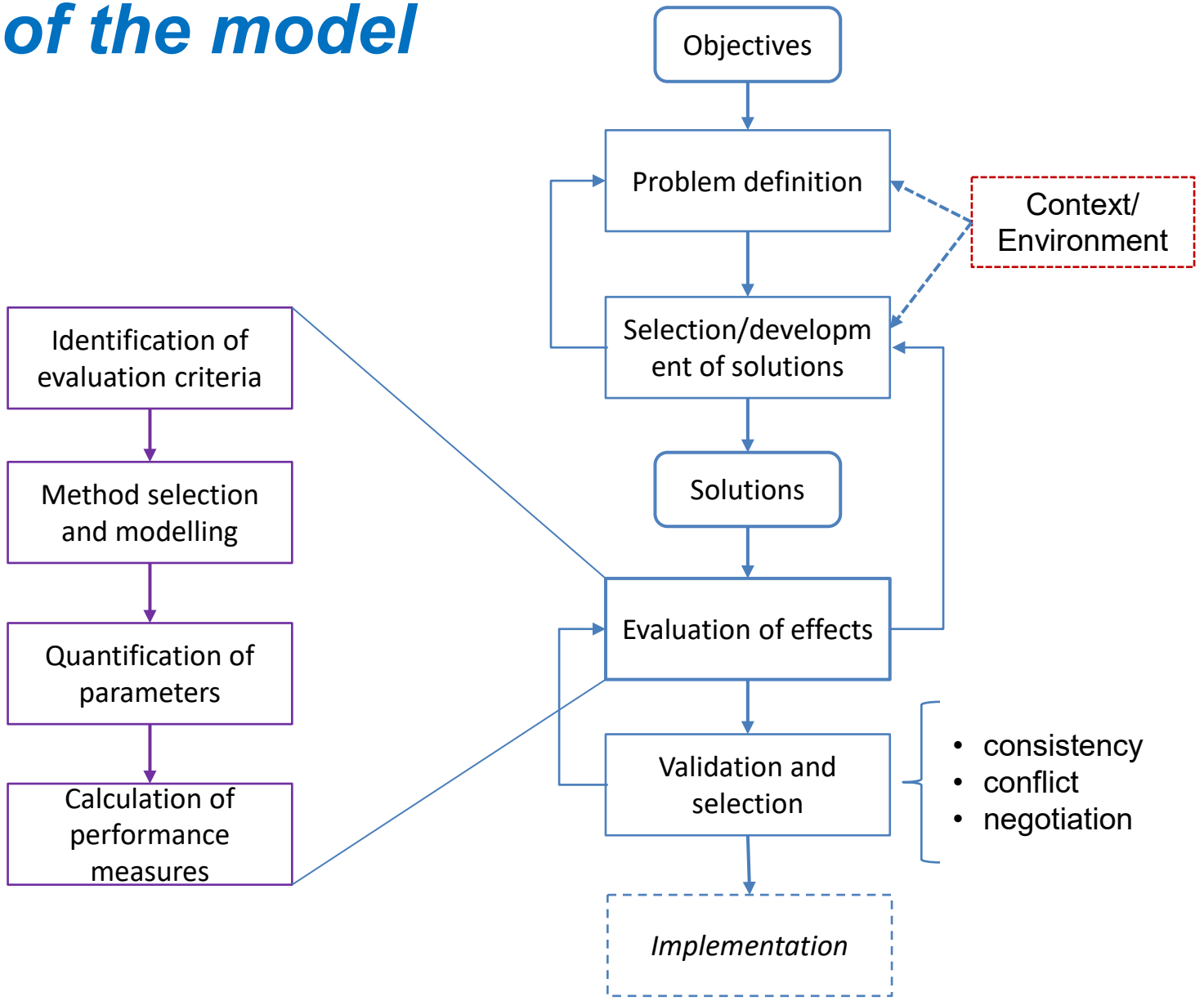
Summary of the process model

- The process model we will see, is derived from an elaboration of the “4-step model” proposed by Herbert Simon*:



(*Simon, Herbert A. 1957. Models of Man: Social and Rational. New York: John Wiley & Sons.)

Summary of the model



Some notes on feasibility studies

- Pre-feasibility study
- Feasibility study

} Before the selection of a specific solution

- Preliminary design
- Detailed design
- Executive (construction) design

The feasibility study (FS)

- The FS is the product of information search and analysis, which is of central importance where decisions about the use of (limited) resources must be made.
- In general, the FS aims to check whether an output (product, service, change...) can be realized and to identify possible alternatives.
- The FS is preliminary to the development of a project and in industry determines whether or not the actual project is started.

- Aspects analysed in an FS:
  1. the “target” context (organizational system, users, policies, functions, etc.) in its current and future state
  2. the problems of the current system that the project seeks to address
  3. the objectives pursued and the requirements to be met
  4. the constraints in the system and context
  5. the feasible alternative solutions
  6. the advantages and disadvantages of different alternative solutions.

- *Example*: introducing a low-emission energy-efficient painting process (LEEP).
  1. The organizational structure, in which the LEEP will be employed, the users and functions it will support
  2. Problems with the existing painting process or the current way in which the functions performed by the LEEP are being carried out
  3. The objectives of the introduction of the LEEP and compatibility requirements.
  4. Technological (e.g., water treatment plant), functional and non-functional constraints (e.g., interface with material suppliers)
  5. The configuration alternatives (among which the current painting process should be included)
  6. The advantages and disadvantages of different functional configurations.

- A FS in industry often considers four types of “feasibility”
- *Operational*: compliance with standards, functions (in the organization) and actual use by users or clients.
- *Technical*: concrete implementation with available technologies or need for the development of new technologies.
- *Economic*: possibility of achieving a positive balance between expected benefits and costs.
- *Timing*: adherence to timelines considered acceptable for development and commissioning.

- Purposes of the FS:
  - ascertain the goodness of the idea or project and its cost-effectiveness compared with alternative uses of resources (comparison of different solutions)
  - identify the most realistic and promising ways to realize the original idea
  - provide the essential elements of the design, and particularly those necessary for collecting the opinions of other agencies or parties interested in the intervention.
- A FS includes technical studies and evaluation studies.

Contents of the evaluation section of a FS

- problem definition and scope of the study
- determination of requirements
- objective setting
- identification of alternatives
- definition of evaluation criteria
- selection of evaluation method
- evaluation of alternatives (application of the method)
- validation of the solution.

Note on the determination of requirements

- Requirements represent the characteristics that solutions *must* have or the results they *must* guarantee.

- *Example*: “the supplier must guarantee an on-call maintenance start time of less than 36 hours.”
- *Example*: “the abatement system for VOC emission must ensure compliance with the limits established under Article 275 of Italian Legislative Decree 152/2006, as amended.”

- Requirements allow for the rejection of ineligible solutions; this is not true for objectives.
- To distinguish requirements from objectives, one may ask:

  “if a solution has good characteristics but does not satisfy this aspect, should it be discarded or can it be considered eligible?”
- If the decision is “discard”, it is a requirement;
  otherwise, the aspect considered must be considered an objective.

- When developing new products or services, two levels of requirements (or criteria) are often adopted:
  - must-meet *criteria*
  - soft requirements (*should-meet criteria*).
- Formally, the former can take only two values: “yes” or “no”. They are the requirements as defined by us.
- The latter may have different levels of satisfaction.
- For example, the *soft* requirement “technical complexity of the solution” could have *very high*, *high*, *medium*, *low*, *very low* levels.
- In this course, *soft* requirements are used as evaluation criteria.

Note on the identification of alternatives

- Several solutions can lead to the change from initial state to desired state.
- The solutions are *alternatives* if:
  - every solution is complete
  - we can at most implement one of them
  - two solutions differ in at least one of the aspects (attributes) considered
  - (the set of solutions is discrete and finite).

Note on the definition of the criteria

- The criteria used in the evaluation must be aligned with the objectives.
- Implicitly, they are also linked to one or more stakeholders.
- *Example*: In the case of process renovation, the criterion “energy used in a year by the plant” is based on the objective “reduction of energy consumption” and can be linked to the DM “Energy manager”.

- Using a set with a few criteria but with high discriminating power makes the evaluation more comprehensible.
- Each objective of the decision must be translated into at least one criterion.
- Each criterion must allow at least a qualitative comparison between alternatives.
- In some cases, it is possible to associate a scale or measure with a criterion.

- *Example (coating process)*:
  - *objective*: minimise the waste of material used in the process
  - *criterion*: material efficiency
    (used material – material wasted)/(used material)
- *Example (manufacturing facility)*:
  - *objective*: increase the energy supplied from renewable sources
  - *criterion*: share of total used energy coming from renewable sources.

Note on the contents

- Data and information
  - Definition of the information sources consulted.
  - Definition of the accuracy, relevance and quality of the data in the different processes.
  - Indication of the measures taken if the data were insufficient or of unverifiable quality.

- The section of the study where the methodologies are applied must include:
  - definition of the methodologies used in the study and their justification
  - clear definition of the changes or adaptations made and their justification
  - clear description of how the methods and models were applied (*procedure*).

- Presentation of results:
  - compact presentation of the main results (tabular or graphical, but no redundancies)
  - clear and concise answer to the main evaluation question (recommendation) and implications in terms of decision-making.