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Types of scenario planning and their effectiveness: A review of reviews

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ABSTRACT

Scenario planning is a popular approach for addressing uncertainty in strategic decision making. An open and adaptable approach from its inception, scenario planning has developed into separate schools and is now used across a wide range of research fields and practical settings. Reviews point to three challenges that limit the spread and the usefulness of scenario planning: conceptual confusion, methodological chaos, and scarcity of evidence on its effectiveness. This review of reviews brings together recent insights offered by the literature that suggest that these challenges have been partly met. A recent proposal for a synthesized definition of what a scenario is turns out to capture novel definitions quite well. The overarching term scenario planning covers a confusing diversity of methods and techniques. Nevertheless, within each of the separate schools the range of methodological choices is more restricted and arguments for choosing between options are clearer. Finally, while there is indeed a scarcity of research into effectiveness of scenario planning, on the level of specific techniques there is evidence of impact. This paper contributes to the literature on scenario analysis. For practitioners this paper provides more clarity on how to implement scenario planning, in terms of available process designs, how to choose between them and which techniques can help in implementation and how to measure effectiveness.

1. Introduction

Scenarios are used to create awareness and prepare for an uncertain future Scenarios are used to deal with the inherent uncertainty in short term disruptions (such as for example flooding, COVID 19, terrorist attacks, or a financial crisis), for exploring long-term developments (e.g., climate change scenarios, social responses to public health interventions), and help to test the robustness of different strategies against multiple possible futures. The use of scenarios is reported in the literature under different names: scenario development, scenario planning, and scenario thinking (Varum & Melo, 2010) or referring to a specific approach to constructing scenarios like participatory scenario planning (Oteros-Rozas et al., 2015; Poskitt, Waylen, & Ainslie, 2021). Judging by the rise in the number of publications on scenarios (Varum & Melo, 2010) an increasing number of organizations are employing some form of scenarios, and for different disciplines (e.g. management, social systems, education, health, climate adaptation, etc.) (Hagens et al., 2022, 2021). In the remainder of this paper, we use the term 'scenario planning', since it is not restricted to a specific phase in the scenario method such as construction, or a specific impact such as (changing) thinking (Varum & Melo, 2010). While the different scenario methods share the assumption that challenging the status quo is an essential basis for strategic planning, they diverge in how

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to concretely go about that.

Many authors quote Martelli (Martelli, 2014) who concludes that despite years of use across a diversity of organizations, scenario planning suffers from several methodological shortcomings. One is the lack of an accepted definition of scenarios (Amer, Daim, & Jetter, 2013; Araújo & Casimiro, 2019; Bradfield, Wright, Burt, Cairns, & Van Der Heijden, 2005; Varum & Melo, 2010; Chermack et al., 2001; Spaniol and Rowland, 2019) following from the use of different theories, principles, and practical rules. A related shortcoming is that there are many different scenario approaches that each use their own techniques (Amer, Daim, & Jetter, 2013; Bishop, Hines, & Collins, 2007). As an approach, scenarios lack clarity (Martelli, 2014). There is an ongoing debate in literature on how to classify scenarios. While some authors contrast qualitative and quantitative techniques to build scenarios, others prefer to distinguish prospective from predictive types, combining them with other more complex techniques for instance based on artificial intelligence (Back, Dandolini, Freitas Filho & Alarcon, 2015). A popular classification of scenario methods divides the field into three schools: the Intuitive Logic method (ILM), La Prospective (LP) and the Probabilistic Modified Trends (PMT) (Amer, Daim, & Jetter, 2013; Varum & Melo, 2010; Chermack et al., 2001). The third shortcoming is the lack of evidence for claimed effects of scenarios. Each school employs a set of techniques, some of which have not been adequately tested, lack practical value or a theoretical base (Varum & Melo, 2010). New types of scenarios emerge for specific situations, but the development process is frequently based on tacit knowledge by expert consultants and not sufficiently documented (Harries, 2003). Over time, the scenario method has been continuously adapted and as a result now covers a wide array of techniques with unclear processes. Still, scenarios have gained popularity among different disciplines under the assumption that they can increase preparedness for the future and evaluate the robustness of the potential strategies. However, claims on the effect of these scenarios are often not empirically or theoretically grounded (Whaley, 2008). Underlying the lack of clarity on the definition, techniques used, and effectiveness of scenarios may be the absence of reporting guidelines, which would greatly help to clarify which form of scenarios to use in which context and what type of outcome can be expected, particularly for prospective users. Baker (2016) points to the "reproducibility crisis" (Hensel, 2021) in management studies, and Mulugeta et al. (2018) point the same need for credibility, replicability and reproducibility for biomedicine that hamper the accumulation of research results. In our review of reviews, we will assess the scope and rigor of the studies found.

With this review of reviews, we try to capture the most relevant evidence published on scenarios in the form of a review until 2021. Our study aims to answer four research questions: 1. Which definitions of scenario planning are used and is a shared definition emerging? 2. Which approaches to scenario construction are reported and how can these be classified? 3. Which techniques for scenario planning are reported? 4. What is reported in the literature on effectiveness of scenario planning? Despite the extensive use of scenarios and many publications, there are few assessments that investigate the process and effects of scenario planning in a rigorous and transparent manner. Hence, this study tries to ensure the quality of the review by appraising the articles between two authors independently and delivering a reproducible and comprehensive overview of scenario planning. Before proceeding it is worthwhile to clarify our use of the terms approach, method, technique, and tool. As Aldabbagh and Allawzi (2019) show, each of these three terms is used to characterize scenario planning. We follow Mingers and Brocklesby in defining an approach and a method. An approach is a framework with ideas that can guide the selection and framing of a problem, which in this case, comes down to a focus on the future; a method is a structured set of guidelines or activities to assist people in undertaking research or interventions (Mingers & Brocklesby, 1997). A technique is a specific activity that has a clear and well-defined purpose within the context of a method. A tool is a set of elements that will help with the implementation of a technique. (Note that we define these terms slightly different than (Bishop et al., 2007). We therefore consider an approach to the way the future is perceived, the 'scenario planning' a method, in which specific techniques such as Trend Impact Analysis are used. The distinction between method and technique is not always clear. For instance, some authors refer to brainstorming as one of the techniques they used in a scenario application, while others (e.g., Stroebe, Nijstad, & Rietzschel, 2010) see brainstorming as a method in its own right. We use the term "strategic" to refer to medium or long term planning, which is relevant in many areas like business, climate change, etc. In the remainder of this paper, we first go into the method of data collection, which helped us to find reviews of scenario planning and techniques used. We then address the comprehensiveness of these reviews by checking their scope, clarity, and rigor. Next, we analyze the reviews found in terms of definitions of scenarios, methods and techniques and reports on effectiveness. We integrate our results in an overall framework for scenario planning. Our paper closes with a discussion of limitations and avenues for further research.

This paper contributes to the literature on scenario analysis by describing the status of the field, in terms of central concepts, process designs and how to choose between them, techniques to use, and practical insights into how to measure effectiveness. For practitioners, this paper provides more clarity on how to implement scenario planning.

2. Method

The planning and execution of this research involved a first phase of data collection aimed at finding reviews of scenario planning. Each review reported on a set of techniques used. These techniques were the input for a second phase of data gathering, aimed at discovering the most often used techniques. Both phases of data collection consisted of several steps which are explained below.

2.1. Data selection and inclusion criteria

Scenarios have been used to support strategic planning for 50 years now (Whaley, 2008) and at various moments the state of the field has been captured in literature reviews. To achieve our research aims, we provide an overview of studies into scenario planning published until December 2021. To this end we included five databases: Web of Science, Ebsco, Embase, PubMed, and Scopus. We searched in different languages (English, French, Spanish, and Portuguese) as we intend to obtain a broad overview of the literature.

The strategies used for searching the articles used the same terms and a similar approach across all databases and languages. We checked the abstract, key words and title for (translations of) "scenario planning" OR "scenario building" OR "scenario thinking" AND "review" OR "systematic" OR "mapping" OR "overview". Appendix A contains all combinations of search terms used. Data were collected on November 5th, 2021, and on May 1st, 2022 to include publications that appeared in 2021, based on different steps detailed in the PRISMA flow diagram shown in Fig. 1(Varum & Melo, 2010). Search results were stored in a database and checked in the following manner. First, data were controlled for duplicates. Second, titles and source titles were checked and we excluded those that were not scientific articles, as well as books, periodical revues, and (master and PhD) theses. The resulting scientific articles were collected into a list to further review the abstract and title to assess for inclusion. The first author searched and selected the first set of

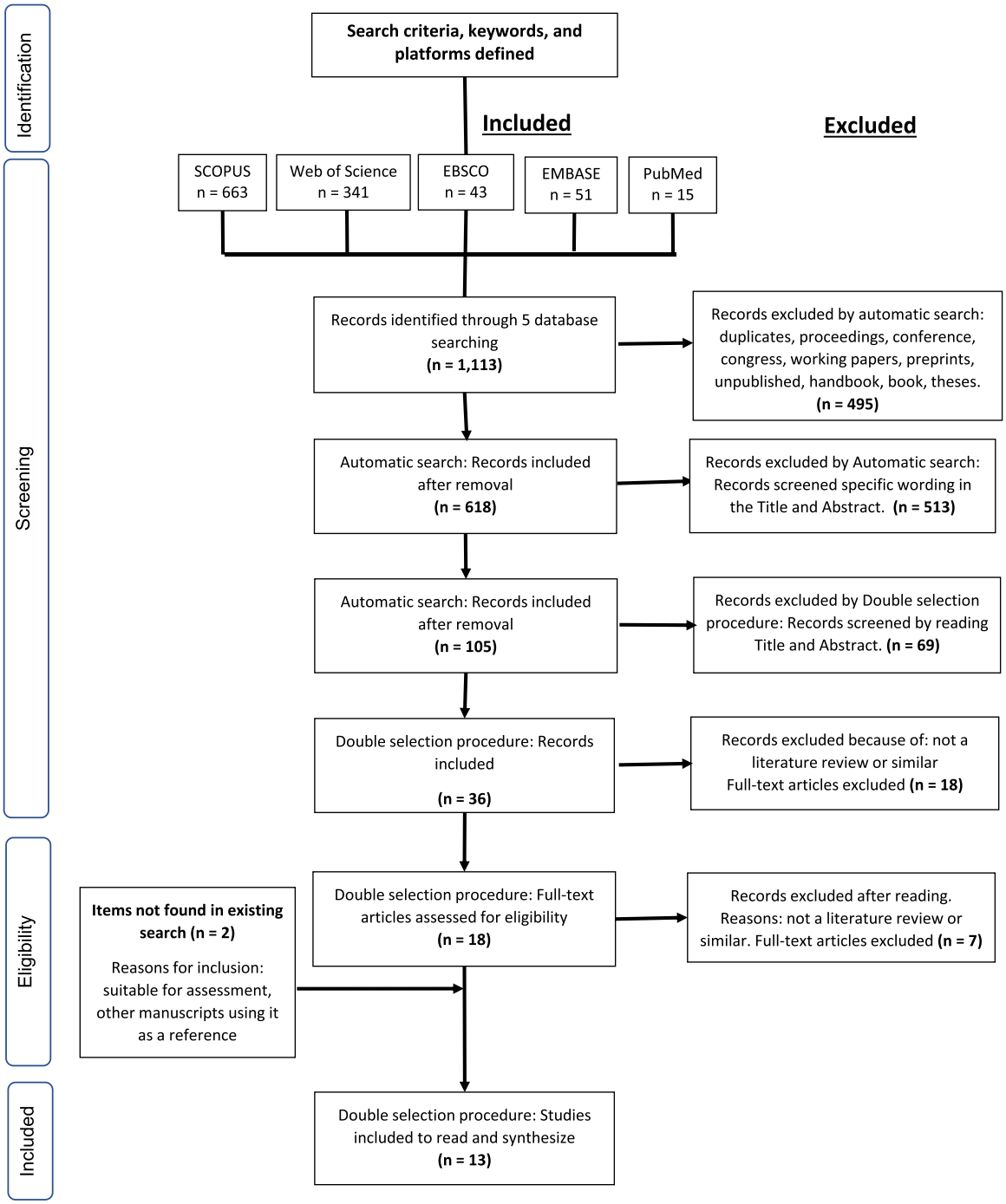


Fig. 1. PRISMA flow diagram displaying the different phases of the systematic review.

studies. Two documents were excluded after reading them because they were not reviews but we still use them to compare our results as both contain empirical data. Oteros-Rozas et al. (2015) analyze 23 cases conducted by the authors, which were not previously published; Poskitt et al. (2021) use primary data on two cases as well as secondary data on 30 cases; both papers have the aim to understand the impact of scenarios on learning.

Data from the included manuscripts was extracted and results were assessed following a framework prepared for this study that served for two purposes, first to extract data and later for quality assessment of the manuscripts (Table 2). Other papers were included in this study as some manuscripts of our review were using them as a reference The second author read the final set of papers, the extracted data within the framework, and checked interpretations. Differences of opinion were resolved through discussion. Once all the steps of inclusion-exclusion were finished, 13 studies were selected for further analysis.

The second phase for data collection consisted of searching the 13 manuscripts for techniques used in scenario planning. The aim of the second phase was to discover which techniques are used most in the past ten years, following the flow chart depicted in Fig. 2. A four-stage process was necessary. In the first stage we searched for techniques mentioned in the chosen manuscripts and grouped techniques into categories. In the second stage we searched the literature for publications on each technique, using the full name of the technique as keyword, for instance "Cross Impact Analysis" or "Trend Impact Analysis". For this search we used Web of Science (search list and results in Appendix A, for more detailed results see supplemental materials). We chose Web of Science for this second phase because most of the included articles resulting from the first phase were found in this database. In the third stage, we kept count of the number of articles using the technique before 2011 and called them traditional techniques, and the articles using the technique from 2011 or after and called them most recent techniques. In the third stage we focused on those articles that had a high number of citations (>=100) that were published in or after 2011 and we extracted the author's name(s), the number of citations, and the field of study. For selected techniques, we determined a) the steps needed to implement the technique (in the methods and results section) and b) the elements needed to include in the process of using this technique (in the discussion, limitations, and future research sections). In the fourth stage, we compared the most recent techniques used with the most known traditional techniques in terms of steps and elements needed to implement the technique.

3. Results

3.1. Data presented – assessment of the manuscripts

As shown in Fig. 1, a total of 13 studies that included an extensive literature review or systematic review were included in our analysis. Table 1 provides more detail on these studies, including their main research aim. Of the 13 studies, eight were from Web of Science and five were from SCOPUS. The ones with the highest number of citations were published in the journals Futures, Foresight, and Technological Forecasting and Social Change. Two of them are in Portuguese and the rest is in English.

To get a first idea on the content of the 13 reviews identified, we looked at their scope, clarity, and rigor. In combination these criteria indicate the comprehensiveness of a review. This is important as a more comprehensive review is easier to reproduce and therefore contributes to accumulation of results, which is as crucial in management studies as in other social sciences (Hensel, 2021). Our approach to assessing comprehensiveness is based on existing frameworks created to assess the worth of health economic studies ("CHEC list: Consensus Health Economic Criteria - Research - Maastricht University," n.d.) and systematic reviews (Charrois, 2015; Cooper, Booth, Varley-Campbell, Britten, & Garside, 2018). As shown in Table 2, the framework contains 21 criteria organized into four categories: methodology, aim and limitations of the study, definition of scenarios, and their effectiveness. Every manuscript was assessed by the first author scoring each element with 1 when the criterion was mentioned and 0 when not found. The evaluation consisted of aggregating all the scores, obtaining the average per criterion, per category for the overall manuscript. We assessed the comprehensiveness of the manuscript as low (<= 0.50), moderate (0.51–0.75), and good (> 0.75) (see Appendix B).

Overall, five reviews score low on comprehensiveness, seven score moderate and one score good. Scores in the categories are as follows: methods score on average 0.41; aim, conclusions, and limitations 0.57; scenario definition and construction 0.57 and evaluation and effectiveness 0.51. While not all scenario reviews were focused on evaluation or effectiveness, the low scores in the first

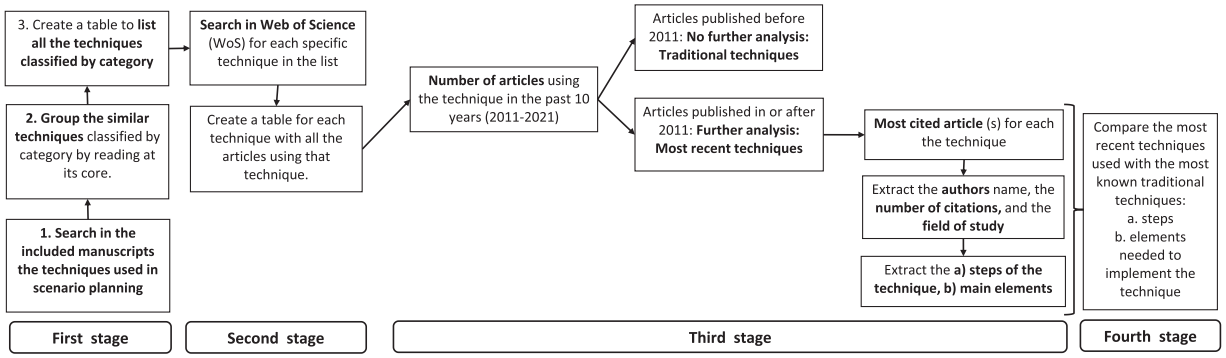


Fig. 2. Flow chart of the second phase to distinguish the most frequently used techniques.

Table 1
Articles included for the literature review of reviews, their aim, citations are based on Web of Science.

Database	Article #	Author	Title	Journal	Year	Citations	Aim
WoS	1	Magruk A.	Uncertainties, Knowledge, and Futures in Foresight Studies —A Case of the Industry 4.0	Foresight and STI Governance	2020	n/a	Types of futures, uncertainty and knowledge
WoS	2	Amer, M; Daim, TU; Jetter, A	A review of scenario planning	Futures	2013	393	Scenario definition Evaluation
Scopus	3	Chermack, T.J.	A review of scenario planning literature	Futures Research Quarterly	2001	3	Scenario definition
Scopus	4	Back, s., Dandolini, G.A., Freitas Filho, F. L., Alarcon, O.E.	As contribuiç ões da construç ão de cenários para a gestão estratégica das organizaç ões	Espacios	2015	n/a	Scenario definition
WoS	5	Harries, C	Correspondence to what? Coherence to what? What is good scenario-based decision making?	Technological forecasting and social change	2003	62	Evaluation for decision-making
WoS	6	Varum, CA; Melo, C	Directions in scenario planning literature - A review of the past decades	Futures	2010	221	Evaluation of using of scenarios
WoS	7	Harries, C	How to develop visions: A literature review, and a revised CHOICES approach for an uncertain world	Systemic practice and action research	2001		Visioning the future
Scopus	8	Aldabbagh, I., Allawzi, S.	Rethinking scenario planning potential role in strategy making and innovation: A conceptual framework based on examining trends towards scenarios and firm's strategy	Academy of Strategic Management Journal	2019	n/a	Evaluation of use of scenarios as a concept
WoS	9	Bradfield, R; Wright, G; Burt, G; Cairns, G; Van Der Heijden, K	The origins and evolution of scenario techniques in long range business planning	Futures	2005	515	Scenario definition
Scopus	10	Araújo W.J., Casimiro A.H.T.	Cenários prospectivos: Revisao sistemática na Lisa, Emerald, Scopus e Web of Science	Revista Digital de economia e Ciencia da Informacao	2019	1	Prospective scenario definition
Scopus	11	Oliveira A.S., de Barros M.D., de Carvalho Pereira F., Gomes C. F.S., da Costa H.G.	Prospective scenarios: A literature review on the Scopus database	Futures	2018	1	Prospective scenario definition
WoS	12	Bishop P., Hines A., Collins T.	The current state of scenario development: an overview of techniques	Foresight	2007	360	Techniques for developing scenarios
WoS	13	Spaniol M.J., Rowland N. J.	Defininig scenario	Futures Foresight	2019	81	Scenario definition

Table 2
List of 21 criteria for assessing the comprehensiveness of each manuscript.

1	Does the review include more than one database?	Methods
2	Does it include or tried to include more than one language?	
3	Search key with date used are presented for replicability?	
4	Number of included papers	
5	Is the inclusion - exclusion method clearly described?	
6	Is the collection of manuscripts clearly described?	
7	Is a well-defined research question posed in answerable form?	Aim, Conclusions and limitations
8	Do the conclusions follow from the data reported?	
9	Does it present limitations?	
10	Does it suggest on future research?	
11	Does it inform on the number of citations or quality of the manuscripts?	
12	Classification of scenarios identified?	Scenario definition and construction
13	Does it state one or more methodologies to construct an scenario? (procedure)	
14	Does it contain the steps for the creation of scenarios?	
15	Does it include other analysis on scenarios (e.g., time differentiation, comparison of schools or authors)?	
16	Does it contain participative approaches?	
17	Does it include an evaluation of uncertainty or plausability?	Evaluation of effectiveness
18	Does it discuss the results and their usability for the organizations? Or implications?	
19	Does it report on effectiveness or an effect on competitiveness?	
20	Does it contain bias analysis?	
21	Does it contain robustness analysis?	

three categories are surprising. Of 13 reviews, the focus of eight is on the concept of scenarios, three focus on techniques for building scenarios, and only four on the evaluation of scenarios (some reviews have more than one focus, see also Table 1). This rather low overall comprehensiveness of the reviews may influence the results reported in the remainder of this paper. To reduce error, only data

Table 3
Definition of scenario and scenario planning.

Scenario	
Araújo W., Casimiro A. (2020)	A tool to help visualize the long-term combining practice and strategy in a world of uncertainty (PEST). The creativity is the main element of an unpredictible future, using mathematical tools to establish the quantitative or qualitative relation among variables. An scenario can be only constructed by an expert that can use sensitivity to elaborate a coherent future.
Spaniol M. and Rowland N. (2019)	Scenarios primarily have a temporal property rooted in the future and reference external forces in that context; scenarios should also be possible and internally plausible while taking the proper form of a story or narrative description; scenarios seem to exist in sets and the scenarios that inhabit those sets are systematically prepared to co-exist as meaningfully different alternatives to one another.
Rawluk A., Ford R., Williams K. (2018)	Scenarios led people to think outside of their area of comfort and fostered reflection, discussion, and consideration for how to bridge value differences. Participatory scenario planning can be a useful tool to explore and evaluate different approaches in natural disaster management
Thomas M.C., Evans M., Davies R.L. (2013)	Are based on a combination of the results of mathematical models of consumption of (canned) moist cat and dog food (a predictor of demand for steel) with a qualitative survey of experts' opinions.
Moritz G., Pereira, M, Souza I., Manoel D., Herling L., Moritz M, Cesconetto S. (2010)	Prospective scenarios are therefore developed in order to assist managers in the definition of the life of the organization through the most varied methodologies, and, as such, to better define the uncertainties of the environment in order to build a better future.
Moritz G., Pereira M. F., Souza I., Manoel D., Herling L., Moritz M., Cesconetto S. (2010)	Planning through the study of prospective scenarios means formulating strategies that will help define the life of organizations in their future. In addition to reducing risks in decision making and increasing the probability of making the correct decision regarding these inevitable changes.
Inayatullah S. (2009)	Are alternative futures resulting from a combination of trends and policies.
Burt G. (2007)	The scenarios are hypothetical sequences of events constructed for the purpose of focusing attention on causal processes and decision-points
Bradfield R., Wright G., Burt G., Cairns G., Van Der Heijden K. (2005)	Generate a range of alternative futures rather than a single point naıve extrapolation of historical data, and when combined with judgments and narratives about the events in these futures, they constitute scenarios.
Kroneberg A., Landmark T., Nilsen R. (2001)	Are "structurally different stories about how future might develop", aiming at treating uncertainty.
Roubelat F. (2000)	Scenarios are based on the assumption that the business world is unpredictable, but certain events are predetermined. No scenario can provide an accurate description of the future. Their role is to help managers.
Porter M. (1998)	Are "an internally consistent view of what the future might turn out to be -not a forecast, but one possible future outcome".
Ringland G. (1998)	A part of strategic planning which relates to the tools and technologies for managing the uncertainties of the future.
Schoemaker PJH. (1995)	A disciplined methodology for imagining possible futures in which organization decisions may be played out. Scenarios are not concerned with getting the future "right", rather they aim at challenging current paradigms of thinking and broadcast a series of stories in which attention is directed to various aspects and stimulating reflexion against status quo.
Godet M. (1993)	A description of a future situation and the course of events which allows one to move forward from the actual to the future situation. Therefore, scenarios need to be useful, plausibel and with the power to break down paradigmas.
Schwartz P. (1991)	Are a set of organized ways to order our thoughts about alternative future environments, in which our decisions might be played out making stories about how the world might turn out.
Herman K. (1967)	A set of hypothetical events set in the future constructed to clarify a possible chain of causal events as well as their decision points'.
Scenario Planning	
IPTS- Institute for Prospective Technological Studies (2018)	Foresight can be degined as a systematic, participatory, future intelligence-gathering and medium-to-long vision-building process aimed to present day decisions and mobilizing joint action".
Dias M., de Souza V., Nildo J., Felby C. (2016)	The methods and techniques to plan for the future are called Scenario Planning, Development Scenario, Forecasting, and Foresight or more generally, Future Studies. Scenarios are the products of Future Studies whilst they are the stories that represent the future that better define the uncertainties of the environment in order to build a better future.
Moritz G., Pereira, M, Souza I., Manoel D., Herling L., Moritz M, Cesconetto S. (2010)	Planning with the use of prospective scenarios, strategies are therefore developed in order to assist managers in the definition of the life of the organization through the most varied methodologies, and, as such, to better define the uncertainties of the environment in order to build a better future.
Roubelat F. (2000)	It is a networking process that challenges strategic paradigms and forces firms to rethink their internal and external boundaries.
Schoemaker PJH. (1995)	Scenario planning is a tool towards the improvement of strategic decision-making, dealing with uncertainty. Their role is to help managers recognize and reflect on the uncertainties and construct scenarios to overcome the usual errors in decision-making: overconfidence and tunnel vision. Scenario planning makes use of the participation of a diversity of people – experts, strategists, managers – organized in networks to create alternative representations of the future.
Kahane A. (1992)	Scenario planning is effective method for identifying critical future uncertainties and investigating "blind spots" in the organization.
Wack P. (1970)	Prospective strategic planning, where the scenarios is used as an alternative to visualize innovation and management.

Table 4
Techniques: School, technique, steps followed, and main elements in the construction of scenarios.

	Most recent used techniques (2011 onwards) in Web of Science		Traditional techniques within the three schools (before 2011) in the 13 manuscripts revised			
School	Probabilistic Modified Trend (PMT)		Probabilistic Modified Trend (PMT)		La Prospective	Intuitive Logic School
Technique	Dynamic scenarios	Cognitive fuzzy maps	Cross-impact analysis (CIA)	Trend impact analysis (TIA)	Broad technique	Broad technique
Originated in:						
School	PMT School	PMT School	PM School	PMT School	PM School	ILM School
Technique type (Appendix C)	Modeling	Backcasting or visioning	Cross-impact analysis (CIA)	Modeling	Intuitive logic, prospective analysis or Judgement	Intuitive logic, prospective analysis or Judgement
Steps to follow while using the technique as part of the school of thought or Approach						
Problem	1. Strategic plans for disruption and macroeconomic risks	1. Create a concept map with the main components while observing the future	1. Define the structure of the subject to be searched	1. Focus setting - issues that need to be answered to define the limits of the scenarios to be created	1. Analyse the problem and delimit the system	1. Define the problem of concern and timescale
Main factors of influence	2. The first step is the ordinary process of generating scenario themes or kernels by clustering events of a similar type from a brainstormed universe of all plausible future events.	2. Experts select the concepts that constitute the FCM graph.	2. Identify and structure areas of influence on the subject (data base + shortest time paths)	2. Mapping of the driving forces that are better able to shape the future of the industry (historical data + extrapolation)	2. Diagnosis of the company (360-x ray)	2. Determine the driving forces (PESTEL base)
Probabilities of occurrence OR clustering OR causal relationships	3. Each theme is defined in a system using causal models, and probabilities.	3. Every expert defines the causal relationship between any two aspects (positive, negative, neutral).	3. Define the descriptors, with the logic for each one and assign initial probabilities of occurrence to each state of them	3. Construction of the scenery space with classification of various future states as a function of the driving forces	3. Structural analysis (SWOT base)	3. Cluster the driving forces with steering variables
(Matrix) for output values of influence	4. The variables that appeared in many different models were brought together in a meta-model that purported to map the whole domain.	4. Experts carefully determine the value of the relationship between the two concepts.	4. Fill the Cross Impact Matrix with the odds identified in step 3	4. Selection of scenarios to be detailed	4. Enterprise dynamics in the environment	4. Define the cluster outcomes with two extremes
	5. The individual themes were then elaborated using different values for the uncertainties in those models"	5. Experts describe initially the causal influence using linguistic variables, such as "low," "medium," "high" etc. The sign of each weight (+ or -) represents the type of influence between concepts.	5. Run the BASICS program (computation of marginal, conditional probabilities, and rank scores for events)	5. Detailing of the scenarios, relating trends and the events required to reach each of the final states.	5. Strategic project scenarios in its given environment	5. Impact/uncertainty matrix (GBN matrix)
Scenario description	6. From qualitative and quantitative data drawing in more quantitative data	6. From qualitative data, drawing quantitative data	6. Select scenarios and elaborate their narrative	6. Documentation, including pictures and narratives that describe the history represented in each scenario		
Strategy identification	7. Identify opportunities for growth, while optimizing horizontal and vertical chain	7. Extract the expert mental mapping for strategic analysis of the future		7. Evidence of the implications of each scenario - how different the decisions will be for each type of scenario.	6. Identify strategies	6. Framing the scenarios

(*continued on next page*)

Table 4 (*continued*)

	Most recent used techniques (2011 onwards) in Web of Science		Traditional techniques within the three schools (before 2011) in the 13 manuscripts revised			
School	Probabilistic Modified Trend (PMT)		Probabilistic Modified Trend (PMT)		La Prospective	Intuitive Logic School
Evaluation (in some probabilities)	8. More quantitative approach to quantify the potential of the future	8. A qualitative or rather semi-quantitative and dynamic method to structure expert knowledge	7. Introduce low probability events (with high impact), and conduct the sensitivity analysis	8. Includes a naïve extrapolation 9. Includes projections based on megatrends, impact,	7. Evaluate & select strategies 8. Develop action plans and monitor strategy	7. Scoping the scenarios 8. Developing the 4 scenarios (storytelling)
	9. Sensitivity analysis	9. Simulation	8. Clustering projections arising from scenarios and assessing their implications	evaluation of influences, clustering of projections. 10. Discussion of implications and scenario transfer	9. Rigor & analysis: stakeholder, expert, morphological, structural, multicriteria	9. Determine the impact on transactional environment 10. Determine robust options
Elements to include in every technique:						
Key issues	Defines the problem, mainly External elements (PESTEL)	Defines the problem, mainly External elements (PESTEL)	Defines the structure of the topic	Identifies the key scenario drivers	A specific phenomenon of concern.	A particular management decision, issue or area of general concern.
Participants	Experts and stakeholdes	Any type of participant	Stakeholders at the beginning to collect main variables that later will be analyzed by the expert	Expert opinions on future events effects combined with data	Combination of some key individuals from within the organization led by an external expert to chose the main factors.	Internal team of the organization that will remain throughout all the process of scenario construction.
Time horizon	Short to long term	Short to long term	3–20 years	Up to 20 years includes time series	3–20 years	3–20 years
Factors	Identifies causalities and nodes	Indentifies causalities and allows hazy degrees of causality	Identifies influencing areas and factors	Creates a list of impacting events	PESTEL	PESTEL
Assumptions	Data and expert based	Based on experience	Data and expert based	Data and expert based	Internal experts	Internal experts
Perspective	Cause and effect	Cause and effect	Cause and effect forecasting	Consequence forecasting	Desirable scenarios	Plausible scenarios
Implications	Description of future state	Prepare estimations	Prepare forecasts	Estimations	Descriptive and normative futures	Different alternatives
Impact	Scenario implications	Scenario implications	Study scenario clustering and its implications	Study implications & scenario transfer	Develop more effective policy and strategic and tactical plans.	Develop strategy, to an ongoing activity related to anticipation and organizational learning.

that was found in more than one manuscript was used in our analysis.

3.2. Definition of scenarios

Every study presents definitions of scenarios which overlap to some extent. Some concepts reflect scenarios as an approach or method, others as a technique or tool (Bishop et al., 2007; Franco & Rouwette, 2015). When scenarios are seen as a method or approach, they are grouped in one of the three main schools (Section 3.1 below). Within these schools several techniques are used (Section 3.3). All authors agree that a scenario is constructed not with the goal to predict the future or make a forecast, but rather to construct multiple possible stories of future situations (Amer, Daim, & Jetter, 2013; Spaniol and Rowland, 2019). The time horizon described ranges from 3 to 20 years (Amer, Daim, & Jetter, 2013). Table 3 captures the definitions of "scenario" and "scenario planning" offered in the 13 reviews (some reviews refer to definitions in earlier papers and these are also included in the table).

As can be seen in Table 3, reviews refer to definitions that are focused on the process (e.g., discuss key drivers and uncertainties), aim (e.g., evaluate real options in the future) or the result (e.g., implications of road-mapping at strategic level) (Varum & Melo, 2010). Some highlight participation (Aldabbagh & Allawzi, 2019; Bishop et al., 2007) or specific process considerations such as preventing bias (Harries, 2003). Aldabbagh and Allawzi (2019) conclude after a review based 59-articles, that scenarios fulfill different roles. Alternatively, they are used as a tool (28.8 %), a technique (18.6 %), a method (28.8 %), an approach (20.4 %), and an art (3.4 %). Based on the definitions used in 13 reviews, the most often used elements of a definition seem to be the following: scenarios are a set of narratives describing different alternative futures, constructed with an iterative approach based on the uncertainties of the context, with the aim to raise awareness of plausible futures and increase performance of the organization. One of the reviews, by Spaniol and Rowland (Magruk, 2020; Spaniol & Rowland, 2019), specifically sets out to find component parts of existing definitions. Their result is a synthesized definition based on analysis of claims in the literature on what "a scenario is…" and "scenarios are…". Six components are found to be part of the definition of scenarios: a scenario is oriented to the future, is concerned with external contexts, has a narrative form, is plausible, is part of a systemized set, of meaningfully different alternatives. This synthetic definition is very similar to our summary of definitions in the 13 reviews, with the exception that the latter includes a reference to two aims (raise awareness and increase performance in the future based on the strategies adapted in the present). Overall, with regard to the definition of scenarios, we agree with Spaniol and Rowland that conceptual differences are more apparent than real and there is evidence for a convergence in definitions.

3.3. Construction of scenarios

Scenarios are constructed in different ways. In this section we first investigate elements that all types of scenarios have in common. Any approach for constructing scenarios will have to incorporate these. Next, we go into schools of scenario approaches. An important difference between schools is the (quantitative and qualitative) data sources they employ. Qualitative data are often obtained from group sessions with stakeholders inside an organization and outside experts. Finally, we go into the different techniques used for building scenarios.

3.4. Scenario elements

The review by Spaniol and Rowland (Magruk, 2020; Spaniol & Rowland, 2019) discussed above identifies several elements that help to determine if a decision support approach can be called a scenario. These are ordered in three main categories, grouping the six components described in the previous section. First, scenario purview includes the orientation to the future and external context. Scenarios depict the future as shaped by uncertain contextual factors. Second, normative qualities refer to quality criteria for scenarios: they need to be formulated as a narrative description that is plausibly possible. Third, scenarios are part of a differentiated set in the sense that they exist in a group, members of the group systematically differ on key variables leading to comparatively different scenarios with limited overlap (Spaniol & Rowland, 2019).

All manuscripts included indicate that uncertainty is a key factor in scenario planning, as without uncertainty there is no reason to explore different future worlds. Authors emphasize the future with uncertainty, innovation, change and complexity (Amer, Daim, & Jetter, 2013); others indicate that there are different dimensions of uncertainty due to the lack of information, changing systems or unpredicted states (Bishop et al., 2007; Varum & Melo, 2010). Different techniques or tools are suggested to deal with the uncertainty while constructing scenarios such as sensitivity analysis, matrix score, etc. (Amer, Daim, & Jetter, 2013; Bishop, Hines, & Collins, 2007; Varum & Melo, 2010). For a meaningful exploration of the future some assumptions need to be made, which in turn rest on different elements that could be summarized in the available data, timeframe, and information or knowledge (Amer, Daim, & Jetter, 2013; Harries, 2003; O'Brien & Meadows, 2001). Magruk takes a closer look at two sources of uncertainty: ontological, a characteristic of the object studied, and epistemic, which pertains to the state of information on the object and can be reduced on the basis of research (Magruk, 2020). Magruk then relates these different types of uncertainty to foresight research methods as most relevant to a middle level of uncertainty, between *statistical* and *'outspread' uncertainty*. In a situation of statistical uncertainty, functional relationships, or the impact of one event on another is known. That means there is knowledge and awareness of trends and probabilities, and possible outcomes are known. Outspread uncertainty refers to a situation in which multiple images of the future are available, often 'borrowed' from various sources: *'advertising, corporate visions, popular 'futurology' and science fiction novels, films, television shows and projects from other places successfully completed'* (Magruk, 2020). However, knowledge on key variables shaping possible futures is very limited. As a result, decision makers in this situation may feel they have a grasp of the future even though there is substantial ontological

uncertainty. In between statistical and outspread uncertainty is scenario uncertainty. Here knowledge is based on our current understanding of the world (Magruk, 2020). Neither the range of future outcomes, their probabilities or the underlying mechanisms are well understood. Scenarios therefore describe plausible futures that do not forecast what will happen in the future; rather they indicate what could happen.

The difference between statistical and scenario uncertainty helps to clarify the distinction between *prospective and predictive scenarios* from Araújo & Casimiro (2019). They indicate that prospective scenarios are based on a set of data collection techniques that help to generate a coherent description of the future and the events necessary for this future to occur. Predictive scenarios on the other hand, result from applying mathematical analysis techniques that help to identify patterns and trends, which can offer some degree of future prediction when applied to large sets of data (Araújo & Casimiro, 2019). The results of the scenario prediction depend highly on the veracity of the data, interactions among variables in the data and the knowledge of the method (Magruk, 2020). Results are strongly dependent on the time horizon that is considered. Predictability is highest for short-term (ST) forecasts, lower for medium-term (MT) simulations and lowest in the case of deep uncertainty analyses applied to long-term (LT) developments (Magruk, 2020). It seems predictive scenarios are most useful in a situation of statistical uncertainty. In this paper we are concerned with constructing prospective scenarios, or in terms of Spaniol and Rowland, plausible scenarios, which are most applicable when we want to consider risks and uncertainties around long-term future developments. Constructing prospective or plausible scenarios makes it necessary to go beyond the current situation and clarify the mechanisms that generate future outcomes, their range, and probabilities, using for instance stakeholder groups as a data source (Araújo & Casimiro, 2019; Schoemaker, 1993; Spaniol & Rowland, 2019).

3.5. Scenario planning schools

Scenario approaches differ in how exactly they gather and analyze information on uncertain contextual factors and rework these into a set of plausible but contrasting narrative descriptions of the future (Spaniol & Rowland, 2019). As mentioned in the introduction, many authors' group scenario planning approaches into three schools of thought. In this study, 10 out of 13 manuscripts acknowledge the three schools, while two of them focus on one specific school. Three manuscripts out of 13 take a broad approach to scenarios as a method to explore the future (Aldabbagh & Allawzi, 2019; Harries, 2003; O'Brien & Meadows, 2001). Other papers contrast use the use of qualitative versus quantitative techniques. Below we describe the three schools of thought; the next section covers the type of data used. Bradfield et al. (2005) present the most important characteristics of each school, which are reproduced in - among others the manuscript of Amer et al. (2013)(Amer, Daim, & Jetter, 2013; Bradfield et al., 2005). Within this classification, many techniques are included (Section 3.4).

According to Bradfield et al., the Intuitive Logic method (ILM) follows a qualitative approach. First used in US defense planning, the focus shifted to private sector planning. An internal team knowledgeable about the organization's surroundings, sometimes together with external domain experts, identifies contextual trends. Using brainstorming and discussion, important and uncertain drivers are identified and used as a basis for developing scenarios. Participants construct scenarios in a facilitated process of cocreation. Following ILM, participants clarify and debate assumptions until reaching consensus. This is then the basis for a set of scenarios that are each equally plausible, meaning that estimation of probabilities has no place in ILM (Bradfield et al., 2005). The resulting scenarios describe a possible future world in the form of narratives supported by graphics. In ILM scenarios are tested on their coherence, comprehensiveness, internal consistency, and novelty. Finally, wind-tunneling can be used to find robust policy options. Intuitive logics can be used for both exploration as well as choosing options, for both one-off and ongoing decision making (Bradfield et al., 2005). The main authors on ILM are the creator Herman Kahn, Kees Van der Heijden, Peter Schwartz and Paul Schoemaker.

The La Prospective (LP) school was created by Michel Godet on the basis of on an earlier methodology developed by Gaston Berger (Godet, 2000). It uses some techniques like intuitive logic but adds more elaborate and complex quantitative analysis. LP thus combines qualitative and quantitative techniques. Initially focusing on national (French) socio-political analysis, its use has spread from the public to the private sector. This approach brings together a team of organizational members. Led by an expert, participants first define key factors which are then the input for structural and morphological analysis and mathematical modelling. LP uses probabilities of variable trajectories, based on assumptions of actor behavior. Outputs are descriptive or normative scenarios of alternative futures. LP scenarios are checked for coherence, comprehensiveness, internal consistency as well as plausibility and verifiability in a retrospective analysis (Bradfield et al., 2005).

The Probabilistic Modified Trends (PMT) school takes a quantitative approach and builds on traditional forecasting methods. Instead of simply extrapolating historic time series, the impact of unprecedented future events is considered. The PMT school uses two distinct approaches: Trend-Impact Analysis (TIA) and Cross-Impact Analysis (CIA). Using TIA, a list of events that could lead to deviations from extrapolated trends is generated, after which experts determine the probability of these events and their expected impact. CIA largely follows the same approach but uses a more elaborate process to determine probabilities of future events. Instead of asking experts to directly estimate probabilities, these are based on the likelihood of future events given that specific previous events have or have not occurred. In PMT scenarios are developed by outside experts with the use of statistical software for trend analysis as well as simulation models. The output consists of descriptive scenarios with probabilities attached and estimations of uncertainty ranges. Scenarios may be summarized in storylines. PMT scenarios can be tested for plausibility and are verifiable in retrospect (Amer, Daim, & Jetter, 2013; Bradfield, Wright, Burt, Cairns, & Van Der Heijden, 2005).

3.6. Data sources

As described in the previous section, the type of data used differs between scenario schools. While the PMT school exclusively uses

quantitative data and ILM only qualitative data, LP combines both. PMT rests on the availability of detailed and reliable time series data (Amer, Daim, & Jetter, 2013; Bradfield, Wright, Burt, Cairns, & Van Der Heijden, 2005). LP uses quantitative data in the form of time series, assumptions underlying actor behavior and expected impact on subsequent actions of others. In addition, LP uses qualitative data gathered in stakeholder interviews. In ILM stakeholders, often in interactive group settings, are the main source of data.

While stakeholder input is important in two of the three scenario planning schools, only six of the 13 reviews we found refer to participatory construction of scenarios (Amer, Daim, & Jetter, 2013; Araújo & Casimiro, 2019; Bradfield, Wright, Burt, Cairns, & Van Der Heijden, 2005; French, 2015; Oliveira, de Barros, de Carvalho Pereira, Gomes, & da Costa, 2018; Chermack et al., 2001). In these articles, the reason to involve actors or stakeholders in a scenario planning process is typically that this helps to obtain a comprehensive overview of contextual developments. The articles generally do not go into details on how and when participation is used (Chermack et al., 2001). Schwartz (1991) had mentioned that participation was important to change decision-making and create impact, and many authors quote him. Still, Chermack et al. (2001) indicate that the literature on scenarios offers little in the sense of theoretical foundations, impact on the client organization, or reflection on the intervention process. Bradfield et al. and Amer et al. are the exceptions and do indicate how each of the three schools uses participation (Amer, Daim, & Jetter, 2013; Bradfield, Wright, Burt, Cairns, & Van Der Heijden, 2005). For the ILM school and LP school, participation includes a team within the organization joined by external experts in the field. Outside experts help to challenge the thinking of the internal team, for instance when eliciting contextual developments using PESTEL (political, economic, societal, ecological, and legal developments in the organization's context). Participation in LP is limited compared to ILM. In LP participation is mainly sought in particular stages such as determining the main trends and is led by an expert who will analyze participant input using cross impact tools (e.g., Micmac, SMIC and Mactor analysis). In the ILM school, participation takes place throughout the entire process. Stakeholders are guided by a facilitator who designs and leads the process from gathering data on external developments to eventual writing of scenarios. The PMT school includes participants from the organization only to list parameters, which are then input to Monte Carlo simulations run by expert researchers or consultants. The similarity between LP and PMT is that both use (outside) experts rather than other stakeholders (e.g., inside experts or decision makers). When scenarios are developed for an organization or collective of organizations, involving an internal team in scenario planning has the advantage that decision makers are more directly impacted. They can directly offer their input, discuss assumptions, and solve disputes which is likely to increase their engagement with the scenario planning process. According to Schwartz (1991), it is important to measure the impact of constructing scenarios on decision-making within the organization, and the eventual results for the organization.

3.7. Techniques

As described in the introduction, the 13 reviews resulting from our initial literature search were the basis for a second search that focused on techniques used in scenario planning. Fig. 2 describes the process followed. In short, for our second search we first identified all techniques described in the reviews and grouped these. Second, we searched for publications on each technique. Third, for selected techniques that had a high number of recent citations, we determined the steps for and central elements in using this technique. This last step was necessary because although authors such as Bishop et al. (2007), Oliveira et al. (2018), and Amer, Daim, & Jetter (2013) ; Bishop et al. (2007); Oliveira et al. (2018)) describe numerous techniques, they do not indicate how to use them (their steps and central elements) nor which outcomes can be expected.

Step 1 of our second literature search resulted in 29 different techniques, grouped into eight categories. The categories developed by Bishop et al.(Amer, Daim, & Jetter, 2013; Bishop et al., 2007; Oliveira et al., 2018) provided a good starting point for ordering techniques and placing additional techniques (not mentioned by Bishop et al.) turned out to be straightforward. For only one category we decided to change the name from 'dimensions to uncertainty' to 'intuitive logic, prospective analyses, as this seemed to reflect the broader set of techniques included. Resulting categories are: 1. judgment, 2. Baseline / expected (trend extrapolation), 3. elaboration of fixed scenarios, 4. event sequences, 5. Backcasting / visioning, 6. Intuitive logic, prospective analysis, 7. cross-impact analysis, 8. modelling. Techniques are about evenly spread over categories, with three to five per group. Appendix C lists categories and techniques and the number of references for each technique. For articles cited recently we also include the authors whose articles were cited highest and their field of study.

Step 2 of our search points to several highly cited techniques. Among these are techniques which are widely used in planning and decision support and frequently referenced outside of the scenario planning literature (some of these may be said to be methods in their own right). These include role playing (235 references) and the Delphi method (300). Sensitivity analysis is also highly cited (255 references) and an integral part of many Operational Research approaches. Two techniques may be said to be methods but typically used with the aim to develop scenarios: cognitive fuzzy maps (156) and dynamic scenarios (287). Then there are several techniques which are used little outside of scenario planning: probability trees (76), option development and option evaluation (22) and trend impact analysis (52). Six techniques were cited never or only once in the database employed in our second literature search (Web of Science). Surprisingly, for 13 of 29 techniques no recent articles (2011 or later) appeared.

Step 3 provides further clarity on selected techniques by specifying their steps and central elements. We selected techniques based on their number of citations and relevance to scenario planning. We therefore decided to exclude generic techniques or phases, such as role playing, Delphi, and sensitivity analysis. In Table 4 we outline two techniques with 100 or more citations (cognitive fuzzy maps and dynamic scenarios). We contrast popular novel techniques (most used in the past ten years) techniques with popular traditional techniques (most used before 2011). We particularly focus on the school, the steps to follow with the technique, and main elements to consider while developing the scenarios. Regarding steps followed in the technique, we look at setting the problem, eliciting ideas or factors from the contextual environment, relating factors, evaluating factors and relations, developing scenarios, strategy

identification and evaluation. Key elements for comparing techniques are issues focused on, participants, time horizon, factors selected for the scenarios, basis for assumptions driving scenario construction, perspective for scenario construction (plausible cause – effect relations, forecasting, normative ideals), implications (products generated) and impact in relation to the effectiveness of the organizational learning, policy or strategics plans.

Both recent techniques are in the PMT school, probably meaning that the other two approaches are stagnant. The two new techniques integrate qualitative and quantitative data sets. CFM may use expert participation throughout the entire process, comparable to the intuitive logic school. Both employ processes for the construction of scenarios similar to those used in traditional techniques up until the point where the most important drivers are chosen. The choice of drivers and subsequent construction of scenarios is different from traditional approaches and differs between the two techniques. Once these scenarios are constructed, there is a large overlap between techniques again as they all explore strategies by contrasting them with scenarios. Finally, with regard to evaluation of the scenarios obtained, techniques again differ. Dynamic scenarios and CFM use quantification, simulation, and sensitivity testing, while the other two PMT traditional techniques do not include a clear format for scenario evaluation.

It is worth saying that the famous techniques of PESTEL, which is used to explore the contextual environment, and the technique GBN matrix which contains four quadrant scenarios to contrast the two driving forces (Bishop et al., 2007; Oliveira et al., 2018) have become so widespread and core to scenario planning that they are not referred to by a specific name anymore, but they are comprised in the steps.

3.8. Effectiveness of scenarios

Our fourth research question addressed reports in the literature on effectiveness of scenario planning. We address this research question by first going into reported empirical evidence on effectiveness. We then look into theoretical considerations of scenario goals and mechanisms through which these goals are reached. These can serve both to criticize the current practice of scenario planning as well as to improve guidelines for future reporting.

3.9. Empirical evidence on the effectiveness of scenario planning

On the basis of the reviews analyzed for this study, the conclusion seems to be that there is little interest in evaluating the effectiveness of scenarios. Only four out of the 13 reviews mention something on evaluation (Aldabbagh & Allawzi, 2019; Amer, Daim, & Jetter, 2013; Harries, 2003; Varum & Melo, 2010). This may be due to the proliferation of scenario planning approaches and the lack of reporting guidelines, which make it difficult to first identify scenario applications and second to systematically compare the many different approaches. Many practitioners do not report on the exact steps followed in constructing scenarios which presents another hurdle to evaluating effectiveness (Chermack et al., 2001; Harries, 2003). Although several manuscripts refer to the effectiveness of using scenarios as part of the claimed benefits of the approach, reporting of actual impacts is scarce.

Aldabbagh and Allawzi (2019) report that of the 59 articles they reviewed, 51 % focused on strategic planning, strategy development and innovation; 24 % focused on strategic thinking, learning and strategy theory development; 12 % on strategic foresight and insight; 7 % on strategic decisions and 5 % on strategic options. None of the articles focused on the evaluation of scenarios or the contribution of scenario planning to the firm's strategy or innovation.

Harries (Harries, 2003) distinguishes between three ways to empirically evaluate the use of scenarios for supporting decision-making: based on single case reports, multiple case studies or experimental research. She notes that positive evaluations of scenario planning, pointing to the benefits of the approach, often seem to be based on single case reports. An example is the successful case reported by Shell (Aldabbagh & Allawzi, 2019; Back et al., 2015; Heijden & der, 1996). These are reports issued by (representatives of) the organizations involved, pointing to the role of scenarios in, for instance, improving prediction or increasing creativity. Harries identifies three problems with evaluations based on case reports. First, the reports cover only a small sample of all applications of scenario planning in business and public policy, and one that is skewed towards successful examples. Second, the results are self-reported which means they tend to emphasize satisfaction with the process over objective impacts on decision making or the organization, and verbal impressions over behavior. Finally, the causal relations between the intervention (e.g., the process followed, the team of participants), context (e.g., organizational structure, problem urgency) and results are difficult to disentangle. Besides, single case reports do not allow for isolating the exact contribution of scenario planning to organizational decision making and results. Multiple case studies can potentially do a better job here, since they analyze a larger set of cases which allows for comparison across organizational contexts and interventions. However, Harries finds only one study that compares several organizations (Hodgkinson & Wright, 2002) which also suffers from a number of limitations.

Another way to evaluate the use of scenarios for decision-making is experimental research (Schoemaker, 1993) On the basis of four experiments, Schoemaker concludes that scenarios can expand people's thinking (indicated by an increase of subjective confidence ranges after having read scenario texts) which is an antidote to tunnel vision and overconfidence. He also finds that participants overestimate the likelihood of conjunctive events, both for pairs of events (A and B occurring) or larger sets of events. In other words, the participants' answers suffer from a conjunction bias. The overall conclusion is that scenarios may exploit one set of biases, such as the conjunction bias, to overcome other biases such as overconfidence, anchoring or availability.

3.10. Theory-informed evaluation of scenario planning

In the absence of a substantial body of empirical research on scenario planning effectiveness, theoretical reasons for using scenarios

Table 5
Process: quality criteria for scenarios (extended from Amer et al., 2013).

General criteria		Wilson	Van der Heijden	Durance and Godet	Bradfield et al.	Alcamo and Henrichs	Harries	Various	Wright and Goodwin
Process	Differentiation (school / approach, technique)	Plausibility: The selected scenarios have to be capable of happening	Each scenario must be plausible	Pertinence	Plausibility	Plausibility	Probability	Probability	–
		Consistency: The combination of logics in scenario has to ensure that there is no built-in internal inconsistency and contradiction	Scenarios bust be internally consistent	Likelihood	Internal consistency	Consistency	–	–	–
		–	–	Coherence	Coherence	–	–	–	Understand human motivations
		Challenge novelty: the scenarios should challenge the organization's conventional wisdom about the future	Scenarios must produce a new and original perspective on the issues	–	–	Creativity	1. Creative thinking 2. Prediction	Reference goal with a good measurement	Change of mindset
	Scenario specificity	Utility /relevance: Each scenario should contribute specific insights into the future that help to make the decision	Each scenario must be relevant to the client's concern	Importance	Logical underpinning	Relevance	Perception of change	Beneficial	–
		Differentiation: they should be structurally different and not simple variations on the same theme	At least two scenarios are needed to reflect uncertainty	–	–	–	Causal and story-like thinking	Distinguish well between the effects of the organization, method and environment	Use a crisis management approach
Decision making	Added value	Decision making	Strategic planning	Decision making	Decision making	Decision making	The pay-off matrix	Potential pay-off	–
		–	–	–	–	–	Mental models	Strategic planning	Evaluate flexibility, diversity, security of strategic options
	Robustness	–	–	Transparency	–	–	Metacognition	Monitoring	
		–	Wind tunnels to test strategies	–	–	–	Adaptivity	Wind tunnels to test strategies	Include counter-scenario alternatives
		–	–	–	–	–	–	SMART and MCDA	
Identification of new topics or problems					Creates organization capacity for the long-term			Participation increases commitment to implement strategies	
	One-off category (exploration)	–	–	–	Explore opportunities for decisions	–	–	Increase decision capacity	–
					Explore the choice for strategies			Increase awareness	

can be explored. This serves the purpose of clarifying which goals scenario planning aims to accomplish and describe via which mechanisms these goals are achieved.

The literature reviews by Varum and Melo's (2010) and Harries (2003) identify a host of advantages of scenario planning in their respective databases of papers. Here we will follow Varum and Melo's categorization into three subsets of advantages and integrate Harries' additions. The first is improvement of the decision-making process by offering a way to envision plausible future states, generate strategies to reduce risk, capitalize on opportunities or avoid threats (Harries: development of robust strategies, adaptability). The second set of advantages has to do with the process of scenario planning. Here they find scenarios that provide opportunities to pre-experience the future, framing emergent ideologies, development, and communication of strategies (Harries: transmission of management ideas throughout the organization, leadership). The third category of advantages concerns the identification of new issues and problems. Here idea exchange between planners and external experts and organizational learning are mentioned (Harries: better understanding of the future, improved perception of patterns and change). Bradfield et al. (2005) order goals on two dimensions: scenario planning can be a one-off project or an attempt to create organizational capacity for an extended period; scenario planning can aim to explore or open opportunities or to achieve closure and result in specific decisions and a choice for strategies. Bradfield et al. note that there is no empirical evidence yet to support this framework. We would like to add that most reported scenario projects fall in the one-off category and that exploration is a necessary step before choosing to commit to strategies.

Harries, (2003) identifies possible mechanisms through which these goals may be achieved. One mechanism involves probabilities and prediction. As mentioned in the previous section, Schoemaker (1993) found that scenarios impact subjective probabilities or subjective confidence ranges. This is beneficial as often decision makers suffer from overconfidence, in the sense that they put too much faith in their ability to predict future developments. This is however also an argument against using judgments of probability for developing scenarios, as is done in for instance TIA. Judgements of probability are prone to a range of biases, of which overconfidence is only one example (Aldabbagh & Allawzi, 2019; Harries, 2003). An even stronger argument against using probabilities or prediction is that they are meaningless in an uncertain, constantly changing world. Another mechanism concerns the payoffs from a scenario exercise. In principle, planners are interested in hits (correct estimations of what will happen) and want to avoid misses (failing to foresee what will happen). Both make consideration of a portfolio of scenarios more informative than considering just one single possible future. An important mechanism via which scenarios impact decision making has to do with mental models. Scenarios should connect with decision makers' mental models and encourage them to challenge their mental maps of the world. Scenarios typically use a causal, storytelling mode to transfer information. This puts choices between options and reasons for choosing center stage and has been shown to engage stakeholders, support communication and help to identify gaps in argumentation (Harries, 2003). Since a scenario describes a coherent possible future world, it should also make decision makers become aware of when the world is moving in the direction of that particular world. Therefore, a possible mechanism is the ability to better distinguish noise from substantial changes. In constructing scenarios, creativity is needed when starting from a set of uncertain developments and reworking them into a plausible scenario. People tend to shy away from unlikely and negative futures and facilitation may be necessary to help them explore a wide range of possible futures. Constructing and using scenarios may also strengthen metacognitive processes. Participants in scenario planning think about how they process information and make decisions. They separate multiple possible states of the world, strategies to address these, as well as reason about their combinations. Metacognition can in turn improve estimations of possible actions and lead to a more realistic estimation of the organization's efficacy. A final mechanism involves adaptability. Not only do scenarios help to identify strategies robust to alternative futures, but they also sensitize decision makers to the need to keep updating their models of the world.

Amer et al. (2013) offer another view on mechanisms and goals of scenario planning. They list quality criteria for scenarios as described by various authors and process elements that contribute to these criteria. Process elements are closely linked to steps in creating scenarios and it is noted that omitting steps or simplifying the process is likely to reduce the overall quality of the scenario planning project (Back et al., 2015) The review of O'Brien and Meadows (2001) also identifies a study that links the process of scenario planning to the quality of the result: Ziegler (1991) indicates that the range and diversity of scenarios is increased if a more diverse group of participants is involved in their construction (O'Brien & Meadows, 2001). Varum and Melo (2010) propose to evaluate the effects scenario planning on the decision-making process, in particular with regard to transparency and openness to criticism, as well as organizational performance and competitiveness (Chermack et al., 2001; Varum & Melo, 2010) underlines the importance of evaluation for advancing the field, calling attention specifically to measuring the impact of participation in scenario planning decisions. All authors highlight the importance of a detailed evaluation.

Table 5 is based on the information presented by Amer et al. (Amer, Daim, & Jetter, 2013) and adds the topics raised by Harries, (2003), and the other authors as described above. The criteria address the core products of scenario planning: internally consistent, plausible, and different scenarios that challenge mental models, impact decision making and help to choose robust strategies (Bradfield et al., 2005; Harries, 2003; Heijden & der, 1996).

For scenarios to be useful, no matter the technique used to develop them, it is important to be consistent, and with the power to break down old paradigms while analyzing a phenomenon of concern, managing existing information, and thinking out of the box. Roubelat (2006) proposes a breakdown of paradigms, forcing us to rethink the internal and external boundaries of an organization with a reasoned judgement and intuition (Araújo & Casimiro, 2019; Oliveira et al., 2018). Scenarios need to provide an enduring vision that can be the base for potential strategies or decisions under uncertainty (Aldabbagh & Allawzi, 2019; Chermack et al., 2001). The scenarios are presented as narratives with a threefold outcome: strategic planning for decision-making, increase of awareness for uncertainty, and a change of the mindset that could lead to implementing specific strategies (Araújo & Casimiro, 2019). Narratives include different combinations of assumptions, serving to reduce uncertainty (Amer, Daim, & Jetter, 2013; Chermack et al., 2001). This gives the organization a basis for evaluating alternatives and focus on (blind spots) (Amer, Daim, & Jetter, 2013; Chermack et al.,

2001) which can impact performance.

3.11. Critique of scenario planning and reporting guidelines

The previous section identified goals of scenario planning and mechanisms that help to achieve these goals. Comparing theoretical goals and mechanisms to actual scenario practice makes it possible to identify shortcomings in the way in which scenario planning is currently used. This section will address these shortcomings and relate them to shortcomings identified in the reviews included in our database. This gives rise to several conclusions on future reporting of scenario studies.

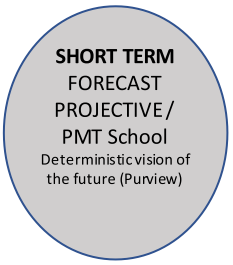
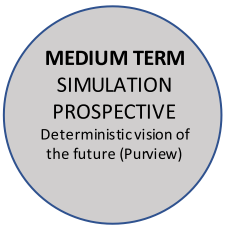
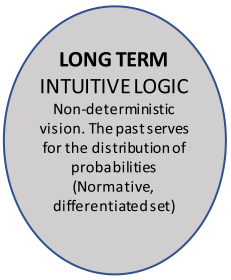
A first point of critique on the present approaches for constructing scenarios is their potential restricted range (Wright and Goodwin, 2009). As described previously, scenarios are typically constructed by internal stakeholders and outside experts. The latter group may include 'remarkable people' and minorities with 'heretical views' (Wright and Goodwin, 2009: 820). A more systematic way to check for too restricted consideration of potential future developments is by using structured techniques to challenge opinions. Examples are devil's advocate and dialectical inquiry, the frame analysis worksheet, using backward logic and the "red team/blue team" method. A second critique concerns the lack of testing the internal logic of scenarios. Amer et al. (2013) offers the consistency matrix as a tool to check the compatibility of developments brought together in a scenario. Wright and Goodwin (2009) recommend strengthening the causal links in a scenario narrative by focusing on human motivation. The idea is to keep basic human needs, following Maslow's pyramid, in mind as potential drivers for future developments. To ensure that all relevant stakeholders are considered, Wright and Goodwin suggest stakeholder identification and analysis techniques. All in all, there is a clear difference in the use of the techniques to evoke and create scenarios. Some authors emphasize analytical thinking and others focus on creative thinking. Creative thinking is based on the external environment (which is described using techniques such as PESTEL) and what participants would like their organization to be, unconstrained by existing conditions or possibilities (Oliveira et al., 2018). Analytical thinking also starts from identifying possible external changes, but the remainder of the process is dominated by quantitative techniques, creating a more rational approach which makes it easier to achieve internal consistency. However, a common critique of the quantitative approach is that it lacks imagination. A good balance between creativity and analysis is needed for the creation of scenarios that are at the same time evocative and have adequate internal consistency for planning and execution.

After having reviewed goals, mechanisms, and major critiques of scenario planning, we can summarize which aspects need to be reported on in future reports of scenario planning. In general, reports should cover as completely as possible on the aims of the project, the process followed, and the results achieved. Aims include the issue that prompted the organization(s) involved to start a scenario planning project. This can be compared against the three categories of goals distinguished by Varum and Melo (2010): improvement of the decision-making process, process of scenario planning, and identification of new topics or problems. Some goals and effects may emerge only later in the process. Phelps, Chan, and Kapsalis (2001) for instance find that the use of scenario planning increased financial performance, but possibly at the cost of worsening customer service levels. With regard to the process followed, the generic scenario planning school that inspired the project planning needs to be noted. Selection of participants, interaction moments with participants and techniques used, intermediate and final products need to be described. Evidence for the operation of any of the mechanisms described by Harries (2003) or listed in Table 5 (extended from Amer et al., 2013) can be provided. Finally, results achieved with regard to the initial and emergent goals need to be specified (Phelps et al., 2001). In general, a report of scenario planning needs to indicate impact on decisions taken, impact on performance against the identified goals, and the possible mitigating effect of internal and external factors. Similar to what is suggested by Caplan on the interaction between science and practice (Mingers & Brocklesby, 1997), a project may only indirectly create impact, for instance by changing agenda setting or decision makers' thinking. It may be challenging to report the impact of scenario planning beyond the team that participated in scenario development (Mulugeta et al., 2018). From an academic point of view, it would be particularly relevant to report on failed case studies. So far, with very few exceptions the literature consists of successful scenario reports (Harries, 2003). Finally, there are other factors mentioned by other authors as important as the personality of the decision maker (Harries, 2003) or match between behavior and performance for the organization (Hodgkinson & Wright, 2002; Phelps et al., 2001; Wack, 1985) All these details are important to determine the influence of the context, the mechanisms that were operational and the eventual results. Reporting in this manner helps to generalize results to other organizations and improve future decision-making (Harries, 2003). Table 2 can serve as a check on the comprehensiveness of a scenario planning report.

4. Conclusion and discussion

This study addressed four research questions: 1. Which definitions of scenario planning are used and is a shared definition emerging? 2. Which approaches to scenario construction are reported and how can these be classified? 3. Which techniques for scenario planning are reported and what is known on their frequency of use? 4. What is reported in the literature on effectiveness of scenario planning? With regard to the definition of scenario planning, we found that scenarios have a temporal property rooted in the future and reference external forces in that context; scenarios should also be possible and internally plausible while taking the proper form of a story or narrative description; scenarios seem to exist in sets that are systematically prepared to co-exist as meaningfully different alternatives to one another (Spaniol & Rowland, 2019). Regarding the second question on approaches to scenario planning, this study also determined the types of scenarios that are based on different schools (*Section 3.1*). Among these schools, the construction of scenarios involves a choice of levels of participation, time, goal, and the validation of the sets of scenarios (Bishop et al., 2007). (Magruk, 2020). The third research question was on the techniques used for scenario planning. The main techniques are dynamic scenarios and cognitive fuzzy maps (Table 4). With regard to research question 4, on the effectiveness of scenario planning, we

Table 6
Framework for scenario construction.

For all cases						
Vision of the future	Uncertainty	Potential error	Phases	Participation	Risk of bias	Evaluation
Exploratory 	1) Veracity of the data 2) interaction between data 3) level of knowledge of the method	1) unbalanced parameters or lack of data 2) inconsistent combinations 3) challenge mental models 4) Include the complex situation	Phase 1. Think-out of the box (PESTEL)	Stakeholders Expert (s)	Data availability for simulation, probabilities	Indicators can inform about the effectiveness while evaluating the construction of scenarios. First, the methodology or the school of thought followed, then, every step followed within every phase, inform about the participation, the uncertainty, the bias and errors
	4) vagueness 5) probability 6) ambiguity	5) lack of understanding of trends 6) struggle with uncertainty 7) delegated participation	Phase 2. Identify the uncertainties and importance	Stakeholders Expert (s)	Forecasting	
Exploratory 	7) It depends on the level of knowledge and level of predictability to forecast (ST),	8) Hard time to evaluate robustness 9) Hard to see the effects in the future 10) Include monitoring for impact	Phase 3. Evaluation of the impact	Stakeholders Expert (s)	Stability (outsourcing)	
	to simulate (MT) or intuitive logic (LT)	11) Differentiate timing: ST, MT, LT	Phase 4.			
		12) Avoid the probability estimation or prediction	Plausible scenarios	Stakeholders Expert (s)	Probability (precision)	
	8) Try to implement the strategies while	13) mental model: knowledge, learning and perception of change				
	anticipating the consequences in other scenarios	14) Partial participation and expert knowledge is mixed			Double scenario analysis	
Anticipatory 			Phase 5.			
	9) One desired outcome	15) creative thinking, 16) quality of ideas 17) think multiple scenarios, also the negative ones	Appraisal of scenarios	Stakeholders Expert (s)	Social biases	
	10) Bias for some variables		Phase 6.		Overconfidence	
		18) Distinguish: desirable, feasible, realizable and risk management. 19) engage on decision-making	Base for policy options	Stakeholders Expert (s)		
	11) Power relations 12) Wind-tunneling for consistency	20) consider multiple states of the world, and the strategy, and its			Consensus	

(*continued on next page*)

Table 6 (*continued*)

For all cases						
Vision of the future	Uncertainty	Potential error	Phases	Participation	Risk of bias	Evaluation
		adaptivity (change quickly) 21) include all relevant issues coherently 22) No inclusion of probabilities				

found that there is little in the sense of empirical evidence. However, theoretical ideas on goals and mechanisms abound and can be used to critique current scenario practice and improve future reporting. We bring these together in Table 5.

Table 5 presents not only the schools of thought but also the steps to follow within that school, and the elements to include while using the technique. Authors claim that new types of scenarios emerge for specific situations that require tacit knowledge on the application but do not include sufficient documentation (Harries, 2003). The lack of clarity and transparency in the procedure of constructing scenarios might be a reason for new techniques to keep emerging. Unclear reporting guidelines complicate assessment of the effectiveness of scenario planning and limit the growth of evidence the impact of the approach. While the diversity of approaches is not necessarily negative, since it adds flexibility and adds to the approach's versatility, the downside is the confusion that it creates for prospective users as it is not clear which form of scenarios to use in which context to which effects, nor which results are reproducible. This can be seen as an attempt to have a realist evaluation that tries to find out "what works, for whom, and in what circumstances" (Salter & Kothari, 2014). The usefulness and value of a technique begins with a clear and transparent description of the steps required, the participants involved, the degree of involvement, and the outcomes achieved while constructing the scenario. Besides, reproducibility is desirable for any method that claims to be scientific, while planners that have more practical or normative goals in mind, likewise can benefit from tested tools yielding reproducible results.

The timeframe considered in the scenario planning intervention is also important. This determines the level of uncertainty and the type of scenario to be employed. On the short and medium-term the current state of external factors can be used for making projections and simulations, as proposed by Spaniol and Rowland (2019), and Magruk (2020). For the long-term scenario planning, two types of scenarios, the normative or differentiated, described by Spaniol and Rowland are likely to be useful. Many would argue that the choice for a method or technique depends on the nature of the problem (Bishop et al., 2007; Charrois, 2015; Varum & Melo, 2010). Nevertheless, at the same time, it is important to consider the way the future is pictured when considering plausible futures. In general, all authors acknowledge the existence of uncertainty while exploring the future. Some of the techniques used in scenario planning treat uncertainty as inherent to the activity of planning for the future. Nonetheless, only four out of 13 manuscripts explicitly address the different levels of uncertainty and their associated techniques (Amer, Daim, & Jetter, 2013; Bishop, Hines, & Collins, 2007; Magruk, 2020; Varum & Melo, 2010). Uncertainty refers to epistemic situations that deal with risk, probabilities, information, and multiple methods have been developed to address this issue and its levels for various disciplines, for example game theory. An important question in this respect is whether the future is understood as a continuation of the present, or is out-of-the-box thinking required? Scenario planning typically aims to use creativity to increasing awareness of plausible futures, and is not usually limited to forecasting (Bradfield et al., 2005; Harries, 2003; Heijden & der, 1996). This may help to avoid bias such as overconfidence when extrapolating past trends or data (Bradfield et al., 2005; Harries, 2003).

While analyzing the concept, approach and techniques, it was noticed that there were indeed many options that may create confusion for novice or even experienced scenario planners. Most of the reviews we analyzed not that although many elements are repeated across papers, reports of scenario applications tend to lack detail on process and results, details that could bring more clarity to the steps taken while using one technique or the impact to be expected in a particular context. The manuscripts used in this research typically describe how the core of the scenarios is constructed, specifying the techniques used, but not how the scenario story is written. This leaves out an essential step in the scenario planning intervention, as the approach to writing the scenarios is an important determinant of changes in decision making and for evaluating its effectiveness (Harries, 2003). Therefore, it is important to report consistently and detail the process sufficiently so that the relation to organizational performance can be determined. Sometimes, the goal of scenarios is to create awareness, particularly when the focus on the long term. In these cases, it is also needed to evaluate the influence on decision making or the extent to which awareness influences in the preparation for the future. A report on this would help to measure the effectiveness of decision making or planning.

Many authors state that participation is important as it is a source for data and internal consistency. Two of the three schools follow this line of thought. Still, in this review of reviews, only six of the 13 reviews refer to participatory construction of scenarios, while the same observation of Schwartz (1991) is quoted, that scenario planning lacks in theoretical foundation and a clear description of its impact on decision-making or the organization. In this respect, the scenario planning literature can benefit from insights built in stakeholder theory and its application in operational research or management science. Theories of stakeholder identification and salience define the principle of who and what really counts and describe how facilitated approaches help to integrate diverse stakeholder views (de Gooyert, Rouwette, & Kranenburg, 2013; de Gooyert, Rouwette, van Kranenburg, & Freeman, 2017). Poskitt et al. (2021) offer one possible explanation of learning effects. For Oteros-Rozas et al. (2015) common understanding and learning are likely outcomes of scenario planning, and that monitoring, and evaluation is needed, in particular for assessing the impact on behaviour

complex which is comples as it needs commitment and a balance between scientific and local goals. To build on these insights, it is important to also report on how the facilitation process was managed to avoid different bias (Table 6).

The authors designed a converging table that compares *grosso modo* the school of thought, methods, steps, and evaluation of effectiveness (Table 6). This table integrates the evidence and points to convergent ideas in the literature. First, it shows the different visions of the future that underly the ILM, LP, and PMT schools in the main based on Spaniol and Rowland (2019) and Magruk's (2020). The purview includes a deterministic vison of the future for the short and medium term. The normative and differentiated set includes the nondeterministic vision. Magruk indicates that while shorter terms could use a deterministic vision of the future, the long term requires a non-deterministic vision, using the past just only to determine the distribution of probabilities and events. The framework in Table 6 may help to reduce the methodological chaos in terms of how to construct a scenario but also on how to evaluate them (Chermack et al., 2001; Whaley, 2008).

Every phase in the construction of scenarios can benefit from the participation of stakeholders or experts. Using experts or stakeholders throughout or in parts of the process, makes it possible to participant opinions for verifying the internal consistency of the scenarios. The inclusion of participants is more effective than an individual approach, because it allows for bringing in diverse thinking, the creation of consensus, and shared understanding. It also increases the quality of analysis, decision making, and engagement. At the same time, it entails challenges such as a) reducing the responsibility (buck passing), focusing on positive aspects (bolstering), or delaying the negative effects (procrastination) mentioned by Rouwette and Franco (2015), b) bias while eliciting the future or towards the internal consistency (Harries, 2003).

Finally, although the manuscripts that we included may have their own reasons on why to include or not include elements of process or results in their report, we found it useful to employ a framework to increase awareness of details in the reporting of research outcomes. The development of the techniques is occurring while the use of scenarios is increasing; therefore, developing the methods through the improvement of the quality of the reports is important. Reporting needs to cover sufficient details on the process followed and results achieved, to keep up with scientific standards of reproducibility and evaluation of its effectiveness. Table 2 could be used as a starting point and improved over time.

This study has some limitations. One is that although this review of reviews intended to only include systematic literature reviews, literature reviews were also included even though they are less rigorous, to increase the number of manuscripts in our analysis. This may have produced a bias, either due to error in the inclusion or exclusion or due to less quality of the manuscripts. The quality of the reviewed manuscripts varies, with most of the reviewed articles scoring low or moderate. The quality of the manuscripts did not influence in the analysis but intends to highlight the increasing need for quality of research, particularly with the use of methods for reporting research outcomes which will serve for its evaluation of effectiveness. Second, the interpretation and the processing of the information was based on the framework created for this purpose only since no assessment framework existed for scenarios, and critical aspects might have been missed. However, authors included ample discussions to reduce bias in the results and the framework was based on medical framework for systematic literature review. Another limitation is that in the search of the most used techniques in the past ten years, we only assessed manuscripts with more than 100 citations. This may lead to bias as the citations may not only follow from the value or practicality of the reported technique, but also from the author's reputation, results obtained or the topic of the manuscript.

Future research is needed to define the circumstances under which, certain scenarios techniques are more effective, particularly for the short, medium, and long-term. A similar framework as Table 2 or improved checklist for its procedure could help practitioners and researchers to construct scenarios better use, monitor and evaluate them in the effectiveness. This could reduce the methodological chaos observed by multiple authors and improve transparency of the procedure and robustness of results which will help to determine better which scenario techniques are useful in which situations.

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Data Availability

Data will be made available on request.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.futures.2023.103153.

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