DESIGNING SOLUTIONS FOR UNCERTAIN FUTURES: A CHECKLIST FOR CHOOSING SUITABLE SCENARIOS

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ABSTRACT

Future scenarios are intermediary artefacts for mid- and long-term design of complex solutions, e.g., to improve urban mobility systems. They allow designers to explore possible alternatives and incorporate uncertainty in the process. While their making is widely studied and implemented in scenario planning, their assessment got little attention. To find out which characteristics of scenarios we can assess, we conducted interviews and an expert workshop. This results in a scenario assessment framework of 3 levels: Assessment of system impact, evaluation of impact on practitioners and quality assurance. We focus on the latter as it represents the key gap and established a checklist for it. We distinguish between the level of engagement, i.e., scenario makers and users who adapt existing sets (or archetypes). Finally, we provide a checklist to aid ensuring that when choosing existing scenario sets, key criteria are fulfilled. This shall enable designers to better integrate scenarios in their workflows. We provide examples of designing mobility solutions. Yet, the findings can be applied to all disciplines where scenarios can aid design processes but are so far limited due to the resources needed for creating meaningful scenarios.

Keywords: Scenarios, Futures, Collaborative design, Design methods, Evaluation

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1 INTRODUCTION

An extensive range of variations of scenarios is used to support the design process of products and services in design engineering. Some of the most common ones are to express narratives, e.g., a Customer (or User) Journey Map that allows understanding better behaviours, motivations, thoughts, feelings and emotions of people, to define design requirements, e.g., through use cases or user stories, or to model scenarios of a product reference to conduct a life cycle assessment (LCA). The latter is paramount to deriving the global environmental impacts of a product solution for a given functional unit of service provided (Cluzel et al., 2014; Bouillass, 2021). These scenarios require a vast amount of accurate data, which is rarely available in simplified and upstream LCA for complex industrial systems or diverse forthcoming marketing strategies. Further, ISO standards (e.g., ISO 14044:2006) provide only basic recommendations for working with such scenarios regarding modelling uncertainties, hypotheses and probabilities.

These approaches all work with a range of alternative states which differ from the current one and support the design practitioner in understanding future needs, immersing in different situations, or understanding complex impacts. This builds the basis for designing products or systems to best comply with a set of usage scenarios systematically modelled and with assigned probability. A segmentation of such usage contexts can be performed to compute the adequacy of commercial car configurations regarding known preferences of customer segments (Yannou et al., 2013). In the case of designing systems on a medium- or long-term in complex and varying environments, the futures or foresight dimension is often added to the methodology. Working strategically with futures using scenario techniques seems highly valuable for designing systems in an uncertain and complex world (McGrail and Gaziulusoy, 2014).

This has particular relevance when addressing systemic sustainability challenges, such as meeting the 2050 net zero targets and the accompanying need for sustainability transitions. Futures studies and strategic foresight have been developed and widely implemented in various contexts since the end of World War II. Numerous methodological contributions resulted from this, as synthesised in Crawford (2019). Among the various methods, creating future scenarios is widespread and acknowledged as a relevant tool for next-generation professionals to 'learn to think and act large change' (Mulder, 2017). This paper focuses on future scenarios, hereafter referred to as 'scenarios.' The development of scenarios usually derives from three different schools (Gräßler, Thiele, and Scholle, 2020): (1) intuitive logics (Chermack, 2011); (2) cross-impact thinking using trend extrapolation; and (3) consistency-based approaches. In this paper, we focus on narrative-based methods in the intuitive logics' tradition due to their conceptual alignment with futures studies principles (Gall et al., 2022). We build on the systemic definition of scenarios as having 'a temporal property rooted in the future and reference external forces in that context', that they should 'be possible and plausible while taking the proper form of a story or narrative description', and 'exist in sets that are systematically prepared to coexist as meaningful alternatives to one another' (Spaniol and Rowland, 2018, p. 1). Scenarios in the design process can thus be described as a specific intermediary object of a design process (see Figure 1 for simplified example).

Figure 1. Dehli 2030 scenarios with population of 26 million (Banister and Hickman, 2013)

Aside from its advantages in designing long-term solutions in complex contexts, scenario-making is known for being time and resource-intensive, creating barriers to its broader adoption in planning and design processes (Goodspeed, 2020; Gräßler et al., 2020, p. 575). Approaches that can reduce this intensity could further propel scenario planning and make it more accessible to potential user groups.

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Therefore, we focus in this paper on supporting methods that could achieve this, for example, by using existing scenario sets or archetypes. To work with existing scenarios, it is necessary to understand what the scenarios should accomplish and what boxes they should check. Scenario modelling (or making) has received considerable attention from scholars in the past years, but the evaluation or assessment of scenarios and their impact is far less documented (Goodspeed, 2020, p. 15; Fauré et al., 2017; Schmidt-Scheele, 2020). Yet, for practitioners, scenarios must have characteristics that allow them to trust in the scenarios, especially when they are not involved in the creation process. Our research question is thus: *Which (type of) characteristics of scenarios can we assess and what methods can be used therefor?*
To respond to this question, we structure the paper in four parts. In section 2, we break future scenario assessment into impact assessment, scenario impact evaluation and quality assurance. Section 3 details the proposition of a scenario assessment framework based on six semi-structured interviews and a multidisciplinary workshop. Section 4 presents the results of the empirical studies and introduces a practical guide for assessing or assuring the suitability or quality of scenarios. In section 5, we provide conclusions and discuss possible perspectives.

2 ASSESSMENT IN SCENARIO LITERATURE

This section reviews some of the literature on the assessment and evaluation of scenarios. We organised the content into three sections that became apparent during its review. The first sub-section focuses on impact assessment, referring to assessing the impacts on the overall system of a particular scenario. For instance, the amount of greenhouse gas (GHG) emissions in a 2030 urban mobility scenario; a field we draw examples from throughout this paper. In the second part, we review the literature on a less discussed issue: the evaluation of impact on practitioners. Here, we refer to the impact the use of scenarios has on the designer or planner working with or being exposed to them. This can include the development of a more critical perspective towards reliance on assumptions that are fed into future forecasts. Finally, we focus on quality assurance by discussing requirements that scenarios should fulfil to be useful for their purpose. A typical example is the number of scenarios within an applied set: Two scenarios lead to an either-or mindset, while 20 scenarios are too many to work with for designers.

2.1 Assessment of impact on the system

With growing complexity, experimenting on big-scale systems and testing their future impact proves difficult without incurring additional costs (Jacyna-Gołda et al., 2017). For this purpose, it is necessary to have methods, tools, or frameworks that support a comprehensive analysis of future impacts of scenarios in their given setting. The need to include impact assessment, e.g., in backcasting[1] processes, has been highlighted by Fauré et al. (2017) but is often neglected. Fauré et al. (2017) identify the relevance of frameworks for guiding assessments. Two main categories for assessment tools are described: 'Procedural tools' focus on the procedure of the assessment and the decision-context while 'analytical tools' highlight approaches that centre on analysing the impacts. Navarro-Ligero and Valenzuela-Montes (2016) propose combined scenario building and assessment through a 10-step framework, considering governance, social, environmental, and spatial criteria applied to explorative (strategic) and normative (backcasting) scenarios. Also, in a combined scenario building and assessment process, Muñoz et al. (2020) assess urban mobility scenarios (predictive forecasting and normative backcasting) on different aspects: energy, environment, and socioeconomic. They propose a methodology to simplify the process, identify the advantages and disadvantages of modelled alternatives and ultimately aid stakeholders within an urban context in taking a decision. Studies also tend to use a combination of different tools and methodologies. Hickman et al. (2012) combined multi-actor participation and multi-criteria analysis. Similarly, Keseru et al. (2021) selected their preferred aspects through expert participation, which was strengthened with a multi-actor, multi-criteria analysis tool. From the reviewed sources, no method is applicable to all cases. Additionally, the choice of methods was not always justified (Fauré et al., 2017). Yet, certain steps appear to be crucial to scenario impact assessment. For instance, setting a set of indicators that is coherent with the overall decision goals (Jacyna-Gołda et al., 2017) and aiming to answer, or knowing the answer to the question: 'What is at issue?' and 'What is the overall goal of the

[1] A process where one or several future states, e.g., scenarios or visions, are used to move backwards in time and identify which actions must be executed or avoided to get to the chosen future state.

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project?' (Kosow and Gaßner, 2008, p. 111). These steps guide the evaluators and potentially participants through the recurrent effort of decision making and representing users' interests. Key performance indicators have established their role as a key characteristic in planning. They can be quantitative, such as pollutant emissions, density, or local growth (Noguès et al., 2020), or qualitative, e.g., social equity and well-being. Tapaninaho et al. (2014) consider (environmental, economic, and social) as the three pillars for analysis, while sometimes the fourth governance pillar is added. Pucci (2021) highlights the importance of including the spatial dimension and combining an approach integrating Environmental, Social, Economic, Technological, Governance, Spatial dimensions. Summarising, we can highlight the need to identify coherent categories and indicators for future scenario assessment which remain applicable in an applied context.

2.2 Evaluation of impact on practitioners

In this section, we discuss measuring the impact working with scenarios has on designers and planners. As Goodspeed puts it, '[scenarios] should be evaluated primarily according to the performance principle, or whether they influence decision making' (Goodspeed, 2020, p. 145). This has been rarely discussed in the literature so far. Further, it is difficult to generalise evaluation across fields of application and types of involved stakeholders. Goodspeed (2020) discusses a limited set of studies that evaluated scenario planning exercises, including cases from environmental planning and management studies. Significant differences appear regarding applied methods, contexts, and which stages were evaluated, if applicable (Goodspeed, 2020). The most important contributions were made in the context of management, with a relevant number of studies in which Chermack was involved. Among others, the impact was measured on characteristics such as participant abilities or perceptions, before and after the workshops, with evident improvements across categories (Goodspeed, 2020). Another structured approach measured the relation between creativity and scenario planning (Curnin et al., 2022). However, three problems are pointed out across the literature: First, the timescale of scenarios makes an accurate evaluation often difficult as multiple processes are happening simultaneously, and it is difficult to attribute which changes can be clearly associated with scenario planning. Secondly, a significant amount of scenario planning and design is done by consultants for companies which hinder academic research due to confidential information and significant resource investments (Goodspeed, 2020). Lastly, the potential impact is primarily on the people involved in a process, such as employees of the planning department of a local authority. However, there is a likely staff fluctuation throughout medium- and long-term scenario planning, which results in the loss of institutional capacity that could be possibly evaluated after a few years. Thus, we can conclude that it is inherently challenging to evaluate the impact working with scenarios has. A main reason for that is that the information required for such evaluation is usually not at all, or at least not publicly, available. However, it might be the most powerful aspect of scenario planning and thus requires more attention (Meissner and Wulf, 2013; Goodspeed, 2020).

2.3 Quality assurance

Following the review of impact assessment and evaluation, this section focuses on what can be done to ensure the scenario 'quality' that allows designers to apply them in their work. Additionally, we can distinguish between possibly differing needs for types of scenarios. Börjeson et al. illustrate a scenario typology with three major classifications, namely 'predictive', 'explorative', and 'normative' (Börjeson et al., 2006, p. 206). While all three can aid design processes in different ways, predictive (i.e., forecasts or what-if) scenarios are often discussed apart. They do not fulfil the requirement of 'meaningful alternatives to one another', according to Spaniol and Rowland (2018). We assume that at least different requirements exist to ensure the quality of both explorative and normative scenarios.

Further elaborations on scenario requirements span from the number of scenarios and the elements within their narration (Vallet et al., 2020) to the methods for their creation and how to integrate impact assessment into the process (Fauré et al., 2017). Different criteria form the quality that makes scenarios engaging enough for stakeholders to consider them (Kosow and Gaßner, 2008; Chermack, 2006). They can be judged based on their internal and logical consistency, decision making utility, distinctness, simplicity, the definition of range, transparency, comprehensibility, and traceability (Kosow and Gaßner, 2008; Wilson, 1998). However, not all criteria are equally considered in the literature. Some are described as central to the scenario process; for instance, plausibility, defined as the feasibility or the possibility of the described futures, is checked to reduce the 'risk of being carried

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away' by the creative aspect of scenario making (Chermack, 2006). Indeed, the more scenarios are considered plausible, the more used they are (Schmidt-Scheele, 2020). Walton et al. (2019) emphasise the necessity of understanding plausibility from their local stakeholder's viewpoint to aid them in understanding uncertainties and enacting the future. They discussed scenarios perception by users based on concepts extracted from cognitive psychology, linguistics or philosophy of science.
This plausibility perception, applied to exploratory scenarios, is shown to be a necessary, yet insufficient, condition for practical use by planners. Along with plausibility, consistency is critical to label a scenario as credible. Consistency describes the non-contradictory images that are portrayed within a specific scenario (Kosow and Gaßner, 2008). It plays the role of both a constitutive element and construction principle to scenarios (Kosow, 2015). Moreover, scenario processes differ not only based on the techniques used but also on the participants involved. Kosow and Gaßner (2008) distinguish participants as scientists/consultants, internal and/or external experts/stakeholders and the affected people. The complex creation process of scenarios involves multiple assumptions and choices and can lead to verifiability issues if decisions are not transparent. Carlsen et al. (2017) commented on the lack of comprehensiveness and irreproducibility of the current scenario creation process. While emphasising the need for a more scientific and neutral approach, the authors described the methodological advances from futures research. Setting criteria and applying them to scenarios or scenario-making methodologies allows evaluators to assess those made by an external party and planners to follow a guide throughout the scenario development process (Kosow, 2015).

2.4 Synthesis and gap analysis

This paper aims to further the work on assessing and evaluating scenarios to enable a resource-considerate application in the design and planning context. We discussed existing research of impact assessment, impact evaluation, and quality assurance. The impacts depend strongly on the analysed system and the underlying ambitions, e.g., reducing GHG emissions or catering for historically underserved user groups. We thus introduced the example of urban mobility systems. We defined the evaluation of impact on practitioners as crucial for scenario-based design and emphasised the need for its integration into an assessment framework and further research. We claimed that working with existing sets of (archetypical) scenarios might address resource constraints as key barrier for broader adoption. We identified key potentials in the context of quality assurance. Thus, we extend the initial research question to if and how we can test if existing sets of scenarios suit design processes. With this as a basis, the next section outlines the conducted research, followed by a discussion of the results.

3 RESEARCH METHOD

To answer the posed research question, we conducted – in addition to a literature review – a set of expert interviews and a workshop described below. The method follows qualitative research standards. The qualitative approach was chosen given the explorative nature of the study to understand the key variables of scenario quality assessment. Qualitative data was collected, followed by an inductive analysis. Homogenous sampling was used for expert interviews and workshop. All participants were enrolled on a voluntary basis. First, we investigated the general perception of future scenarios through six semi-structured expert interviews conducted between 17/02/22 and 10/03/22 (duration between 30 and 60 minutes), which were partially transcribed, and its outcomes grouped into categories (Figure 2). The profile of participants, experienced scenario users in the field of mobility or urban planning, were: two industrials in mobility/transport; three scholars (PhD to full professor), and one senior expert of a French mobility association. The questions were mainly related to the activity of building or using built scenarios, as well as to their assessment methods. No exposure to existing scenarios or references was given to interviewees at this stage. Building on the insights from the interviews, an expert workshop was organised facilitated by two of the authors (duration 2:15h on 18/03/22). It involved five new academic participants (PhD/post-doc level) from three institutions who represented different disciplines and roles (Table 1), and one scholar from the previous interviews. All were mainly scenario users in the field of mobility and urban planning. The workshop followed an immersive approach to ensure engagement and enable the expression of participants. We focused on the activity of using explorative scenario sets ‘off the shelf’. Participants were asked to give a comparative perception of four scenario sets in groups. Each scenario set was presented briefly and handed out in a shortened format.

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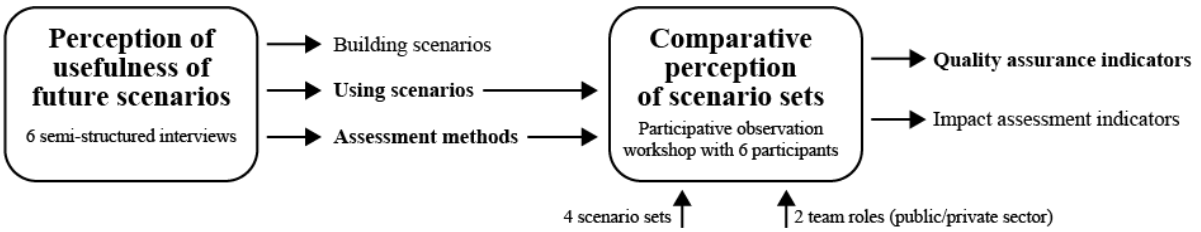

Figure 2. Empirical setting

Different sets of scenarios were presented from the mobility context. The four scenario sets are comprised of two to five scenarios:

- Carbone4 (Grandjean et al., 2021) presented two prospective scenarios, both respecting the carbon budgets of GHG emissions reduction trajectory of the National Low Carbon Strategy. The scenario 'sobriety' seeks to limit consumption and, therefore, the use of materials and energy, while the scenario 'pro-techno' focuses on technological developments whose maturity is not yet demonstrated today.
- Banister and Hickman (2013) discuss the benefits of three scenarios in determining alternative transport futures in 2030 and apply them to Dehli. The 'Lower carbon emission motor vehicles' points out the implementation of new technologies with an increase in rail use. The scenario 'Increased active transport' describes the reversal of current trends and an increase in distance walked and cycled. The last scenario 'Sustainable transport' assumes a dominance of lower carbon emission motor vehicles combined with increased active mobility.
- Futura Mobility (2021) created scenarios to explore trends observed or assumed in the distant future (2050). The 'Growth first' scenario describes unpredictable and rough environmental conditions. The 'Technology first' scenario showcases decreased inequalities with high technological growth and affordable zero carbon emission energy. 'Resources first' represents strict social rules about conduct with a decline in openness and a going-back-to-basics attitude.
- The French Government (CGEDD, 2022) started with the 2022 situation as baseline and built five forecasting and two backcasting scenarios.

The participants were separated into two groups (Table 1), balancing gender and institutions/profiles, in which they took on a role in a public actor (local authority) or private sector (vehicle manufacturer and mobility service provider) institution.

Table 1. Profiles and roles of workshop participants

Group 1: Public Sector	Mobility-as-a-Service expert Mobility services expert Public transport expert Facilitator	**Group 2: Private Sector**	Public policy expert Assessment expert Simulation expert Facilitator

The participants discussed the utility of the presented scenario sets. The groups ranked the scenarios according to the assumed utility they would have for their organisation. This was followed by a discussion on the reasons for the ranking. The second step was mapping indicators. Participants individually compiled indicators for assessing both the quality and the impacts of scenarios, again from the perspective of the taken role. The participants were tasked to determine key indicators (quality, social, environmental, economic, and other impacts) and the measures (qualitative, semi-quantitative, quantitative) that they would use to assess scenarios. The group members presented and discussed their ideas with each other and organised them in an assessment framework. A focus was on the category of 'quality of scenarios.' With that as a basis, the decision of the most adequate set of scenarios from the previous step was repeated. In the final part, a series of questions were posed:

- What is your perception of the adequate scenario set (and why)? What is an appropriate number of scenarios in a set?
- What is a good balance between the different dimensions (e.g., social, economic, or environmental aspects)?
- What information should be provided or addressed by the scenarios?

The following discussion focused on the advantages and disadvantages of each of the scenario sets and how their characteristics were useful for the public and private sector groups. Finally, possible additions or improvements of the scenarios were discussed that would allow to better respond to the

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initially defined needs. The consistency of findings between interviews, workshop, and literature was finally checked individually by three of the authors and reported in a checklist format (see Table 2).

4 RESULTS AND DISCUSSION

This section briefly describes the outcomes of the performed interviews and a conducted expert workshop. This is followed by this paper's central contribution: A proposed checklist to help designers to verify if existing sets or archetypical scenarios are suitable for their planned activity.

4.1 Outcomes from interviews: Perception of usefulness of scenarios

In the interviews, environmental, social, and economic factors were the most recurrent answers. The spatial setting was also highlighted as it is believed to define social and economic needs. Scenarios were seen to explore ideas and concepts that do not currently exist. Time and resources that are usually allocated for the scenario-making and assessment process are limited. However, they showed great interest and knowledge in them and highlighted their importance for their work. A need to include people from different backgrounds in the participatory approaches was pointed out to get a more diverse evaluation [P4 (Quality Indicator, Table 2)]. Furthermore, involving different people at different stages of the process could prove fruitful. It was also deemed important to have experts in 'retro perspective' to do this. Both the assessment of quality and the impact of scenarios were highlighted (P2). The participants talked about participatory approaches and the importance of evaluating already built scenarios to determine their quality (e.g., plausibility (C3), comprehensiveness (C9), feasibility). The quality of scenarios was mentioned to be checked but not explicitly. The interviews showed further that including too many scenarios in the process of assessment (participatory approach) could lead to 'cognitive overload' and inefficiency (A1). The interviewees mostly worked with scenario sets of three to five scenarios. Considering too many indicators was also believed to cause the same issues (one participant stated 18 indicators as too high for participatory approaches). Further, multi-criteria tools and participatory approaches were the most mentioned assessment methods. The economic aspect was said to be evaluated through economic models, whereas the environmental and social aspects are evaluated through indicators defined by experts. Great interest was shown in having appropriate methods to update scenarios when necessary following external changes or the realisation of a lack of quality.

4.2 Outcomes from the workshop: Comparative perception of scenario sets

In the workshop, the group representing the public sector preferred the Banister and Hickman scenario set (BH), followed by the ones from the French government (FG), Carbone4 (CF) and Futura Mobility (FM). The participants chose the scenario set based on criteria that respond to their needs (C5). A link here can be made to the impact assessment of scenarios and the according set of indicators. If, for example, as a policy maker, the primary objective is the reduction of GHG emissions, then the scenario sets need to provide sufficient information about this. As the public sector represented a local authority, a strong focus was on the spatial scale and localisation of the scenarios, most importantly if the scenarios could be adjusted to the local setting (A3). Further, the satisfaction, performance and safety in public transport, as well as the temporal perspective in the context of elections, were mentioned (A2). The second group, representing the private sector (a ride-hailing provider), ordered the scenario sets into CF, BH, FM, and FG. The factors which guided the choice were primarily the number of criteria considered in scenarios, the level of technicity, and the comprehensiveness of scenarios (C5). More detailed findings will be included in the checklist in the next section.

The subsequent discussion between both groups and the facilitators highlighted a few key elements. First, a strong focus was on the content of the scenarios. Most importantly: Do the scenarios provide relevant information for the concerned sector (C5)? In the case of the ride-hailing company, it was pointed out that some of the sets did not offer any qualitative or quantitative information on such services, thus rendering the scenarios irrelevant to them. Another point, strengthened by the diverse set of participants, was the importance of both qualitative and quantitative information (C6). The FM set of scenarios was, for example, criticised for its lack of clear numbers but praised for its narrative character. The opposite can be said for the scenarios sets FG and BH. Thus, to allow for broader

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applicability, scenarios should provide diverse types of information (R7). Lastly, their representation was discussed (R1, R3-R7). We will focus on this point further in the following.

4.3 Quality assurance checklist

In this section, we combine the findings from the literature, interviews, and workshop into a checklist (Table 2) that can support designers in choosing, depending on the situation, if scenarios can be adapted to the needs of a design process. We emphasise that different actors have different needs. For example, those that compare different options and those that require qualitative and quantitative inputs and creative stimulation for the design processes of potential future solutions. The checklist is organised into four sections, namely the process of creating the scenarios, their attributes, their content, and the way they are represented. The first column shows the origin of the indicator, and the core represents the checklist. On the right, the authors tested how each of the previously presented scenario sets would respond to the needs of a potential private sector user who intends to test the utility of a developed autonomous mobility shuttle service across multiple scenarios. It shows that a mix of scenario sets might in some cases be suitable and that universal scenario sets are not common.

Table 2. Checklist for designers and decision makers with features (I = individual scenario, S = scenario set, E = expert interviews, W = workshop, L = literature) and exemplary application to test if scenario sets are suitable

ORIGIN	CHECKLIST		APPLICATION			
Feat.	ID and Quality Indicator		BH	FG	CF	FM
S, W	Process	P1: Are the provided materials about the scenarios clear?	X	X	X	X
S, E		P2: Is the creation process known and sound?		X	X	X
S, W		P3: Are the involved participants and their roles transparent?	X	X		
S, E/W		P4: Do the participants have diverse profiles?				
S, E/W	Attributes	A1: Is the number of scenarios adequate for the purpose?	X	X	X	X
S, W		A2: Is a specific timeframe assigned to the scenarios and does it match the project's needs?	X	X	X	X
S, W		A3: Were the scenarios created for a specific location and match the project's needs?		X	X	X
S, L		A4: Do the scenarios provide distinct alternatives*a,b?	X	X	X	X
S, L		A5: Are the scenarios equally preferable (and not, e.g., utopia vs dystopia)?			X	X
S, L		A6: Are they temporally rooted in the future?*a	X	X	X	X
I, L	Content	C1: Are all scenarios addressing the same topic and challenges?	X	X	X	X
I, L		C2: Is each scenario coherent, and can its events described be presented as a story?*b				X
I, E/L		C3: Are the scenarios plausible and possible?*c,b	X	X	X	X
I, L		C4: Is each scenario interesting?*b	X		X	X
I, W/L		C5: Is the information provided by the scenario relevant?*b	X	X	X	
I, W		C6: Does it combine qualitative and quantitative information?			X	
I, W, L		C7: Does the story encourage creativity?*d		X		X
I, L		C8: Is there information on the pathway between today and the futures?	X	X	X	
I, E/W		C9: Is the scenario comprehensive?	X	X	X	
I, W	Representation	R1: Does each scenario have a catchy, coherent, and descriptive name?	X	X	X	X
I, L		R2: Is it possible to relate to the scenarios?*b,e		X	X	X
I, W		R3: Is the scenario communicated with an interesting narrative?*a				X
I, W		R4: Does it (allow to) integrate specific elements, places, and details?		X	X	X
I, W		R5: Is it easy to understand in a setting with and without a facilitator?		X	X	X
I, W/L		R6: Does it provide the required types of cross-media formats, e.g., graphics and text?		X	X	X

** a: Spaniol and Rowland, 2018; b: Chermack, 2006; c: Schmidt-Scheele, 2020; d: Curnin et al., 2022, e: Vallet et al., 2020*

5 CONCLUSIONS AND FUTURE WORK

We set out to respond to the question which (type of) characteristics of scenarios we can assess and what method we can apply therefor. Following a literature review and expert interviews, we established an

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initial framework distinguishing between impact assessment, evaluation of impact on practitioners, and quality assurance. We identified a potential in formalising the latter as it enables more design practitioners to work with scenarios and thus more adequately integrate complex environments and uncertainties as factors into medium- and long-term solution design. Complemented by data collected through a multidisciplinary workshop, we developed an initial checklist of characteristics designers need to pay attention to when choosing to work with existing scenario sets. Additional to 11 criteria from literature, 13 new criteria resulted from interviews and the workshop. We argue that this can support the scaling up of working with multiple futures in complex system design environments even if the resources do not allow creating scenarios from scratch. On the other hand, the criteria could be equally guiding the design brief for, e.g., outsourcing scenario-making. A few limitations and avenues for further research exist. Methodologically speaking, the personal and subjective assessments provided by experts can be questioned. This relates to a common question raised by qualitative studies: Is objectivity possible and desirable? In line with Patton (1987, p. 166), we look for 'multiple "truths" depending on different points of views', and hence used multiple data sources to maximise the findings' validity. Second, we could further distinguish between different roles. More precisely, is there a significant difference between requirements for scenarios aimed at designers compared to decision-makers? More extensive testing is required to explore this. Further, different types of scenarios are frequently used. Two of the most common ones are exploratory and normative scenarios. It is likely that their use also comes with different needs. However, our focus is foremost on exploratory scenarios, which is the reason for omitting a more extensive discussion of normative works. Finally, the impact on designers of working with scenarios – impact evaluation – bears various potentials, mostly to quantify the accuracy and validate the proposed criteria. We would assume that working with more adequate scenarios would result in a higher positive impact on the designer. However, similarly to the previous points, this requires more and larger in-depth studies to test such assumptions on an empirical level.

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