

# decision-making for sustainability

A Systematic Review of the  
Body of Knowledge



Network for  
Business Sustainability  
Business. Thinking. Ahead.

Prepared by  
Joseph Arvai,  
Victoria Campbell-Arvai and  
Piers Steel

Managers face  
many decisions,  
but they often make  
unsustainable choices.

How can we  
encourage individuals  
in organizations  
to make more  
sustainable choices?

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Dear Business Leaders and Policy-Makers,

Many decisions individuals make – from what food to buy to how much energy to use – involve sustainability-related tradeoffs. Organizations, too, make sustainability decisions. Some decisions, such as where to site a new facility or how to manage a natural resource, can involve a range of interests and criteria and have significant implications for profits, the environment and society. This challenge motivated the NBS Leadership Council to ask “How do individuals make decisions regarding social and environmental issues?”

This report represents the culmination of a year-long research study. The research team from the University of Calgary filtered through thousands of articles to summarize the best available evidence to provide an understanding of how individuals inside and outside organizations make decisions and how we can support better decision-making.

You will find valuable insights throughout this report. In particular, we encourage you to review the decision support techniques described on pages 43 to 44 and in the executive report. These techniques have been employed to help decision-making in a range of contexts by individuals and organizations around the world.

We hope this report will provide insight and clarity into the sustainable decision-making process for you, your organization and your stakeholders.

Sincerely,

The NBS Decision-Making Committee and Advisors



Peter MacConnachie, Suncor Energy Inc. (chair)



Brenda Goehring, BC Hydro



Rich Grogan, Antioch University



Chris McDonell, Tembec

Dear Reader,

I am pleased to share with you this report on decision-making for sustainability. Businesses face numerous decisions daily, most with sustainability implications. It's often hard, however, to make sustainable choices – particularly when faced with competing demands, tight deadlines and personal biases. This research sheds light on how people make decisions and the levers that enable sustainability.

This report systematically reviews the body of knowledge in this area, including 207 articles, books and reports from more than 60 years. It helps explain why individuals often don't land on the most sustainable outcome. It argues that there are two types of decisions, routine and complex, each with its own stumbling blocks. This report provides the reader with the tools to help get to better outcomes under both types of decisions.

This research was authored by a team based at the University of Calgary, Joseph Arvai, Victoria Campbell-Arvai and Piers Steel. The team has benefited from the insights offered by their guidance committee, which included Peter MacConnachie, Brenda Goehring, Rich Grogan and Chris McDonell.

This systematic review is one of many that form the backbone of NBS. The topics are chosen by

our Leadership Council, a group of multi-sector organizations leading in sustainability whose names you will find at the end of this report. This group meets annually to identify the sustainability topics most salient to business. Identifying how individuals make sustainability decisions was near the top of their list in 2011. The reports from all their past priorities are available freely on our website at [nbs.net](http://nbs.net).

We are proud of our systematic reviews. Popularized in the field of medicine, they systematically and rigorously review the body of evidence from both academia and practice on a topic. The result is an authoritative account of the strategies and tactics of managing sustainably, as well as the gaps for further research.

I hope this report will help you understand how you and your organizations can improve your decision-making processes to reach more sustainable outcomes.

Sincerely,



Tima Bansal, PhD  
Executive Director, Network for Business Sustainability  
Professor, Richard Ivey School of Business

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# introduction

This report draws from over 60 years of research on decision-making to provide insight into why people may face difficulties when balancing social, economic and environmental considerations in decision-making scenarios.

A sustainability officer is tasked with finding ways to encourage employees to reduce office waste.

A manufacturing company is looking to address a broad array of health, environmental and economic considerations when remediating and reclaiming the grounds of one of its old facilities.

A non-governmental organization is seeking to increase the adoption of energy-efficiency measures among homeowners.

A large university is considering several options to power its campus — but how to choose among them to ensure that environmental, economic, educational and social objectives are met?

An energy utility is investigating how to manage river flows to continue to provide reliable electricity, but in doing so to also accommodate the needs of other river users and to maintain the river's ecological integrity.

These scenarios represent the kinds of tough, sustainability<sup>1</sup>-related decisions faced by individuals, organizations and governments. Traditionally, home- and office-based sustainability decisions, like those above, have relied on employee or homeowner education, while manufacturing and management decisions have been approached in largely unaided and unstructured ways. This report draws from more than 60 years of research on decision-making to provide insight into why people may face difficulties when balancing social, economic and environmental considerations in these types of decision-making scenarios. In addition, we describe specific techniques to help individuals, organizations and governments overcome these difficulties and more effectively incorporate sustainability goals into their decision-making.

<sup>1</sup> We define sustainability as “meeting the needs of the present without compromising the ability of future generations to meet their own needs” (from *Our Common Future: Report of the World Commission on Environment and Development*, <http://www.un-documents.net/ocf-ov.htm#1.3>). We add to this definition the idea that decision-making for sustainability requires explicit social, environmental and economic considerations during the decision-making process (often referred to as the triple bottom line).

The decisions faced by individuals, organizations and governments have become increasingly difficult. In addition to needing to address more basic considerations such as costs and convenience, the decisions we face today need to encompass a host of other objectives, including the broader environmental, ethical or social aspects of a particular action. One view of decision-making suggests that people can carefully sort through information and options to choose a course of action that maximizes the achievement of these different objectives. However, research suggests that this view does not represent how decisions are actually made. Thus, finding a way to more effectively incorporate environmental, social and economic concerns into our decision-making is of paramount importance.

In 2010, the Leadership Council of the Network for Business Sustainability identified decision-making for sustainability as a priority research topic for a systematic review. In response to this request, we conducted a systematic review of both the existing body of knowledge regarding how people actually make decisions and the decision-support techniques currently available to better incorporate sustainability concerns into group and individual decision-making. The general goals of our review were (i) to provide insights to analysts and managers about the nature of human judgment and decision-making, particularly as it pertains to incorporating and addressing social and environmental concerns and (ii) to catalogue the currently available decision-support tools and techniques to more effectively facilitate decision-making for sustainability.

To address these issues, we conducted a broad search of the literature using keywords relating to decision-making, decision-support and intervention techniques for sustainable outcomes. Ultimately, **207 sources** were included in this report: 174 academic journal articles (from psychology, marketing and decision analysis), 22 books, and 11 government and private industry reports. A detailed description of our search methods, the scope of the data reviewed and the full list of these 207 articles, books and reports can be found in the appendices.

This literature was analyzed systematically to identify key insights into human decision-making (particularly as they related to incorporating sustainability concerns) and key techniques to support sustainable decision-making. Through an iterative process of identifying these key themes (insights and techniques) and relationships among the themes, we developed a number of models to summarize and reflect the data. These models were refined and modified through discussions among the co-investigators and through ongoing consultations with the data to ensure the models completely and accurately represented that data.

It is of acute importance to find ways to help decision-makers both deal with the complexities inherent in today's society and make choices that result in better outcomes across a broad variety of environmental, social and economic concerns. Overall, our research suggests that many of the obstacles we routinely encounter during the process of decision-making stem from the absence of proactive decision-support strategies. Such strategies help us account for our own values, complex scientific and technical

considerations, and the systematic shortcuts and biases that interfere with our ability to carefully consider information and make decisions that lead to better sustainability outcomes. This report will help decision-makers fill those gaps.

## UNDERSTANDING BEHAVIOURAL DECISION RESEARCH

Behavioural decision research is an interdisciplinary approach to the study of decision-making behaviour that seeks to describe and understand how people make decisions (which researchers call “descriptive” models of decision-making) and to develop techniques that can help people make better decisions (which researchers call “prescriptive” models of decision-making). More specifically, behavioural decision research can benefit from insights from the disciplines of psychology, economics, business, marketing and organizational behaviour.

Understanding why we do or do not engage in sustainable behaviour can be tackled from a variety of research perspectives; for example, through research on values, beliefs and norms. However, this report was specifically based on research that sought to understand and support actual decision-making *behaviour* (as opposed to attitudes or *intentions* to perform a particular behaviour). This specific focus was employed to keep the scope of the study manageable and to ensure that the suggested techniques will result in decision-making behaviour that better incorporates environmental and social concerns.

**Normative Decision-Making:** Decision-making the “textbook” way: Standard economic theory assumes that people are *rational* decision-makers. Thus, this review takes as a starting point a rational (or, what some researchers and practitioners refer to as *normative*) view of decision-making. Rooted in classical economic theory, rational decision-making suggests people possess a set of stable preferences that they consult during the process of making decisions and that all decision-relevant information about alternatives can be carefully weighed and considered to ensure decision outcomes are in line with these preferences.

**Descriptive Models:** How people actually make decisions: The descriptive models of decision-making in this report reflect more than 60 years of research that has been geared to understanding how and why decision-makers do not adhere to the strict principles of rationality. Researchers have attempted to explain this phenomenon by using concepts and theories, such as bounded rationality (discussed in the following section) and prospect theory, and heuristics and biases (explained starting on page 23). While this descriptive work encompasses a vast and often complex body of literature, we specifically focussed on identifying descriptive models that can help us understand why people do (or do not) engage in sustainable behaviour or why people may have difficulty tackling the pressing social and environmental challenges of today. Ultimately, we included only those descriptive models (see the Prescriptive Models of Decision-Making section) that help to explain why or how the prescriptive models work.

**Prescriptive Models:** Helping people make better decisions. Deciding which prescriptive models to include in this report was challenging. Our specific goal was to identify and include models that either were already being used to support and motivate decision-making for sustainability or could lend themselves easily to this context (e.g. from human health and obesity research). Many of these decision-support techniques are strictly based on and inspired by principles derived from descriptive models of decision-making (e.g. accounting for or counteracting known heuristics and biases). Other intervention techniques we identified were rooted in more disciplinary perspectives, such as social psychology and economics. We included these techniques because, although their appearance in the literature is not always directly linked to the descriptive models of decision-making described in this paper, their effectiveness can be improved by adopting many of the key principles of behavioural decision research.

## HOW THIS REPORT IS STRUCTURED

**Normative Models of Decision-Making:** This section provides important background information on normative (or ideal) models of decision-making. While the information for this section was not derived from the systematic review, it provides much-needed context for the following sections on descriptive and prescriptive models of decision-making.

**Descriptive Models of Decision-Making:** This section outlines the key descriptive models of decision-making, including such concepts as bounded rationality, prospect theory, the constructive nature of preference and the role of affect (emotion) in decision-making. We also discuss the implications of these models for understanding, motivating and supporting decision-making for sustainability.

**Prescriptive Models of Decision-Making:** This section focuses on prescriptive models of decision-making, describing these decision-support tools and how they work. A particular focus of this section is on identifying where and when these models are best applied.

As with previous NBS systematic reviews, we also provide a brief assessment of the “state of research” on these decision-support tools. For each decision-support tool we note: (i) whether it has not yet been put into practice or empirically tested ... or only to a limited extent ... (ii) whether it has been used to support other types of decision-making (e.g. in the areas of finance, food or health) but has yet to be applied within an environmental context or (iii) whether it has been extensively tested and reported on (in decision contexts with environmental implications) in both academic literature and practitioner reports (adapted from Bertels et al. 2010).

**Conclusions:** The concluding section of this report provides a “take-home” message for practitioners, managers and executives, which summarizes how the models and decision-support tools described in this systematic review can best be used. We also suggest future avenues for research on incorporating insights from behavioural decision research into decision-making for sustainability.

**Appendices:** The research methodology, scope of the data reviewed and a list of the sources (articles, books and reports) used in this report can be found in the appendices.

## REFERENCES

Bertels, S., Papania, L. & Papania, D. 2010. *Embedding sustainability in organizational culture: A systematic review of the body of knowledge*. Network for Business Sustainability.

# normative models of decision-making

Normative models of decision-making define good decision-making by using the rules of rationality, probability and utility.

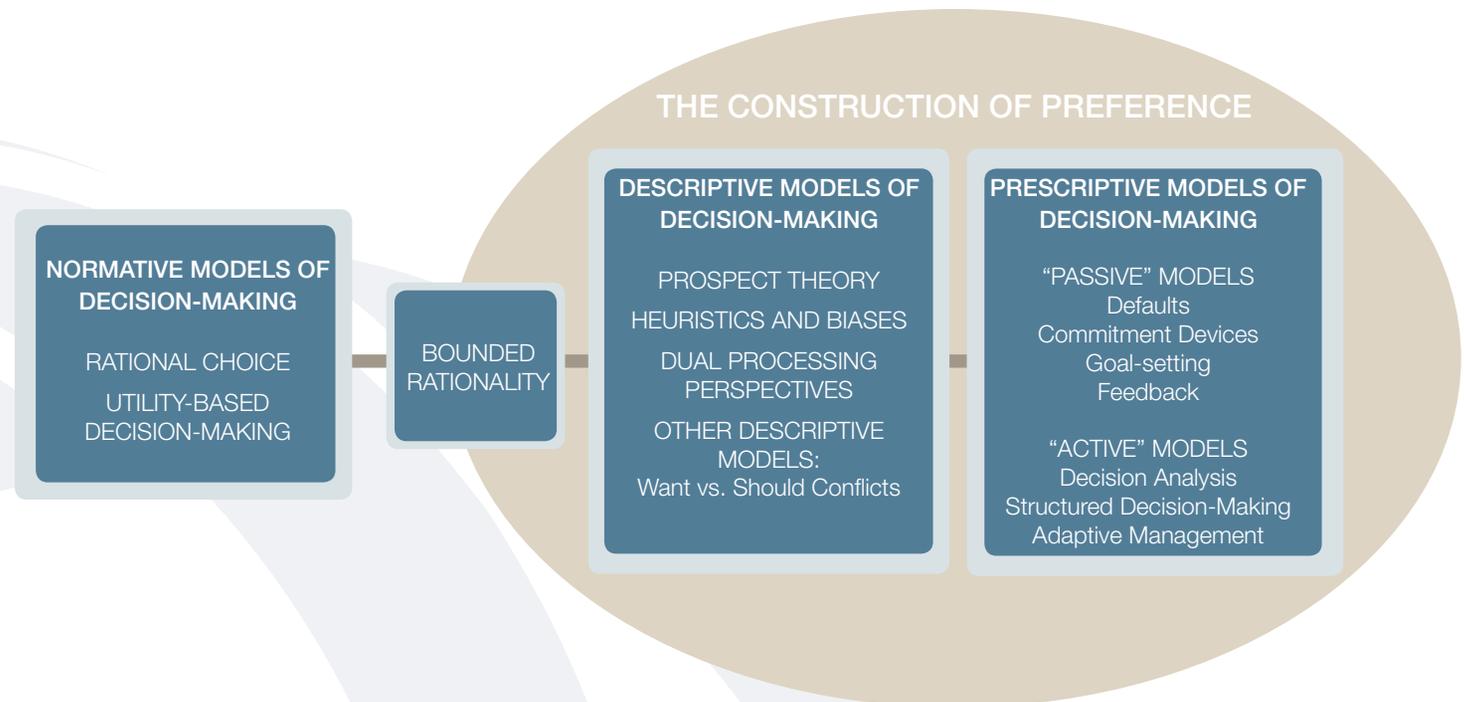
Before we can begin to explore what the literature can tell us about decision-making and what, if any, improvements can be made to the way we tackle decisions that lead to sustainability outcomes, we need to develop some understanding — or at minimum, a set of rules — to help define what a “good” decision looks like.

What does it mean to make a “good” decision? For some, it means carefully weighing information and deciding on the best course of action given a particular set of needs. For others, a good decision means following a gut feeling or “hunch”. For researchers who study decision-making, the truth is somewhere in between.

*Normative — or ideal —* models of decision-making (Kleindorfer et al. 1993) define good decision-making by using the rules of rationality, probability and utility. These models reflect both the process of decision-making and, to a much lesser degree, its outcomes, assuming that decisions can be made with perfect information that can be acted upon with perfect computational abilities. Descriptive and prescriptive models of decision-making make reference to normative decision-making as a benchmark against which *actual* decision-making behaviour is gauged. The overall relationship between normative, descriptive and prescriptive models of decision-making is summarized in Model 1.

Model 1

**SUMMARY OF NORMATIVE, DESCRIPTIVE AND PRESCRIPTIVE APPROACHES TO DECISION-MAKING**



## RATIONALITY

Rationality has come to hold many different meanings with little agreement (outside of the study of economics) regarding its true definition. To some, a rational decision simply implies adhering to the rules of deduction and logic and is therefore the product of careful thought. To others, rationality implies that a decision is the opposite of a decision based in emotion (i.e. clear-headed or thoughtful) or at very least, a decision that achieves a desired *right* outcome, however that may be defined. More salient to this review, does “rational” decision-making automatically translate to more sustainable decision-making? Or, put another way, can sustainable decision-making be considered rational? Ultimately,

a rational decision is less concerned with a particular outcome, such as achieving sustainability goals, and instead results from adhering to a set of guiding principles are adhered to during the process of decision-making.

In its simplest form, rationality can be seen as evaluating the costs and benefits of a particular course of action or option available to a decision-maker. In pursuing this evaluation of costs and benefits, the “rational” decision-maker will consistently adhere to a set of guiding principles during the decision-making process (von Neumann & Morgenstern 1947); the rational decision-maker’s behaviour exhibits six characteristics which are illustrated using the example of the decision to purchase a washing machine (see Table 1).

Table 1

### THE SIX CHARACTERISTICS OF RATIONAL DECISION-MAKING

CHARACTERISTIC	DESCRIPTION
<b>Ordering</b>	A rational decision-maker is able to <i>order the alternatives</i> (e.g. brands and styles of washing machines) in a set of choices (e.g. all available washing machine options) from best to worst or from worst to best. In this sense, rational decision-makers will prefer some alternatives to others while leaving open the possibility of liking some washing machines equally.
<b>Dominance</b>	A rational decision-maker will not select an alternative that is <i>dominated</i> by another alternative. So if one washing machine (Option A) is superior in terms of cost, load capacity, energy efficiency and quality to another washing machine (Option B) (assuming these were the only characteristics we were considering), then A should always be preferred to B.
<b>Cancellation</b>	If two or more alternatives share a common characteristic (e.g. if three competing washing machine options share an identical cost), then this characteristic (cost) is <i>cancelled</i> and should be ignored when choosing among these three machines. Thus, a choice among alternatives should depend only on those characteristics that differ and not on shared characteristics.
<b>Transitivity</b>	If a rational decision-maker prefers washing machine A to washing machine B, and washing machine B to C, then s/he should also prefer washing machine A to C. In other words, a preference order of $A > B > C$ also implies $A > C$ , which is known as <i>transitivity</i> in choice.
<b>Invariance</b>	A rational decision-maker will not be influenced by seemingly alternative, but essentially identical, “frames” of the same set of choices. Imagine (1) claims that a washing machine will provide savings of \$100 (out of a potential maximum of \$135) per year on utility bills and (2) claims that a washing machine will provide savings of \$35 less than the potential maximum of \$135 per year on utility bills. Rational decision-makers should be indifferent between two essentially identical but seemingly alternative frames of the plan. This situation is referred to as the principle of <i>invariance</i> .
<b>Continuity</b>	A rational decision-maker will base choices on the expected value of the available alternatives, which will lead to choosing the alternative with the largest expected payoff. Imagine a choice between (1) an inexpensive, but inefficient, washing machine (whose operating costs will be high) and (2) an expensive and efficient washing machine that will provide savings over the life of the washing machine, recouping the initial purchase cost and then some. Rational decision-makers should prefer the more expensive washing machine option.

Ultimately, a “good” decision from the point of view of strict economic rationality adheres to the six principles outlined in Table 1 and not *necessarily* to whether the decision outcome is sustainable (although sustainability considerations can certainly be part of a rational decision-making process).

### EXPECTED UTILITY

The six principles of rationality are summarized within *utility theory*. Utility theory suggests that the usefulness or goodness (i.e. the utility) of any alternative can be defined by its performance across all of its characteristics. For example, the utility of the hypothetical washing machine decision discussed

previously would be the highest if a decision-maker scored it most highly, among all machines being considered, in terms of those characteristics being considered by the decision-maker (e.g. operating costs, load capacity, model features and energy efficiency).

By calculating the expected utility of all of the alternatives under consideration, the task of achieving ideal rationality in choice is, in theory, relatively straightforward. Once calculated, the expected utility associated with each alternative in a decision is associated with a single number or utility “score”. With these scores in hand, maintaining ideal rationality is the result of calculating the expected utility of each alternative, ordering the alternatives from worst to best and then selecting the superior performer. When

When each attribute of an alternative, including its level of performance, is known with certainty, expected utility can be calculated using the following equation,

$$EU = \sum_i w_i \cdot u_i$$

where  $EU$  stands for expected utility,  $i$  stands for the possible characteristics,  $w(i)$  stands for the weight that a decision-maker places on each possible characteristic (i.e. the importance of each washing machine characteristic to the decision-maker) and  $u(i)$  stands for the expected level of performance associated with each characteristic (e.g. the performance of a particular model of washing machine in terms of operating costs, load capacity, model features, energy efficiency, etc.).

Under conditions of uncertainty, where the characteristics are accounted for, but the probability that they will be realized is not certain (e.g. a decision-maker may desire an alternative washing machine model that is 50 percent more energy efficient than the standard models, but the probability that these savings can be achieved outside of the testing laboratory is uncertain), expected utility may be calculated using the modified equation,

$$EU = \sum_i p_i \cdot u_i$$

where  $EU$  stands for expected utility,  $i$  stands for all of the possible,  $p(i)$  stands for the judged probability with which a given characteristic will be realized and  $u(i)$  again stands for the level of performance associated with each characteristic.

a decision-maker has selected the ideal alternative, the decision-maker is said to have optimized, or maximized, expected utility.

## **BOUNDED RATIONALITY**

The concept of rational decision-making has strong appeal. Who would not desire, when making any decision, the ability to evaluate an exhaustive set of decision alternatives across the entire set of characteristics by which these alternatives are defined? In reality, however, we do not have perfect information or unlimited time to assess all the alternatives in terms of all the defining characteristics.

Take again our washing machine example. Dozens of washing-machine manufacturers (e.g. Miele, LG, Maytag and Kenmore) each manufacture dozens of models (e.g. the Miele “Touchtronic”) and variants of models (e.g. the “Touchtronic W4802”). Each model from each manufacturer constitutes an alternative that a consumer may choose to purchase and each of these alternatives has a unique set of characteristics (e.g. load capacity, top vs. front loading, exterior colour, number of wash and spin programs, energy efficiency, warranty length and cost). In choosing a washing machine according to the ideal model of rationality, the consumer must identify (1) the exhaustive set of alternatives (2) the exhaustive set of characteristics for each alternative and (3) the specific measures or levels of performance associated with each characteristic (e.g. washing machine A uses 186 kWh of energy annually while washing machine B uses 139 kWh). The consumer must then establish relative weights for each characteristic to reflect their importance to the decision-maker and, finally, the consumer must compute the

overall expected utility of each alternative (using one of the equations outlined above).

Even if it were possible to make such a choice according to the strict rules of ideal rationality, the outcome would be very short lived. The set of alternatives from which to choose is dynamic; certain alternatives will disappear (i.e. a particular model is discontinued) while new ones take their place. Thus, a choice operating under a strictly rational model must be flexible enough to account for these changes (which, according to the example above, would mean that a consumer would *never* actually purchase a washing machine!). Similarly, characteristics, like the alternatives themselves, are ever changing, such as when old characteristics (e.g. specific colour options) are being discontinued and new characteristics are added (e.g. “Silver Care”). Such shifts will ultimately alter the overall ranking of alternatives and, by extension, the final choice.

For these reasons, decision researchers often refer to the concept of *bounded rationality* (Gigerenzer & Selten 2002; March 1978; Simon 1956) as a more realistic and practical counterpart to ideal rationality. The concept of bounded rationality, for which Herbert Simon received the Nobel Prize for the Economic Sciences in 1978, assumes that rational decision-makers will strive to make the best possible decisions given imperfect information, limited resources and less-than-perfect computational ability. It assumes that decision-makers will strive to use available and relevant information (e.g. in terms of the alternatives and their characteristics) to inform choices that will lead to positive outcomes. However, this concept also recognizes that the number of alternatives and characteristics that one considers in making these choices will be constrained or *bounded*,

so that the decision-maker can efficiently work through the process of solving a decision problem. This process of constraining the number of alternatives or characteristics under consideration is often referred to as *satisficing*. Bounded rationality also allows for “inspirational adaptation,” which is a process of adapting to changes in the weights that one places on characteristics and the changes in or emergence (or disappearance) of characteristics and alternatives (Simon 1955, 1956).

### **IMPLICATIONS OF RATIONALITY IN DECISION-MAKING**

Standard economic theory assumes that people are rational decision-makers. This assumption implies that rationality serves as a standard or theoretical benchmark, against which actual examples of decision-making can be compared. We have learned much about how people actually make decisions by challenging these assumptions outside of strict economic theory development and by cataloguing the instances within which the rules of rationality and utility maximization do not apply. Despite these theoretical developments, our economic theories still generally assume that people (1) know about the pertinent information that distinguishes decision alternatives and (2) are capable of making the necessary calculations for weighing the ramifications of selecting one alternative over the other (Ariely 2008).

As will be discussed in the following sections of this report, ample evidence from both experiments and case studies suggests that people do not operate as strict (or even casual) maximizers of “utility” when

making decisions. Instead, people routinely violate the principles of rationality and make judgments that could best be described as fluid. A range of variables, such as how a decision is framed (i.e. as a gain or a loss) or the extent to which emotional (vs. analytic) responses are triggered can have a drastic influence on decisions. The following section is devoted to these descriptive (vs. normative) tendencies of decision-makers.

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# descriptive models of decision-making

Descriptive models of decision-making refer to *how* people actually make choices. Although many descriptive models were developed in contexts other than decision-making for sustainability, they can help us understand why we may find it difficult to act in a more sustainable manner or address complex social and environmental problems.

In contrast to normative models, which describe theoretically optimal processes and underlie current economic thinking, *descriptive models* of decision-making refer to how people actually make choices. As we shall see, although many descriptive models were developed in contexts other than decision-making for sustainability, they can help us to understand why we may find it difficult to act in a more sustainable manner or address complex social and environmental problems. This section summarizes the descriptive models of decision-making that are most relevant to sustainability contexts and highlights how they specifically contribute to our understanding of decision-making for sustainability.

Note, however, that descriptive models of decision-making ought not to be characterized as undesirable compared with their normative counterparts. Indeed, decision-makers must confront an important trade-off: to either take inordinate amounts of time to make *every* decision and risk never making forward progress or accept that the ideal decision-making standard is difficult — if not impossible — to achieve and take some proven shortcuts (Payne et al. 1993). For the most part, these shortcuts serve us well in our day-to-day lives. For example, choosing to remain with a vendor or particular product line because it has performed well in the past can yield an outcome that is “good enough” by many objective standards. But in other cases, as described on the following page, remaining with the status quo can prevent us from acting in a manner that better accounts for sustainability considerations (or at the very least in a manner that best serves our self interest).

Our systematic review revealed five descriptive models to be key in helping us to understand why decision-making may deviate from rationality (both in general decision-making contexts and, more specifically, in decision-making for sustainability): (1) prospect theory (2) heuristics and biases (3) affect and the affect heuristic (4) models relating to want/should conflicts and (5) the construction of preference. Table 2 presents a summary of the descriptive models referred to in this report and we describe each model in detail in this section. Note that we include in this report only those descriptive models that, in terms of the prescriptive models identified in the following section, relate either directly (i.e. those that provide an underlying mechanism for a particular decision-support tool) or indirectly (i.e. those that provide an explanation for why individuals and organizations may find decision-making for sustainability challenging).

Table 2

**SUMMARY OF DESCRIPTIVE MODELS OF DECISION-MAKING AND THEIR APPLICATIONS TO DECISION-MAKING FOR SUSTAINABILITY**

MODEL AND RELATED CONCEPTS	DEFINITION	EXAMPLES OF APPLICATIONS TO DECISION-MAKING FOR SUSTAINABILITY
<b>PROSPECT THEORY</b>	The view that decision-makers tend to (1) over-weight outcomes that are certain (relative to outcomes that are probable), (2) place a higher absolute value on losses relative to equivalent gains and (3) judge losses and gains relative to an easily accessible reference point (e.g. their current situation).	This theory informs communication efforts relating to sustainability issues (e.g. climate change). Messages that are framed in terms of <i>avoiding future losses</i> appear to be more effective than those highlighting future gains.
<b>Endowment Effect</b>	Property in our possession and our current state of being are automatically endowed with greater value.	In the face of difficult sustainability-related decisions, people often stick with the status quo to avoid confronting difficult trade-offs or dealing with complex information (highlighting the need to employ structured decision-making techniques). The tendency to stick with the status quo can also be exploited <i>in certain circumstances</i> to ensure more sustainable choices are made, e.g. offering sustainable options as a default choice will increase the likelihood they will be selected.
<b>Loss Aversion</b>	An aversion to losing property in our possession (even if only randomly or recently acquired) or to losses relative to our current state of being.	
<b>Status Quo Bias</b>	The reluctance to adopt new behaviours or give up property already in our possession (because of the endowment effect and aversion to loss).	
<b>HEURISTICS AND BIASES</b>	Heuristics are decision short-cuts or “rules of thumb” we employ in our daily lives.	Decision heuristics are helpful much of the time, but can result in systematic and predictable errors and biases in our decision-making (particularly in complex and unfamiliar decision-making contexts).
<b>Availability Bias</b>	The tendency for decision-makers to gauge the likelihood that an event will occur because of the ease with which similar events can be brought to mind (regardless of the number of times the event has actually occurred). This bias is also true for events that are particularly vivid and/or associated with strong emotions.	Decision-makers may feel insufficiently motivated to act if salient or vivid examples of sustainability-related issues (e.g. climate change or air quality) cannot be easily brought to mind. In other circumstances, decision-makers may over-weight issues for which they have recent or particularly vivid examples (e.g. the perceived risks associated with nuclear power may be now be heightened because of the accident at the Fukushima Daiichi nuclear plant).
<b>Anchoring With Insufficient Adjustment</b>	The tendency for decision-makers to base (or “anchor”) their judgment on some initial — and often unrelated — reference point.	

<b>Evaluability</b>	In the absence of suitable points of comparison, decision-makers will often focus on easy-to-evaluate characteristics and ignore more difficult-to-evaluate characteristics (even if they are more important for the decision at hand).	When deciding on a particular decision option, cost (an easy-to-evaluate characteristic) may trump more difficult-to-evaluate characteristics such as scenic beauty, quality of life or species extinctions.
<b>AFFECT AND DUAL PROCESSING PERSPECTIVES</b>	Our understanding of the world comes from the simultaneous operation of two systems: (1) the <i>Experiential System</i> , which is intuitive and automatic and (2) the <i>Analytic System</i> , which is deliberative and effortful. The main characteristic of our experiential system, affect, is defined as an emotional feeling-state that we express in terms of <i>happiness or sadness, goodness or badness</i> . These assessments occur rapidly and automatically, without conscious effort.	Affect is often employed to help explain why we overreact to some issues (e.g. terrorism and accidents at nuclear power plants, which can elicit a strong affective reaction, despite the probabilities of occurrence being low) and underreact to others (e.g. climate change and genocide, which may elicit an insufficient affective reaction despite pressing societal problems). The tendency to over-rely on affect and the affect heuristic (at the expense of the analytic/deliberative system) is exacerbated when the decision-maker faces difficult or unfamiliar choices, or when he or she is tired, distracted or hungry.
<b>Affect Heuristic</b>	The tendency for decision-makers to rely on affective feelings during judgment and decision-making; in other words, use of an affect heuristic leads to judgments about objects, activities and other stimuli that are quick, intuitive and without conscious effort. Affect and the affect heuristic have been invoked to help explain availability bias, evaluability bias, and the want/should and present/future conflicts described below.	
<b>WANT/SHOULD AND PRESENT/FUTURE CONFLICTS</b>	We often face decisions in which we must choose between satiating an immediate “want” vs. holding out for a later “should”. “Wants” are typically choices that provide immediate satisfaction or pleasure, but have negative longer-term consequences. “Shoulds” are choices that may not be immediately pleasurable, but that provide benefits over the longer term. The conflict between “wants” and “shoulds” is exacerbated by our tendency to consider and weigh the future differently from the present. In most decision-making circumstances, the present is given much more weight than the future (a phenomenon known as <i>discounting</i> ).	The tendency to satisfy “wants” (e.g. driving a car, buying a cheaper but less efficient furnace or putting short-term profit ahead of environmental remediation efforts) at the expense of “shoulds” (e.g. taking public transit, buying a high-efficiency furnace or investing in remediation technology) can interfere with the achievement of sustainability goals.
<b>CONSTRUCTION OF PREFERENCE</b>	Collectively, descriptive models of decision-making illustrate that decision-makers often construct their preference for a particular option or course of action “on the spot” in response to cues that are available during the decision-making process (e.g. through the use of heuristics or affective reaction).	The construction of preference is most likely to occur when we face decisions that are unfamiliar, require trade-offs among closely held objectives and where outcomes are difficult to quantify (e.g. the choice between scenic beauty or saving endangered species conflicts with issues of costs, jobs or profit, which often characterize decision-making for sustainability). Decision-support techniques should approach decision-making as a process of carefully constructing participants’ preferences (based on their fundamental values relevant to that particular decision). Other kinds of decision-support efforts serve to subtly change the <i>context</i> within which decisions are made, such that sustainable choices are more likely to be made.

## PROSPECT THEORY

Summary of the theory and related concepts: Prospect theory describes the tendency for decision-makers to (1) over-weigh outcomes that are certain (relative to outcomes that are probable), (2) place a higher absolute value on losses relative to equivalent gains and (3) judge losses and gains relative to an easily accessible reference point (e.g. the current situation). A related concept, the endowment effect, posits that property in our possession (or our current state of being) is automatically endowed with greater value. As a result of this endowment effect, we often have a strong aversion to losing possessions (even if only recently acquired) or to losses relative to our current state of being. The reluctance to adopt new behaviours or give up things already in our possession is also referred to as status quo bias.

Prospect theory (Kahneman & Tversky 1979; Tversky & Kahneman 1981) — for which Daniel Kahneman was recognized with the Nobel Prize for the Economic Sciences in 2002 — describes decision-making behaviour that violates the tenets of expected utility theory. In its most basic form, it describes decision-making behaviour whereby individuals:

1. Place a higher value on (i.e. are willing to pay more for) outcomes that yield certainty (e.g. by reducing the probability of an error in production from 0.1

to 0) relative to outcomes that are equally probable but do not yield certainty (e.g. by reducing the probability of an error in production from 0.9 to 0.8), and

2. Place a higher absolute value on losses than they do on equivalent gains (i.e. a decision-maker places a higher [negative] value on the prospect of a 10 percent *reduction* in profit when compared with the [positive] value placed on the prospect of a 10 percent *increase* in profit).

Likely the most famous experiment to test prospect theory involved two groups who were asked to respond to alternative versions of the following problem (known as the *Asian Disease Problem*):

*Imagine that the United States is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed.*

In one group, study subjects were asked to select one of the following two alternatives:

- Program A, which will save exactly 200 people and Program B, which has exactly a one-third probability that 600 people will be saved and a two-third probability that none of the 600 will be saved.

In a second group, study subjects were asked to select either:

- Program C for which exactly 400 people will die or Program D, which has exactly a one-third probability that nobody will die and a two-third probability that 600 people will die.

Of course, the expected utility of all four programs is the same. But among those respondents assigned to the first group, the majority (72 percent) preferred Program A. And in the second group the majority of respondents (78 percent) preferred Program D. These results constitute a preference reversal — and violate two of the central principles of rational choice: transitivity and invariance — in that the expected utility of each program is the same. The only difference lies in how the decision problem was framed; Programs A and B were framed in

terms of lives saved and Programs C and D were framed in terms of lives lost.

This study highlights the manner in which alternative frames of the same problem activate different decision-making strategies. For the alternatives (A and B) presented to the first group, framed in terms of gains, subjects prefer the risk-averse option and tended to select Program A — a sure bet or risk-averse strategy, for saving lives. The alternatives presented to respondents in the second group, framed in terms of losses, incite risk-taking behaviour to minimize the loss of life.

Why does preference reversal occur in the experimental scenario described above? Research suggests two main reasons. First, people tend to evaluate potential outcomes on the basis of discernible changes in welfare relative to their current, rather than final, state. For many judgments (e.g. financial or environment-related decisions), changes in welfare can accrue over a long period. Thus, for an individual holding \$100 (i.e. the initial reference point), a gain (or loss) of \$50 seems greater than the same gain (or loss) to an individual with an initial reference point of \$10,000. As a result, the value function that describes these evaluations (see Figure 1) is concave in the domain of gains and convex in the domain of losses (Kahneman & Tversky 1979; Tversky & Kahneman 1981). Second, in the minds of most, losses loom larger than gains; as Kahneman and Tversky (1979, p. 279) put it, “the aggravation that one experiences in losing a sum of money appears to be greater than the pleasure associated with gaining the same amount.” As a result, the value function defined by prospect theory (see Figure 1) is steeper in the domain of losses (on the left-hand

side of the figure) than in the domain of gains (on the right-hand side of the figure).

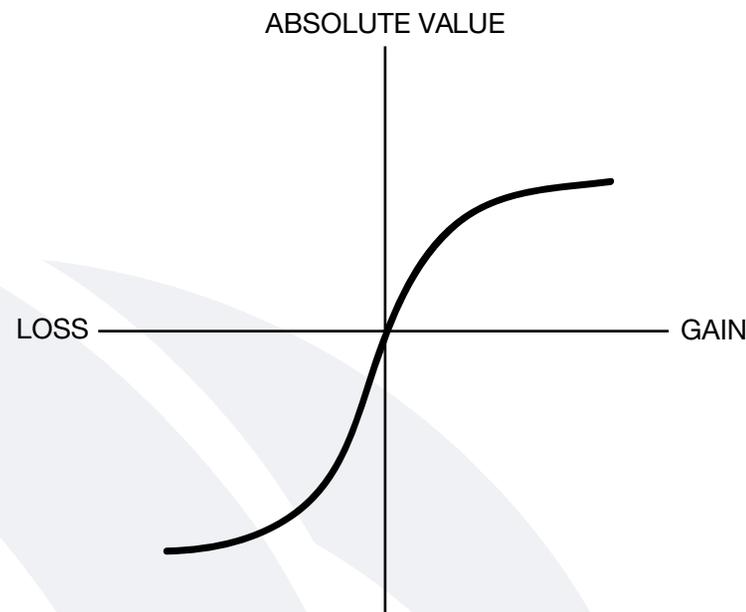
Prospect theory has contributed to our understanding of decision-making for sustainability through work on (1) the effect of message framing and (2) the endowment effect and loss aversion. For example, researchers interested in exploring ways to effectively communicate information about climate change (to enhance understanding of the issue, to increase acceptance of mitigation efforts and to motivate remedial action) have employed in their messages about climate change both gain frames

(describing the *benefits gained* as a result of mitigation efforts) and loss frames (describing the *losses avoided* as a result of mitigation efforts).

A recent publication from the Center for Research on Environmental Decisions (CRED 2009) on communicating climate change information suggests that environmentally responsible behaviour can be more effectively motivated by communication efforts that highlight people's ability to *avoid future losses* (e.g. buying a fuel-efficient car will help to avoid large fuel expenses in the future). This strategy is in opposition to framing the purchase in terms of potential money

Figure 1

### THE VALUE FUNCTION DESCRIBED BY PROSPECT THEORY



Note: The function describes the tendency for decision-makers to place a higher absolute value on losses when compared with equivalent gains. It also describes the tendency to make judgments about value on the basis of a decision-maker's current reference point.

Source: Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, 47, 263–291.

savings. Other studies have found that when the information was framed in terms of preventing further increases in severe flooding and weather or in loss of ice sheets people were more likely to (1) rate potential climate change impacts as severe (2) adopt a more positive attitude toward climate change mitigation efforts and 3) engage in pro-environmental behaviour (Spence & Pidgeon 2010).

Prospect theory also plays a role in our understanding of actual decision-making behaviour. *Status quo bias* describes people's reluctance to adopt new behaviours or options or to give up property already in their possession. This bias is thought to occur because of two effects associated with prospect theory: (1) the endowment effect (i.e. property in our possession — or our current state of being — are automatically endowed with value) and (2) loss aversion

(i.e. our dislike of losing property in our possession — or losses relative to our current state of being). The *endowment effect* and *loss aversion* (Kahneman et al. 1991; Knetsch 1989) describe a situation wherein the worth of a good (e.g. a coffee mug or theatre tickets) increases when it becomes an individual's property (even if only arbitrarily or recently acquired). In other words, people ask for a higher selling price for these items (i.e. to compensate for or avoid its loss) than they normally would to purchase the same item (i.e. a gain). These tendencies present a challenge since many decisions for sustainability ask people to give something up (e.g. single-occupancy vehicles or the “consumer lifestyle”). As we shall see in the next section on prescriptive models of decision-making, however, the power of the status quo can be exploited to encourage environmentally sustainable choices.

## HEURISTICS AND BIAS

**Summary of the theory and related concepts:** Heuristics are decision shortcuts or “rules of thumb” we employ to deal with what are often large amounts of information or many options in our daily lives. The specific heuristics and biases we describe in this section are: (1) availability bias (the tendency for decision-makers to gauge the likelihood that an event will occur on the ease with which similar events can be brought to mind, regardless of the number of times the event has actually occurred; this tendency is also true for events that are particularly vivid and/or associated with strong emotions), (2) anchoring bias (the tendency for decision-makers to base or “anchor” their judgment on some initial — and often unrelated — reference point) and (3) evaluability bias (in the absence of suitable points of comparison, the tendency of decision-makers to focus on easy-to-evaluate characteristics and ignore more difficult-to-evaluate characteristics — even if they are more relevant to the decision at hand).

Decisions are highly dependent on how individuals instinctively approach problems. People tend to rely heavily on heuristic principles — or decision “shortcuts” — that reduce complex judgment tasks to simpler ones (Kahneman et al. 1982). The advantage of heuristics is that they may reduce the amount of time and level of effort required to make decisions without — for many of our routine decisions — compromising the quality of the choice (i.e. yielding close approximations to “optimal” answers suggested by normative models). Unfortunately, the use of heuristics may also lead to systematic and predictable biases, especially in the context of unfamiliar or complex judgments (which we are more likely to encounter when dealing with environmental issues).

### *Availability*

The *availability* heuristic is applied when a decision-maker bases a judgment about the likelihood that an event will occur on the ease with which related instances or occurrences can be brought to mind — regardless of the number of times this event has actually occurred (Tversky & Kahneman 1981). For example, decision-makers may conclude that the likelihood of protests around a potential resource-development initiative is high on the basis of the widespread media attention on recent demonstrations surrounding exploitation of the oil sands. Similarly, decision-makers may assign higher probabilities to the threat of terrorism on the basis of their association of terrorism with the attacks of 9/11 (Sunstein 2007).

One obvious problem with the availability heuristic is that some events — such as the examples provided here — are easier to recall not because they are highly probable but because they may have occurred recently or may have been made salient by media scrutiny. However, researchers have also found that people may not be sufficiently motivated to respond to an issue such as climate change because few climate- and weather-related instances can be brought to mind to support the idea that these global changes are actually occurring. In other words, people may be unwilling to act now to prevent future climate-associated changes because they assign a low probability to future negative weather events (which is based on what they have experienced thus far). Research has also shown, however, that exposure to extreme weather events and/or movie portrayals of extreme weather events have been associated with increases in the belief that global warming is occurring (Marx et al. 2007; Sunstein 2007).

#### *Anchoring and Adjustment*

An additional potentially biased heuristic is *anchoring with insufficient adjustment*. Suppose you ask a group of executives to estimate the dollar losses from their firms as a result of climate change and associated regulatory changes. You ask one group whether the losses will be more or less than \$100,000 and they agree that the answer is *more*. When you then ask them to estimate an actual dollar amount, they may agree that \$500,000 sounds reasonable. When you ask another group of executives whether the dollar losses of global climate change will be more or less than \$100,000,000 they agree that the answer is *less*. When

you ask for a specific dollar judgment, they might reply that \$10,000,000 is a good estimate. The differences in the two groups' judgments can be explained in terms of judgments that are anchored on an initial reference point (\$10,000,000 and \$100,000,000 in this example) and insufficiently adjusted down or up (Kahneman et al. 1982). Similarly, researchers have found that when two groups of people are given different estimates of the increase in the earth's temperature as a result of climate change, those people who received the higher temperature estimate are more likely to believe global warming is occurring (Joireman et al. 2010).

The magnitude of the effect induced by anchoring without sufficient adjustment tends to be largest when decision-makers confront problems that have received little past thought (e.g. emerging environmental problems). Clearly, anchoring with insufficient adjustment plays a significant role in influencing judgments that require the evaluation or incorporation of quantitative scientific data (as was the case with the previous example). Anchoring with insufficient adjustment also manifests itself when decision-makers are asked to think about important concerns that can be influenced by an impending choice. In many cases, our judgments are more heavily influenced by those factors that first come to mind and we minimize those factors that become apparent later in the decision-making process. In the case of many environmental decisions, for example, decision-makers routinely focus on the financial costs associated with an endeavour. Other classes of benefits (e.g. cultural values, "ecological services" such as the removal of CO<sub>2</sub> from the atmosphere) and costs (e.g. lost recreation value) often become apparent only later

in the process, but are seldom incorporated in a final evaluation of alternative courses of action (Arvai et al. 2001).

### *Evaluability*

Research on the concept of *evaluability* and *evaluability bias* during judgment and decision-making has focused on how the presentation of difficult-to-evaluate or easy-to-evaluate characteristics influences preferences for options. These researchers found that — in the absence of suitable reference information — decision-makers will focus on easy-to-evaluate characteristics and avoid more difficult-to-evaluate characteristics (even when they are more relevant to the decision at hand).

In the seminal work on this subject, Hsee (1996) conducted an experiment in which students at the University of Chicago and the University of Illinois were asked to partake in a hypothetical transaction involving the purchase of a music dictionary. Subjects were asked to spend between \$10 and \$50 on one of two dictionaries: Dictionary A, which had 10,000 entries and was in like-new condition and Dictionary B, which had 20,000 entries and had a torn cover (but was otherwise in excellent condition). Prior to making judgments about how much to spend for a given dictionary, subjects were assigned to one of three groups: two separate groups whose subjects were asked to indicate a purchase price for only Dictionary A or Dictionary B, and a third group whose subjects were asked how much they would be willing to pay for each dictionary in a side-by-side comparison.

In this study, Hsee (1996) demonstrated a preference reversal, whereby subjects in the separate-evaluation conditions were willing to pay more for Dictionary A (10,000 entries, like new) than their counterparts who were asked to express a buying price for Dictionary B (20,000 entries, torn cover). However, subjects were willing to pay more for Dictionary B than Dictionary A in the joint-evaluation condition. According to the evaluability hypothesis, this joint-separate preference reversal occurs because one of the attributes (i.e. the number of entries) in the set of alternatives (i.e. the dictionaries) is difficult-to-evaluate independently, whereas the other attribute (the physical condition of the dictionary) is easy to evaluate independently.

When evaluating the dictionaries separately, respondents do not have pre-existing notions of the benefits of 10,000 (or 20,000) entries. However, respondents can more easily evaluate the dictionary on the basis of its physical condition (i.e. like-new or damaged). Hence, in separate evaluations, respondents assign higher values — on average — to the dictionary that is like-new than to the dictionary that has a torn cover because they find it easier to establish a preference (or preference order) on the basis of the easy-to-evaluate attribute. In contrast, when evaluating the two dictionaries jointly, respondents are better able to compare one dictionary against the other, thereby increasing the evaluability of the otherwise difficult-to-evaluate attribute (the number of entries). Here, it becomes clearer to respondents that, regardless of the defects on its cover, the dictionary with 20,000 entries is superior (and hence valued more highly) to the one with 10,000 entries.

A similar study replicated the music dictionary experiment using two different cups of ice cream as the alternatives to be evaluated (Hsee 1998). In this experiment, one group of subjects was asked to indicate their maximum willingness to pay for eight ounces of ice cream served in a 10-ounce cup (i.e. the cup was under-filled by two ounces). A separate group of subjects was asked for their maximum willingness to pay for seven ounces of ice cream served in a five-ounce cup (i.e. the cup was over-filled by two ounces). As was the case with music dictionaries, the attribute that was easier to evaluate (the fullness of the cup) received greater emphasis during separate evaluation when compared with the attribute that was difficult-to-evaluate (the absolute amount of ice cream served in each cup). As a result, a higher mean willingness to pay was observed for the over-filled cup (that contained less ice cream) when compared with the under-filled cup (that contained more ice cream). However, when these alternatives were evaluated jointly, the subjects indicated a preference reversal, wherein the under-filled cup now commanded a higher price.

Despite the trivial decision contexts (dictionaries and ice cream), these results are noteworthy for two reasons. First, these examples point to the importance of establishing a comparative framework for characterizing the value of alternatives. Often, decision-makers are asked to indicate their preference for an alternative in *isolation*. Energy executives may be asked, for example, to indicate their preference for a single management alternative by assessing the extent to which they prefer carbon capture and storage as a means of mitigating the effects of climate change in contrast to evaluating this option alongside several other carbon management strategies. Work on evaluability suggests that difficult-to-evaluate attributes (e.g. the long-term effects on ecosystems) may be ignored in favour of easy-to-evaluate attributes (e.g. the cost or the ease with which a strategy can be articulated to shareholders). This preference for the easy-to-evaluate option — as in the case of the dictionary and ice cream examples — may lead to poor choices. The concept of evaluability is associated with two related and important components in both descriptive and prescriptive approaches decision-making: that of affect and the affect heuristic. A review of these concepts is presented in the next section.

## AFFECT AND DUAL PROCESSING PERSPECTIVES

Summary of the theory and related concepts: Our understanding of the world comes from the simultaneous operation of two systems: (1) the Experiential System, which is intuitive and automatic and (2) the Analytic System, which is deliberate and effortful. Affect, the main characteristic of our experiential system, is defined as an emotional feeling-state that we express in terms of happiness or sadness, goodness or badness. These assessments occur rapidly and automatically, without conscious effort. The use of the affect heuristic leads to judgments about objects, activities and other stimuli that are quick, intuitive and without conscious effort. Such judgments may lead us, however, to over- or under-react in certain circumstances.

Results from studies of evaluability prompt an important question: What makes a characteristic easy- or difficult-to-evaluate? Many researchers (e.g. Hsee 1996, 1998; Slovic 2000; Wilson & Arvai 2006) have argued that easy-to-evaluate characteristics are those for which it is possible to make a rapid, emotion-based judgment about their *goodness* or *badness*. Difficult-to-evaluate attributes, by contrast, are those for which it is not possible to make such a rapid, emotional judgment; instead, these attributes require both contextual knowledge and effortful analysis to determine their relevance.

Epstein (1994) has written clearly and eloquently about these *dual processes* involved in thinking, knowing and deciding. Specifically, he points to two parallel systems (see Table 3) that operate in the mind: One (*System 1*) is variously labelled intuitive, automatic, natural, non-verbal, narrative and experiential. The other (*System 2*) is labelled analytical, deliberative, verbal and rational.

The main characteristic of the experiential system is the psychological concept of *affect*, defined

as an emotional, feeling-state that people experience, such as *happiness* or *sadness* (collectively referred to as *arousal*) or the quality associated with a stimulus, such as its goodness or badness (collectively referred to as *valence*). Responses that are based on affect occur rapidly and automatically, with or without conscious thought or effort from decision-makers.

Reliance on these feelings during judgment and decision-making has been characterized as the *affect heuristic*. In other words, use of an *affect heuristic* leads to judgments about objects, activities and other stimuli on the basis of the varying degrees of affect attached to them (Finucane et al. 2000; Slovic 2000).

Discussions about the interaction between emotions and analysis during decision-making frequently provoke thoughts of one basis for judgments — usually *System 2* — as being more rational or subjectively better than the other (in that it leads to “better” decisions, regardless of how poorly defined these may be).

Characterizing the interaction between *System 1* and *System 2* in this way is problematic

Table 3

**TWO MODES OF THINKING, KNOWING AND DECIDING**

SYSTEM ONE (EXPERIENTIAL SYSTEM)	SYSTEM TWO (ANALYTIC SYSTEM)
Holistic	Analytic
Based on affect	Based on reasoning and deliberation
Connections by associations	Connections by logical assessment
Behaviour mediated by “vibes” from past experiences	Behaviour mediated by conscious appraisal of events
Encodes reality in images, metaphors and narratives	Encodes reality in abstract symbols, words, formulae and numbers
Intuitive, fast; oriented toward immediate action	Slow and effortful; oriented toward delayed action
Self-evidently valid: Experiencing is believing	Requires justification via logic and evidence

Source: Adapted from Epstein, S. (1994). Integration of the cognitive and the psychodynamic unconscious. *American Psychologist*, 49, 709–724.

for two reasons. First, ideal rationality makes room for affect-based preferences, specifically in terms of assigning weights to characteristics. For example, the characteristic “colour” in the hypothetical washing machine purchase described on page 16 is an attribute that clearly differentiates the alternatives. The weight that a decision-maker assigns to this characteristic provides little utility to the individual beyond satisfying the decision-maker’s preference for one colour over another. In this sense, the assignment of weight — which adheres to the strict rules set forth by the maximization of expected utility — is both rational and driven by some emotion-based indicator of value (*System 1*).

Second, the decision-making context under which *System 1* and *System 2* are being applied matters. In many cases, a judgment requires a rapid, affect-based assessment of one’s surroundings. Consider, for example, the case of a decision by one of our early human ancestors about whether to flee from a growling sound coming from a nearby bush. The sound may be coming from some dangerous prehistoric beast but, at the same time, may also be the result of the benign wind moving through the bushes and trees. The question from the standpoint of judgment and decision-making is whether to engage in some time-intensive, deliberative mode of judgment. Alternatively, should our ancestor rely on instincts —

which are driven by affect — and flee, thereby deciding to leave hunting and gathering for another day? Of course, the answer is the latter.

Thus, we must recognize the important role that affect and its associated heuristic play in helping to simplify certain complex (and potentially life-saving) choices that must be made under time-pressure (Slovic et al. 2002). At the same time, we must also recognize that complex environmental management decisions of the type addressed by stakeholder groups require the integration of, and a thoughtful balance between, affective and deliberative elements. On the one hand, we want stakeholder groups to bring to the table the strong emotions and contextual factors that are essential roots of their concern; on the other hand, and particularly in cases characterized by highly uncertain but consequential risks and benefits (as is the case with climate change), we seek decisions that reflect thoughtful, deliberative modes of judgment (Wilson 2008).

As is also the case, however, one system can dominate the other— often with unintended or undesirable consequences. For example, anecdotal observations of judgment and decision-making in the context of real-world policy problems clearly show significant resource expenditures on the affectively charged risks such as the global war on terror in contrast to relatively small expenditures on more mundane, but often higher-risk, problems such as degrading infrastructure or road safety (Slovic et al. 2004; Sunstein 2007). Complicating matters further, Kunruether et al. (2002) note that, when faced with decisions involving a large amount of uncertainty and

difficult trade-offs, decision-makers are likely to over-rely on affective cues (as opposed to tackling the problem through deliberation).

Experimental work reveals similar trends. Arvai and Gregory (2003), in a study to test the usefulness of decision aids for prioritizing the clean-up of contaminated sites, also found that unaided participants routinely set priorities that were driven by the affective characteristics of the sites (a production facility for nuclear weapons, a fertilizer depot and an agricultural irrigation project) rather than by the magnitude of the risks present at each site (e.g. environmental, economic and human health risks). This trend was observed despite the risks at each site having been depicted side-by-side (in an effort to enhance their evaluability) in a three foot by five foot poster-size table affixed to the wall in front of each participant while they made judgments about their priorities.

In another example, Wilson and Arvai (2006) conducted an experiment where subjects were asked to state their management preferences for two problems that might occur in a nature preserve or park setting: deer overpopulation and petty crime. One problem, crime, was affect-rich (i.e. emotionally charged) but was of relatively low risk to human and environmental health. The other problem, deer overpopulation, was affect-poor but was of relatively high risk. In this experiment, subjects largely ignored the presented risk information and set their preferences on the basis of their affective responses to the problem contexts alone — focusing on petty crime. This result occurred despite the different risk levels having been clearly communicated to the subjects.

These two cases are examples of situations where affective responses to problems outweigh analytic responses. It is also possible for overly analytic modes of judgment to outweigh necessary emotional responses. Recent research on this phenomenon focusing on genocide (Slovic 2007) has led to the finding that people largely ignore instances of genocide because most presentations of the problem are based in figures and statistics. This presentation, in turn, dehumanizes the problem because the numbers — no matter how large — fail to convey the true meaning of the atrocities. In other words, the numbers alone fail to trigger the affective emotion or feeling required to motivate action.

By drawing a connection between this line of research on genocide and the problems associated with, for example, climate change, one could argue that public perceptions of the latter suffer from a similar problem. Much of the current focus on climate change is technical in nature, emphasizing scientific findings characterized by numeric magnitudes and probabilities. As with genocide, these numbers — no matter how alarming to scientists and some policy makers — are unlikely to motivate the kinds of emotional responses that will motivate action on the part of many people (Slovic 2007; Weber 2006). This effect is particularly acute when people are asked to make immediate sacrifices (and endure all of the negative affect associated with such a loss) to address a problem with considerably more abstract and distant consequences (Weber 2006).

## WANT/SHOULD CONFLICTS

**Summary of the theory and related concepts:** We often face decisions in which we must choose between satiating an immediate “want” vs. holding out for a later “should”. “Wants” are typically choices that provide immediate satisfaction or pleasure but have negative longer-term consequences. “Shoulds” are choices that may not be immediately pleasurable but provide benefits over the longer term. The conflict between “wants” and “shoulds” is exacerbated because we consider and weight the future differently than we do the present. In most decision-making circumstances, the present is given much more weight than the future (a phenomenon known as discounting).

As has been alluded to earlier, decision-making for sustainability often pitches immediate action against future considerations, such as by choosing to give up something at present for the purpose of conserving energy or resources for future generations. Many of these decisions fall under the general umbrella of “want/should” conflicts, an approach to decision-making that incorporates several principles from economics and psychology, such as discounting, temporal construal theory and present-biased preferences (Bazerman et al. 1998; Milkman et al. 2008).

At the heart of this approach is the idea that we often face decisions in which we must choose between satiating an immediate “want” vs. holding out for a later “should”. “Wants” are typically choices that provide immediate satisfaction or pleasure but have negative longer-term consequences (e.g. eating chocolate cake or driving a car). “Shoulds” are choices that may not be immediately pleasurable (e.g. eating bran cereal or taking public transit) but have longer-term benefits for personal health or the health of the environment. The formal definitions of “wants” and “shoulds” refer back to our definition of *rationality*, encountered earlier in this

report: the immediate utility of a want option is greater than that for a should option. Over time, however, the utility of the should option will accrue to the point where it exceeds that of the want option.

Why does this want/should conflict occur? Most people would prefer to make choices that benefit themselves over the longer term (e.g. maintaining an exercise regime, saving for retirement, eating healthily or taking measures to minimize their environmental impact). Unfortunately, in practice such choices are not usually the case. Instead, because of the way we perceive and respond to the decision context, we tend to side with a want option (e.g. watching TV on the couch as opposed to exercising, or driving to work in a single-occupancy vehicle as opposed to biking or taking public transit). In some circumstances (e.g. when hungry, distracted or when faced with the necessity of making an immediate decision), we are more likely to respond to the aspects of a set of choices that are *immediately* enjoyable or not enjoyable. When we have time and opportunity to think and deliberate about a choice, however, we are more likely to respond to the more abstract and higher-level qualities of a

set of choices (e.g. longer-term personal health and well-being). This phenomenon is known as *temporal construal theory* (Trope and Liberman 2000).

The conflict between these different approaches to decision-making is exacerbated by our tendency to consider and weigh the future differently than we do the present. In most decision-making circumstances, the present is given much more weight than the future (referred to as *discounting* or *present-biased preferences*). While this heavier weighting of the present makes sense because of the great deal of uncertainty about the future, the tendency to satisfy immediate “wants” at the expense of future “shoulds” (albeit more uncertain) can be problematic for our long-term health or the health of the environment.

This phenomenon is also observed when people are asked to think about the likelihood of performing a “should” option in the future (e.g. eating healthier, driving less or donating to a charity). In these circumstances, people usually state that their likelihood of engaging in a “should” option in the future is high. However, when the time comes to make the actual choice (a should option instead of a want option), people are much more likely to opt for the “want” choice (e.g. eating a hamburger, taking the car or spending money on a new designer outfit). This phenomenon has also been ascribed to our overestimation of our willpower in these circumstances, caving to the “siren’s call” of the want choice and abandoning all intentions of sticking with the “should” option (Ariely 2008; Loewenstein 1996).

## THE CONSTRUCTIVE NATURE OF PREFERENCES

Summary of the theory and related concepts: Collectively, descriptive models of decision-making illustrate that decision-makers often construct their preference for a particular option or course of action on the spot in response to cues that are available during the decision-making process (i.e. how the options are framed or on the basis of the affective reaction elicited by a particular option).

Collectively, results such as those described on pages 23 to 36 serve as evidence for the concept of *constructed preferences*. Rather than approaching decision problems by using the stable and thoughtful preferences that are merely revealed during decision-making, people instead construct their preference for a particular option or course of action on the spot, in response to cues available either from past experiences or during the decision-making process (Payne et al. 1993; Slovic 1995). These descriptive models (and — by extension — the construction of preference) have been shown to apply to many different types of decision-makers. In other words, experts, lay decision-makers, consumers, managers and executives are not immune to the errors and biases outlined in this section.

Ultimately, decision-support techniques — whether employed by individuals or groups in household, government or business settings — have the purpose of serving to construct the decision-making *process* to better incorporate sustainability goals (Gregory et al. 1993). As we shall see in the next section, other kinds of decision-support efforts serve to construct the decision-making *context* so that sustainable choices are more likely to be made. These structuring processes are the focus of the next section of this report.

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# prescriptive models of decision-making

There are two primary categories of decision-support techniques

1. Active: Active decision-support techniques are high-stakes decisions which involve multiple stakeholders. These are complex decisions that take a long time and are often surrounded by uncertainty.
2. Passive: Passive decision-support techniques are low-stakes decisions which are small, frequent and quick decisions usually made at the individual level.

The previous section suggests that predictable shortcuts and biases in our decision-making prevent us from behaving as “rational” decision-makers (in the strict economic sense). Despite these shortcuts and biases, we are — for the most part — able to make optimal choices given the constraints of the decision at hand. The problem arises for example<sup>2</sup>, when we face decisions that require us to process a large amount of novel information or when we are called on to make value judgments about the relative merit of one option over another. Additional difficulties are faced when we must weigh future options against the present or when we must make choices when tired, hungry or distracted. Unfortunately, we face many of these difficulties when making decisions under the umbrella of sustainability.

A review of the literature suggests that a variety of decision-support techniques are available to help motivate and support choices and processes that more explicitly take into account sustainability considerations. These decision-support techniques take as their starting point the predictable and systematic shortcuts and biases associated with our decision-making and then work either to mitigate or to take advantage of these shortcuts and biases to achieve more defensible and sustainable choices. Collectively, they are known as *prescriptive* models of decision-making.

Our synthesis of the literature related to prescriptive models of decision-making revealed two primary categories of decision-support techniques:

*active* and *passive*. Active decision-support techniques break decisions into manageable parts and employ specific methods to mitigate and avoid the systematic and pervasive errors and shortcuts described previously. A facilitator is often present to help guide this process.

Ultimately, active decision-support techniques focus on the *process* of decision-making and not necessarily on any specific outcome. In contrast, passive decision-support techniques take advantage of known errors and biases, exploiting them to help people make decisions that are in their own self-interest or, as is the focus of this review, to make decisions that are sustainable. These two categories of decision-support techniques differ by the circumstances under which they are applied and, in turn, are associated with some unique approaches to helping individuals and groups make decisions that are more sustainable (see Table 3).

In this section of our review, we use real-world examples and case studies to highlight specific decision-support techniques within the active and passive categories. We first explore active decision-support techniques in more detail. We then finish this section with an exploration of passive decision-support techniques. Models 2a and 2b illustrates the different active and passive decision-support techniques and identifies the circumstances under which these techniques have been applied in the papers we reviewed for this report.

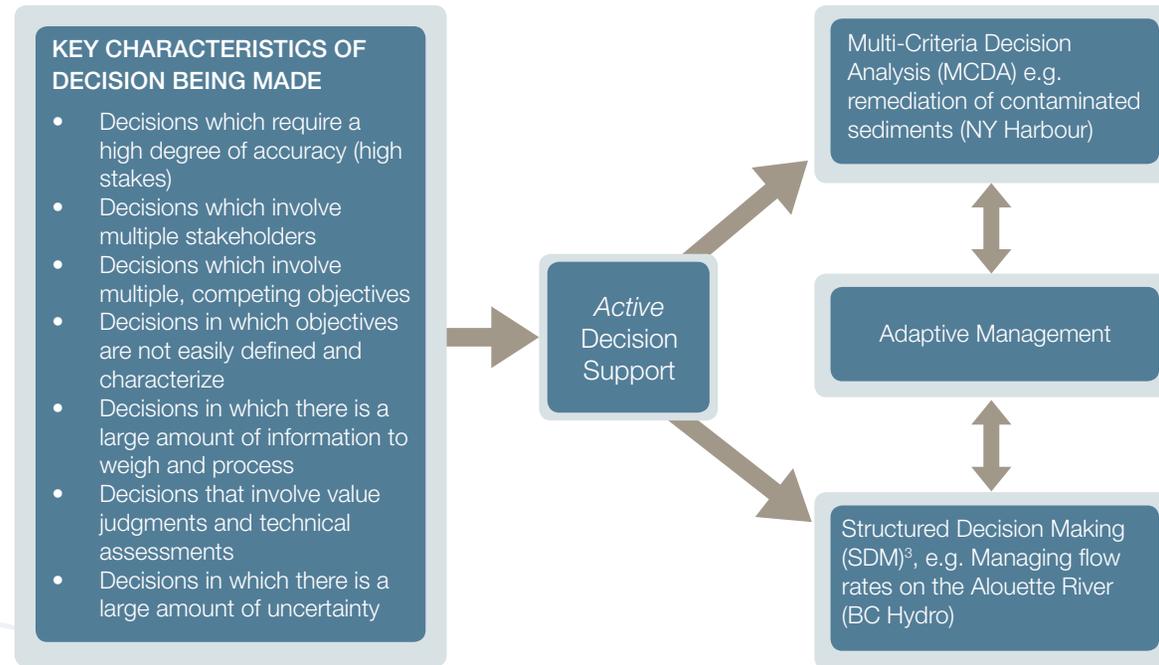
<sup>2</sup> We discuss a more comprehensive list of potentially problematic decision characteristics in Table 3.

Table 3

**CHARACTERISTICS OF DECISIONS REQUIRING ACTIVE AND PASSIVE DECISION SUPPORT TECHNIQUES**

ACTIVE DECISION-SUPPORT TECHNIQUES	PASSIVE DECISION-SUPPORT TECHNIQUES
<p><b>High-stakes decisions:</b> decisions that have significant political, social, environmental and economic ramifications are subject to public scrutiny and are not easy to reverse once put in place (adapted from StructuredDecisionMaking.org, Kunruether et al. 2002).</p>	<p><b>Low-stakes decisions:</b> decisions that are reversible and have fewer consequences (other than for the decision-makers themselves). However, negative consequences may accrue over time and may not, ultimately, be reversible.</p>
<p><b>Decisions that involve multiple stakeholders:</b> decisions that involve participants from a variety of backgrounds and levels of subject matter expertise, who have emotional involvement in the decision context.</p>	<p><b>Decisions made frequently:</b> decisions that are repetitive, such as daily or weekly decisions.</p>
<p><b>Decisions that involve multiple, competing, objectives:</b> decisions in which objectives such as minimizing project costs or maximizing economic growth are seemingly in conflict with the desire to reduce greenhouse gas emissions or maximize public transit infrastructure.</p>	<p><b>Decisions made quickly:</b> decisions in which people tend not to put a significant amount of thought and preparation.</p>
<p><b>Decisions in which objectives are not easily defined or characterized:</b> decisions in which the characterization of the objective is difficult to arrive at, such as when the objective is to remediate or maintain the scenic beauty of a river and the decision-makers are challenged to arrive at a characterization of “scenic beauty” that is meaningful to the participants.</p>	<p><b>Decisions that are made at the individual or household level:</b> decisions that do not involve a diverse set of stakeholders.</p>
<p><b>Decisions in which a large amount of information needs to be weighed and processed:</b> decisions in which the participants in the active decision-making process are asked to integrate data from a variety of sources (e.g. economic data, parameters describing the resource in question, human health and social wellbeing statistics, etc.).</p>	<p><b>Decisions in which objectives are already identified:</b> decisions in which passive decision-support techniques assist in the accomplishment of clearly specified goals (of the individual or of the society at large). Therefore, some thought, effort and consultation have previously been directed at defining those goals (i.e. through active decision-support means).</p>
<p><b>Decisions that require the integration of value judgments and technical information:</b> decision in which the active decision-support techniques are predicated on the meaningful incorporation of stakeholder values and complex technical information, which are explicitly incorporated into the choice process.</p>	<p><b>Decisions for which the consequences are not readily apparent:</b> the many small decisions we make every day, whose consequences may not be immediately apparent. However, as has already been mentioned, negative consequences may be revealed over time.</p>
<p><b>Decisions characterized by a large amount of uncertainty:</b> decisions in which active decision-support techniques tend to be applied in situations with a long time frame (years) and are ecologically, socially and economically complex. By definition a great deal of uncertainty surrounds how a particular course of action will play out over time and within these complex decision contexts.</p>	<p><b>Decisions that tend to be made when hungry, tired or distracted:</b> decisions in which other demands may prevent us from devoting the necessary attention to the decision at hand or may direct our focus to affective cues at the expense of decision-relevant information.</p>

## HOW CAN WE MOTIVATE AND SUPPORT DECISION-MAKING FOR SUSTAINABILITY? (Active Decision Support)



### WHY DO THESE TYPES OF ACTIVE DECISION SUPPORT WORK?

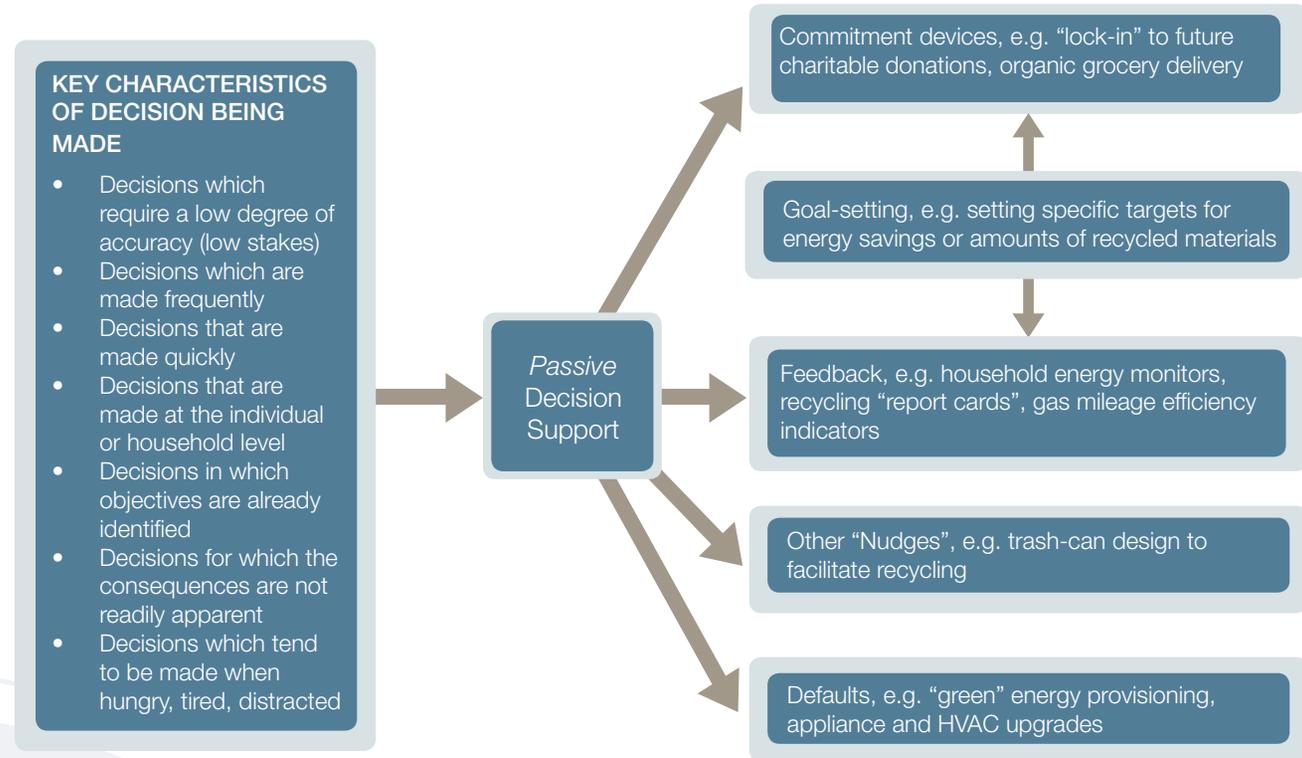
- Break decisions down into manageable steps
- Avoid the use of potentially biasing shortcuts, e.g. availability, anchoring, and status quo bias; or an over reliance on affect heuristic
- Explicitly address consequences and trade-offs
- Account for objectives which are not easily defined or quantified
- Structured process to incorporate subjective values

### WHAT ARE THEIR PROS AND CONS?

- Can be time consuming
- Not suitable for everyday decision-making
- Best for group work, larger-scale decisions - but can work for individuals
- Require expertise in identifying information needs; gathering and communicating this information
- Require expertise in DA and SDM process

Please note that SDM techniques do lend themselves to individual decision-making, especially relating to large and infrequent purchases, e.g. cars, homes; or high stakes decision-making, e.g. moving to a new city or accepting a new job

**HOW CAN WE MOTIVATE AND SUPPORT DECISION-MAKING FOR SUSTAINABILITY?  
(Passive Decision Support)**



**WHY DO THESE TYPES OF PASSIVE DECISION SUPPORT WORK?**

- Take advantage of known biases and errors in decisionmaking. e.g. availability and status quo bias; over reliance on affect heuristic; discounting
- Make the "right" decision easier, e.g. providing defaults, or increasing the convenience of certain actions
- Provide immediate and meaningful feedback
- Make the consequences of decisions more tangible

**WHAT ARE THEIR PROS AND CONS?**

- Can be perceived as manipulative, therefore must be transparent in their employment
- Best geared towards individuals
- Must advance societally- or individually-agreed upon objectives (i.e., previously identified through the use of active decision support techniques)
- Require advance planning
- Long-term effectiveness not known

Note that: the active decision support techniques described Model 2a, e.g. SDM can help identify decision objectives for use in passive decision support; Goal-setting used in conjunction with commitment devices and feedback efforts - not a decision support technique on its own; and Feedback can involve normative information (i.e. what others are doing), as well as quantitative information (e.g. energy usage or energy costs)

## ACTIVE SUPPORT-DECISION TECHNIQUES

A review of the literature revealed two key approaches to providing active decision support: structured decision-making (SDM) and multi-criteria decision analysis (MCDA). These approaches are discussed below. A brief description of adaptive management is also included, although adaptive management is not a decision-support technique in and of itself. Adaptive management is increasingly used to augment the effectiveness of SDM and MCDA.

### *Structured Decision-Making*

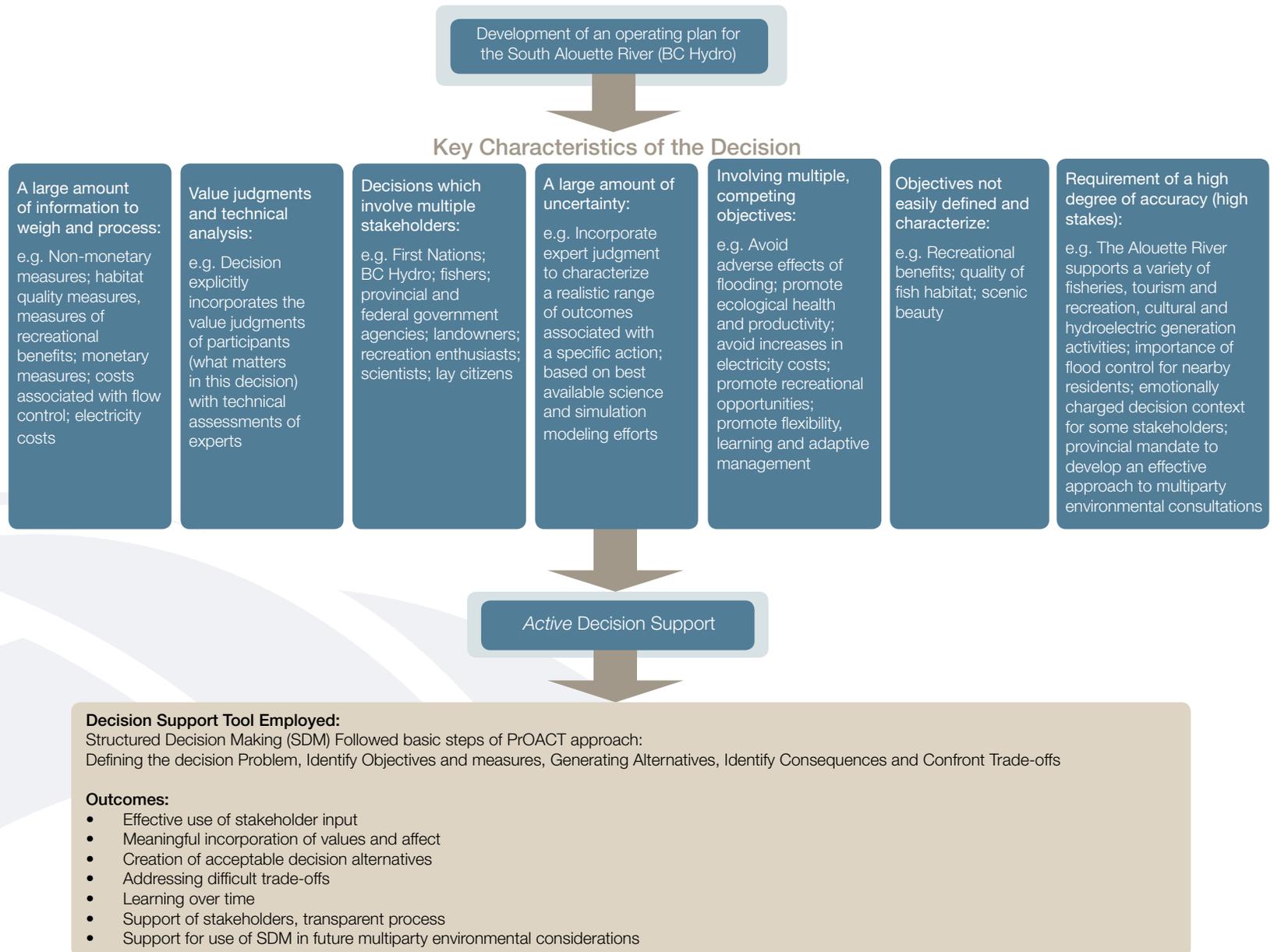
This section reviews the use of structured decision-making (SDM) approaches from the perspective of bringing together necessary and multiple perspectives — in either individual or group decision-making processes — as part of decision-making for sustainability. A key facet of this discussion is the use of normative benchmarks (see page 14 of this report) as guides for this prescriptive process. Overall, the SDM

approach is best viewed as a kind of decision-making tutorial that builds understanding of a decision problem and works to overcome common biases as it informs a choice. More specifically, SDM addresses the need to (1) recognize and account for potentially biasing heuristics — such as status quo bias — that people typically utilize when faced with complex choices (2) more effectively balance affect-based responses to stimuli alongside technical analyses of information and (3) push aside superficial treatments of information or alternatives that can lead to suboptimal choices.

The specific SDM process that we describe here (and that was used — in whole or in part by the articles and reports included in this review) is referred to by the acronym ProACT (Hammond et al. 1999): define the decision **PR**oblem, clarify **O**bjectives and measures, generate **AL**ternatives, identify **C**onsequences and confront **T**radeoffs.

Each of these steps will be described briefly (Model 3 illustrates the application of SDM to a real-world decision problem).

**EXAMPLE APPLICATION OF A DECISION SUPPORT TOOL:  
ALOUETTE RIVER WATER USE PLANNING (adapted from Gregory et al. 2001)**



1. **Define the Problem:** Perhaps the most important step in the SDM process is the definition of the decision problem. Without a clear scoping of the decision at hand, the structured decision-making process will not produce a satisfactory outcome. For example, if a decision problem is defined too broadly, it will provide little guidance in the initial clarification of objectives. If a decision problem is defined too narrowly, then you may not be able to address all relevant objectives. Ultimately, researchers and practitioners alike (BC Hydro 2009; Gregory & Keeney 2002; Keeney 1996) suggest taking a great deal of care and — as appropriate — creativity in defining a decision problem and looking at the problem at hand as an opportunity to create a solution with multiple benefits (a “win-win” solution).
2. **Clarify Objectives:** A critical element in a SDM effort is to engage participants in a process of thinking carefully about their objectives as they relate to the decision problem at hand. One part of this process helps people focus on their values (e.g. the importance of sustainability), which can be expressed, for the purpose of decision-making, as objectives (e.g. taking actions that *promote* sustainability). A subsequent step in the process helps people distinguish between *means* and *ends* objectives, which helps to facilitate clear thinking about decisions related to the environment (Keeney 1996).

For example, many decision-making efforts that deal with climate change focus on transportation and fuel efficiency, such as the U.S. Environmental Protection Agency’s (EPA’s) program on alternative fuels and General Motors’ “Live Green, Go Yellow” campaign, which encourages the use of vehicles

that can make use of corn-based ethanol/gasoline blends. A decision-focused effort will go a step further by omitting endorsements of a single course of action and instead prompting people to think about the difference between *means* and *ends* objectives. Whereas promoting fuel efficiency in one’s personal vehicle is a *means* objective, the *ends* objectives are to decrease greenhouse gas emissions and reduce the rate at which the climate is changing. Encouraging people to think about *ends* objectives helps to avoid their anchoring on a single course of action, such as the use of ethanol-blended fuels in motor vehicles, by opening the door to other possible management alternatives (e.g. any transportation or non-transportation option that also works to reduce greenhouse gas emissions). Note that a SDM effort of this type does not preclude a person from eventually choosing a more fuel-efficient vehicle; however, it does help people to realize that a single option is not a panacea and that it — alongside other options — may be combined in many ways to achieve a desired effect.

Beyond helping to widen the range of possible alternatives that might be considered by a decision-maker, the process of helping people to identify and clarify their *ends* objectives — and the decision alternatives — serves two other important functions. First, a thorough exploration of decision objectives helps to achieve a much-needed balance between what are traditionally technical concerns (such as reducing small particulates in the atmosphere, restoring or maintaining estuary health) and those that are affective or values-oriented in nature (such as reducing affective responses of dread in the face of climate change). Second, exploring a comprehensive set of objectives at the front end of a decision-

making process is an important first step toward avoiding many of the problems associated with potentially biased heuristics. In the case of framing, for example, the consideration of a wider range of decision-relevant objectives helps decision-makers realize that identified problems cannot be solved by focusing on only one dimension. Likewise, helping an individual or group to more fully understand what they might want to achieve by a decision places the focus squarely on objectives and weakens the appeal of sticking with the status quo.

3. **Attaching Attributes (Measures) to Objectives:** A frequently ignored aspect of clarifying objectives that will guide a decision is thinking about ways to *operationalize* the objectives. In other words, it is of little help to a decision-maker to express an objective (such as improving the health of the environment) without also offering a very clear and appropriate sense of exactly how to measure it. To complete this important step, decision-makers must identify the *attributes* of the objective that are appropriate.

Research has focused on developing a specific, operational typology of attributes to help inform their selection in a given valuation context (Gregory & Keeney 2002; Keeney 1996). Generally speaking, attributes that help to define the different aspects of a decision context fall into one of three categories: natural attributes, proxy attributes or constructed attributes.

*Natural attributes* are direct measures of conditions that exist in a system. For example, if one attribute of an environmental system being evaluated is the economic value of a commercially important species (e.g. fish or trees), then the specific value of this attribute can be expressed directly in dollars. Likewise, if an attribute

characterizing the health of an ecosystem is the number of a key indicator species living in it, then a straightforward count of this species represents another direct measure of health.

*Proxy attributes*, by contrast, are used when it is not possible to directly measure an attribute of interest. For example, if one attribute of an ecosystem (e.g. a river) is the recreational opportunities that it provides to tourists, economists may estimate the recreational value of the resource by calculating how much people are willing to pay to visit that river. Similarly, a particular mudflat may be valued from an ecological standpoint because of the migratory shorebirds it attracts. However, as is frequently the case, accurate direct counts of shorebirds, which would be a natural attribute, are impossible to achieve. In these cases, an analyst may rely on the mudflat's carrying capacity or the amount of available habitat as a reasonable proxy for the number of shorebirds that may use the mudflat over the course of a season.

*Constructed attributes* are most often used when neither a direct, natural attribute nor a reasonable proxy attribute exists. Constructed attributes are typically used to operationalize objectives that are psychophysical in nature (e.g. the objective to improve the aesthetic quality of the grounds around a manufacturing facility). Scales that may be administered during surveys often need to be constructed (e.g. by psychologists, sociologists and others) as a means of characterizing these attributes.

4. **Generating Alternatives (Options):** Decision-makers often adhere too strongly to available decision options as a result of the availability heuristic or status quo bias. Instead, part of the

decision-making process should be directed at not only identifying available decision alternatives but also generating new ones that better encompass stated objectives (e.g. by combining components from existing alternatives). The identification and generation of alternatives is an important step in the structured decision-making process, both in terms of seeking out creative solutions to the problem at hand and in providing an additional opportunity for meaningful input by stakeholders (e.g. through a brainstorming process to challenge decision constraints and conventional thinking as well as devise a list of workable alternatives).

#### 5. Identifying Consequences and Confronting Trade-offs:

Engaging people in a process of identifying what matters to them and what they want to achieve with a decision leads to another question: how can people choose which alternative is “best”? In some cases — such as when only a single objective matters — a single best option can be clearly identified. More often than not, however, many conflicting objectives are in play (e.g. minimizing costs, maximizing safety). Thus, decision-makers must realize the inevitability of trade-offs — the need to give up one item that is valued to gain another item that is also valued, but for different reasons.

The trade-offs inherent in choosing one alternative over another are difficult for most decision-makers because of the psychological conflict that such trade-offs evoke (Gregory 2002). SDM approaches can help in some cases simply by reminding people of the need to address trade-offs. In other more complex cases, SDM efforts can be designed to provide guidance or specific tools to decision-makers to help them to carry out more

formal trade-off analyses. In their most basic form, these trade-off tools involve ranking and weighing objectives as they relate to the performance expectations of different risk management options. Several useful methods are available for helping people to reconcile complex trade-offs.

Common to each of these methods is the important concept that the prioritization of objectives should be undertaken only in a comparative framework. All too often, decision-makers will state that a certain objective (e.g. minimizing the financial costs associated with implementing a management plan) is of paramount importance. Lost in this kind of comparison-free prioritization is the important concept of relative benefit. While decision-makers may indeed wish to focus on the importance of one objective, they must also be aware of large increases in benefit (e.g. environmental protection) that may be accompanied by just an incremental increase in cost. A starting point during trade-off analysis is, therefore, the construction of a table that displays the various alternatives across the top row of the table; the objectives and measures form the subsequent rows of the table and the expected performance — or *consequence* — of each alternative is then displayed in the individual cells of the table (see Table 4 for an example). This systematic, tabular presentation — known as a *consequence matrix* — of how well the different alternatives satisfy each objective is a powerful tool for clarifying the acceptability of different options and is useful as the starting point for the in-depth consideration of trade-offs and conflict across objectives.

Table 4

**A SAMPLE CONSEQUENCES MATRIX**

OBJECTIVES	MEASURES	1: GREEN A	2: GREEN B	3: DIVERSIFIED COAL	4: STATUS QUO (but update)
Minimize capital cost	Start-up Cost (in \$)	\$395,000	\$400,000	\$240,000	\$140,000
Minimize operating costs	Annual Costs (in \$)	\$22,000	\$22,000	\$35,500	\$25,500
Maximize employment	Number of Full-time Employees	37	24	22	25
Maximize student employment	Number of Student Employees	80	120	0	0
Minimize carbon emissions	Annual Emissions (tonnes of CO <sub>2</sub> /yr)	600,000	550,000	570,000	950,000
Ensure good air quality	Sulphur dioxide [SO <sub>2</sub> ] in air (ppm)	0.1	0.1	0.2	0.35
Show leadership/innovation	Relative to Peer Institutions (Constructed Scale 1–10)	4	6	5	2

This consequences table has been adapted from a structured decision-making exercise designed to determine (in this particular case) the best option for power generation for a large university (given the objectives identified in this table). The shaded area represents the expected performance — or consequence — of each alternative for each of the decision objectives. The university is looking to

transition to a form of power generation that minimizes the costs associated with power generation (and the carbon and sulphur dioxide emissions) and maximize the number of employees hired (both student and regular), to provide opportunities to exhibit leadership and innovation to peer institutions and to provide educational and research opportunities. Numbers are for illustrative purposes only.

Following the construction of a consequences table, decision-makers must determine the relative weight to be placed on each objective when comparing alternatives. This determination of relative weights is a critical aspect of a prescriptive decision-aiding process because it helps to clarify the meaning of different trade-offs in terms of the outcomes associated when one alternative is selected over another. Although the weights can be elicited from participants in numerous different ways, all methods are based on the assumption that weights are a reflection of the values held by a particular individual and thus are another way to explicitly incorporate value judgments into these decisions. Ultimately, decision-makers should be encouraged to adjust their weights across the various objectives and attributes as they become more familiar with both the weighting procedure and the trade-offs implied by their weighting judgments.

SDM has been successfully applied in a wide range of decision contexts that relate to sustainability:

- Decisions regarding sanitation in developing countries (Arvai & Post 2011)
- Endangered species management (Gregory & Long 2009)
- Fisheries management (McDaniels et al. 2006)
- Risk communication and risk management (Arvai et al. 2001)
- Strategic planning and visioning (Keeney & McDaniels 1992, 1999)
- Infrastructure (transportation) planning (Wilson & McDaniels 2007)
- Water use planning and river flow management (Gregory et al. 2001; McDaniels et al. 1999)
- Watershed management (Gregory 2000)
- Wilderness preservation (McDaniels & Roessler 1998)

### *Multi-Criteria Decision Analysis*

Like SDM, multi-criteria decision analysis (MCDA) is employed in sustainability contexts because decision-makers recognize that decisions involving social, environmental and economic considerations are, by nature, complex (i.e. such decisions involve difficult trade-offs, multiple stakeholders and an often-overwhelming amount of technical data).

One of the most commonly employed MCDA techniques in environment-related decision-making is multi-attribute utility theory (MAUT), a technique for formally drawing multiple perspectives and evaluations into a decision-making process. The ultimate goal of MAUT is to arrive at a *numerical* expression of the decision-maker's preferences, which is accomplished by calculating a utility function (similar to the description of normative models of decision-making on page 8) that incorporates all decision criteria (e.g. the costs of a particular course of action) and assigns weights to these criteria on the basis of stakeholders' and/or the individual decision-maker's values and preferences. The MAUT approach further mimics the rational decision-making approach by ranking decision alternatives according to the criteria and preferences described above (Kiker et al. 2005; Linkov et al. 2006), although these steps are typically accomplished by using a computer program. The decision-maker is then expected to opt for the alternative with the greatest net benefit (i.e. with the greatest summed or averaged scores across all criteria), as determined by the computer program.

Other MCDA techniques applied in environmental decision-making contexts include outranking and analytical hierarchy process, which differ from MAUT in the way that alternatives are

scored, compared and ranked (although the underlying assumptions are the same). However, it is beyond the scope of this review to describe the algorithms and computer programs<sup>3</sup> associated with these advanced decision analytic techniques. For a more detailed review of these approaches, see Yatsalo et al. (2007), Linkov et al. (2006), Kiker et al. (2005) and Linkov et al. (2004).

MCDA has been applied in a range of sustainability contexts. Similar to SDM, MCDA has been utilized in land and resource management (fisheries, forests), watershed management and water use planning (Kiker et al. 2005; Linkov et al. 2006). MCDA has been used almost exclusively in decisions that involve:

- Environmental impact assessment (Kiker et al. 2005)
- Managing pollutants (Linkov et al. 2006)
- Remediation of contaminated sediments (Linkov et al. 2004; Sparrevik et al. 2011)

#### *A Word about Adaptive Management*

Adaptive management is an iterative approach to resource management that aims to make optimal short-term decisions while also giving equal weight to information gathering with the express purpose of improving future decision-making and reducing uncertainty. In other words, an adaptive decision-maker seeks to make decisions that improve her understanding of a system or process such that future decision-making efforts are more informed. Adaptive

<sup>3</sup> Some examples include Expert Choice Software (based on AHP): [www.expertchoice.com](http://www.expertchoice.com) and Criterium Decision Plus (based on a simplified MAUT approach): [www.infoharvest.com/ihroot/index.asp](http://www.infoharvest.com/ihroot/index.asp).

<sup>4</sup> BC Hydro, "Lower Columbia River Fish Management Plan," [www.bchydro.com/planning\\_regulatory/water\\_use\\_planning/southern\\_interior/columbia\\_river/lower-columbia-fish.html](http://www.bchydro.com/planning_regulatory/water_use_planning/southern_interior/columbia_river/lower-columbia-fish.html).

<sup>5</sup> British Columbia Ministry of Forests and Range, "Adaptive Management Initiatives in the BC Forest Service," [www.for.gov.bc.ca/hfp/amhome/index.htm](http://www.for.gov.bc.ca/hfp/amhome/index.htm).

management is not a decision-support tool in and of itself, but has been used successfully in conjunction with MCDA and SDM (Gregory & McDaniels 2005; Linkov et al. 2006). For example, BC Hydro, by utilizing the results from experimental water flow manipulations to reduce uncertainty about fish mortality and spawning success in rivers with regulated flows, has incorporated adaptive management into its water use planning.<sup>4</sup> The BC Ministry of Forests also utilizes adaptive management in broad variety of decision contexts, ranging from specific forestry practices to whole ecosystem management.<sup>5</sup>

#### *Concluding Comments on Active Techniques*

MCDA and SDM share many similarities. Specifically, both techniques acknowledge the inherent complexity of, in this specific case, decision-making related to sustainability. Both SDM and MCDA incorporate stakeholder values for the purposes of setting priorities, giving weight to various decision options and seeking to ensure broader acceptance of the outcome of the decision-making process. Both forms of active decision support also rely on mechanisms to assist with difficult trade-offs. Finally, MCDA and SDM have been used in a wide variety of sustainability contexts and most typically at the behest of federal and provincial or territorial/ state government agencies, although many private and quasi-private corporations also utilize these techniques (e.g. BC Hydro and BC Gas).

MCDA and SDM techniques also have their differences. MCDA techniques rely on mathematical algorithms and computer software to calculate an overall utility score and to approximate rational decision-making by calculating those utility scores; whereas the SDM process incorporates stakeholders in the construction of meaning at all steps of the process (from the identification of objectives to the generation of alternatives, in addressing trade-offs and in arriving at a final decision) and has as its explicit goal the generation of trust and legitimacy among stakeholders through an adherence to transparency of process and the meaningful involvement of stakeholders.

When to use SDM or MCDA? The short answer is “it depends”. MCDA has largely been applied to in-house decision-making and relies more heavily on mathematical and computer modelling to identify the optimal course of action. This form of decision support focuses less on stakeholder input, deliberation, transparency and building trust. SDM, on the other hand, views decision-making as an opportunity to explicitly incorporate stakeholder values in the definition of the decision problem, identification of objectives and alternatives, and as a way to build trust through an iterative and deliberative approach to decision-making. SDM techniques also lend themselves to individual decision-making (i.e. when no or few additional stakeholders are involved). SDM can support infrequent purchases or capital outlays that require the synthesis of large amounts of information (e.g. new equipment or facility improvements) or high-stakes decision-making (e.g. relocating a company or production facility). That said, these applications have not been discussed to any great depth in the papers and reports relating to decision-making for sustainability.

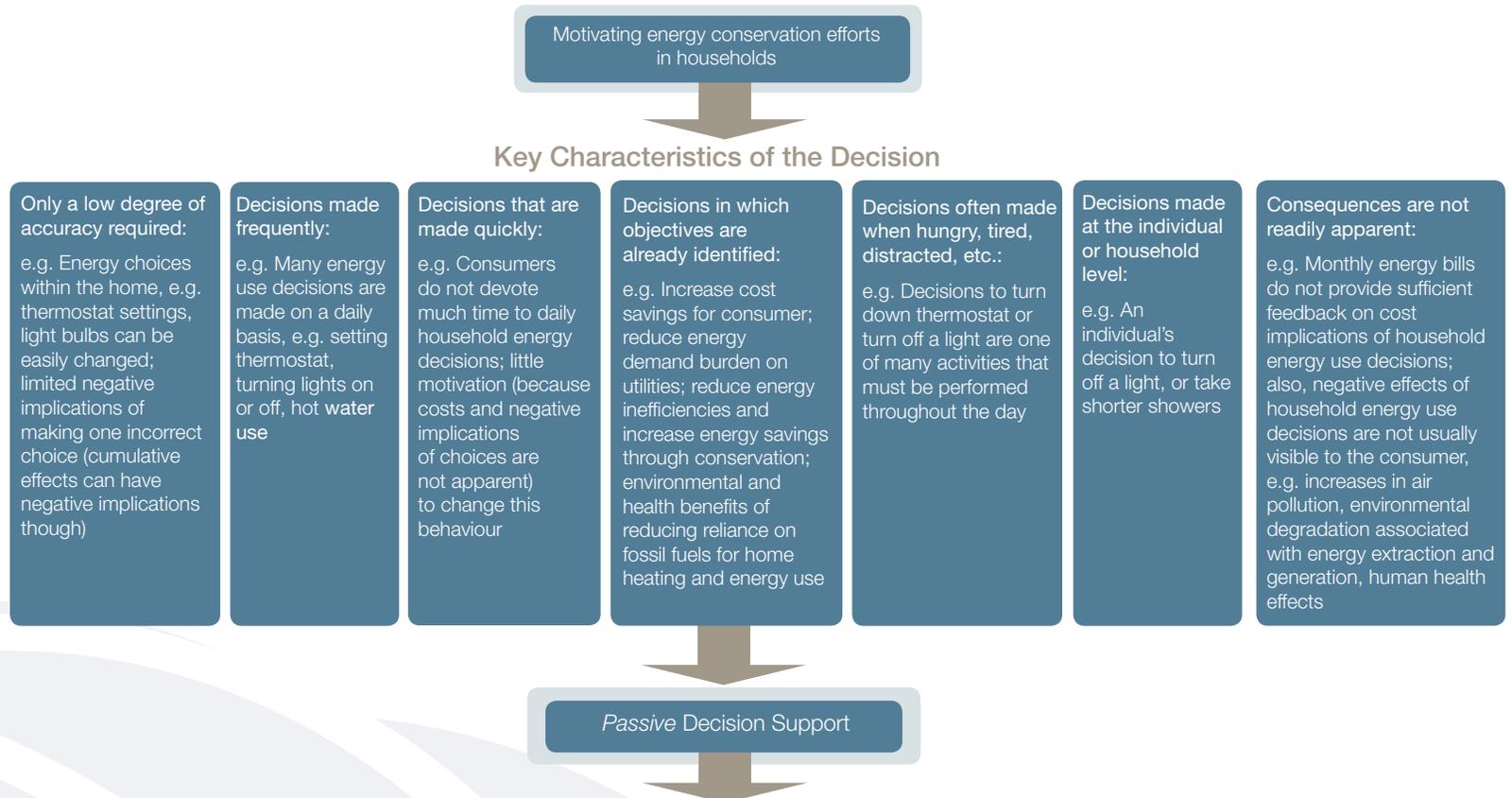
## **PASSIVE DECISION-SUPPORT TECHNIQUES**

This systematic review revealed five passive decision-support techniques that adhere to the principles of behavioural decision research: (1) providing feedback (2) establishing goals (3) using commitment and commitment devices (4) employing defaults and (5) using “other” nudges (a general category we developed to encompass some unique and interesting passive decision-support techniques, but for which limited information is available in the literature). The rest of the report describes these techniques.

### *Providing Feedback*

With few exceptions, the decisions we make daily tend to provide no information about implications for the health of the environment (e.g. the contribution to atmospheric particulate loads from our daily commute). Compounding these difficulties is that many inputs (e.g. energy) and outputs (e.g. long-term costs, contributions to greenhouse gas) are all but invisible to most individuals. One way of addressing this information deficit is to devise ways to deliver information to individuals and households in a manner as specific and up-to-date as possible. Providing immediate and meaningful feedback on behaviours that have sustainability implications has been identified as an important way to make these invisible inputs and outputs more apparent to the individual, to enhance future implications so they are more meaningful for the present, and to motivate and support more sustainable behaviours (Ehrhardt-Martinez et al. 2010; Thaler & Sunstein 2008). Model 4 illustrates the application of feedback to a real-world sustainability context.

**EXAMPLE APPLICATION OF A DECISION SUPPORT TOOL (1): RESIDENTIAL ENERGY SAVINGS  
(adapted from Fischer 2008)**



**Decision Support Tool Employed:**

**Feedback**

- Providing feedback on electricity use
- Specifically: daily computerized feedback that allows for user interaction and appliance-specific breakdowns

**Outcomes**

- Studies show five to 12 percent reductions in electricity consumption when households are provided with computerized feedback on their energy use
- Feedback can serve to capture consumer's attention, to link specific actions to their outcomes, and to make energy consumption visible

Note: Obviously replacing appliances and HVAC components in the home would not fall under the category of "frequent" or even "regular" energy use decisions. However, providing meaningful feedback to consumers can help make the energy and cost savings associated with these upgrades more salient, i.e. make it easier for consumers to justify the initial expense of purchasing and installing a more efficient washing machine or furnace  
Also as noted in Model 1, large and infrequent purchase decisions, i.e., repairing or replacing a furnace, can also be supported by SDM techniques

Providing feedback to individuals and households regarding their electricity and energy use has been a practice since the energy crisis of the 1970s (Ehrhardt-Martinez et al. 2010) and the techniques utilized to provide that feedback have become increasingly user-friendly, interactive and integrated. Because numerous comprehensive reviews on providing energy make use of feedback to households (e.g., Ehrhardt-Martinez et al. 2010; Faruqui et al. 2010; Fischer 2008), it is not the intent of this review to replicate such an intervention-specific effort. Instead, we gleaned data from these reviews and key feedback studies to draw a number of conclusions regarding (1) the circumstances under which feedback is typically provided (2) the most effective ways of providing feedback and (3) some drawbacks to using feedback to convey the consequences of energy- and conservation-related behaviours.

Feedback efforts range from (i) low-cost and less effective interventions such as personalized energy bills (which provide a more detailed breakdown of energy use and more targeted conservation information than is found on a typical energy bill) to (ii), a more frequent weekly or daily feedback regime (again, on paper or over the computer), which is moderately more effective than enhanced monthly energy bills, to (iii), the more costly but more effective real-time feedback schemes using digital-display formats (with and without appliance-specific information). These decision-support interventions have been shown to reduce energy usage between four and 12 percent, with the low end of this range achieved by the enhanced billing feedback and the upper end of the range associated with real-time feedback and appliance-specific breakdown. However,

these average reductions in energy use were calculated from both European and North American research efforts; if only the United States and Canada are included in the calculations, then reductions in energy usage range from 2.2 to six percent (Ehrhardt-Martinez et al. 2010).

New “Smart” or “Advanced” metering initiatives and in-home energy use displays allow for two-way communication of energy use information between a residence and a utility, and set the stage for fully automated home energy-monitoring systems (i.e. systems that are automatically responsive to peak energy demands and pricing shifts) (Ehrhardt-Martinez et al. 2010; Faruqui et al. 2010). These new “Smart” meters have been the subject of numerous practitioner reports, most notably for Ontario’s HydroOne, BC Hydro and a host of utility providers across the United States (EPRI 2009; Faruqui et al. 2010). However, these Smart meter initiatives have been employed for the primary purpose of *load management* i.e. to prompt energy users through dynamic pricing structures conveyed through Smart meters and via more frequent energy bills to shift demand away from peak times. In these cases, energy conservation is a secondary goal. The effectiveness of energy feedback also has been enhanced through the provision of contextual information. OPower, a third-party, web-based “customer engagement platform” for utility providers, provides customers with normative feedback on their energy bills by illustrating through user-friendly graphical representations (i.e. “smiley faces”) how a particular household’s energy use compares with that of its neighbours and the surrounding community.

Many researchers caution, however, that the installation and monitoring of in-home smart energy use technology may be hindered if consumers become overwhelmed with information or find the systems too inconvenient (Ehrhardt-Martinez et al. 2010; Faruqui et al. 2010; Franklin Energy 2009). We also suggest that compliance can be hindered if consumers feel they have not been consulted sufficiently on goals and objectives of these advanced metering and billing efforts. Nonetheless, these studies examining energy feedback efforts suggest that, to be effective, feedback should have the following characteristics:

- Provide data in real-time (or at the very least daily or weekly)
- Offer information that is as specific as possible
- Be convenient and easy to understand
- Provide meaningful contextual information (as was discussed with respect to evaluability)

Other examples illustrate the use of feedback to encourage decision-making for sustainability. Providing personalized feedback on recycling behaviours (i.e. documenting the volume of materials recycled and amount of contamination for individual households) can increase both participation rates in community recycling programs and the total amount of material recycled (Haldeman & Turner 2009; Schultz 1999). Finally, the implementation of dashboard fuel-efficiency displays in cars has been associated with the development of more efficient driving practices and reduced fuel consumption (Barkenbus 2010; Gonder et al. 2011).

### *Establishing Goals*

Goal setting is shown to be an important first step in ensuring that environmentally sustainable choices are made. While goal setting is not a stand-alone decision-support intervention, encouraging individuals to set specific goals relating to sustainability has been shown to enhance the effectiveness of feedback relating to home energy use and recycling efforts (Constanzo et al. 1986; Lehman & Geller 2004; McCalley & Midden 2002). Goal setting increases the efficacy of these efforts because the goal is thought to provide a much-needed benchmark against which individuals can judge their progress.

### *Gaining Commitment*

Like goal setting, sustainable behaviour is more likely to be performed when a public commitment is made. Public commitments have been used effectively in campaigns to reduce automobile idling (the Canada-wide Turn It Off campaign) (Armstrong & Montagnese 2009) and to promote backyard composting in Langley Township, British Columbia (Lura Consulting 2010). Making public commitments to energy savings has also been used to augment the effectiveness of household electricity use feedback programs.

Commitment devices or pre-commitment strategies present another promising option to support decision-making for sustainability. However, these have thus far been used only to encourage savings and charitable giving (Milkman et al. 2008; Thaler & Sunstein 2003). In these situations, individuals commit to, for

example, increasing the proportion of their paycheque going to savings with future pay raises (coined the Save More Tomorrow plan) (Thaler & Benartzi 2004). Such a commitment strategy works because it capitalizes on the tendency of people to delay self-control restrictions, on loss aversion (linking increases in savings with pay raises means that paycheques never decrease) and behavioural inertia (once enrolled in this program, drop-out rates are low) (Thaler & Sunstein 2008). The popularity of online resolution websites — where people publicly pledge to fulfill a resolution and commit to paying a penalty if they don't — is testament to the power of commitment both in making the positive outcomes of behaviours more salient and in increasing the (social and monetary) costs of not fulfilling the promise (Rosenbloom 2011).

### *Employing Defaults*

A *default* is the choice one has in the absence of actively choosing another option; it can mean either sticking with the status quo or remaining with an option provided by someone else. The key point to remember with defaults is that they do not *remove* options, but simply make some decision options more (or less) convenient or available.

Defaults have been employed in a variety of pro-environmental and pro-social contexts, including the following: (1) motivating environmentally friendly food choices in a campus dining hall (Arvai & Campbell-Arvai, in review) (2) promoting healthier food options in a fast-food restaurant (Downs et al. 2009), (3) facilitating the choice of “green” energy providers for household energy needs (Pichert & Katsikopoulos

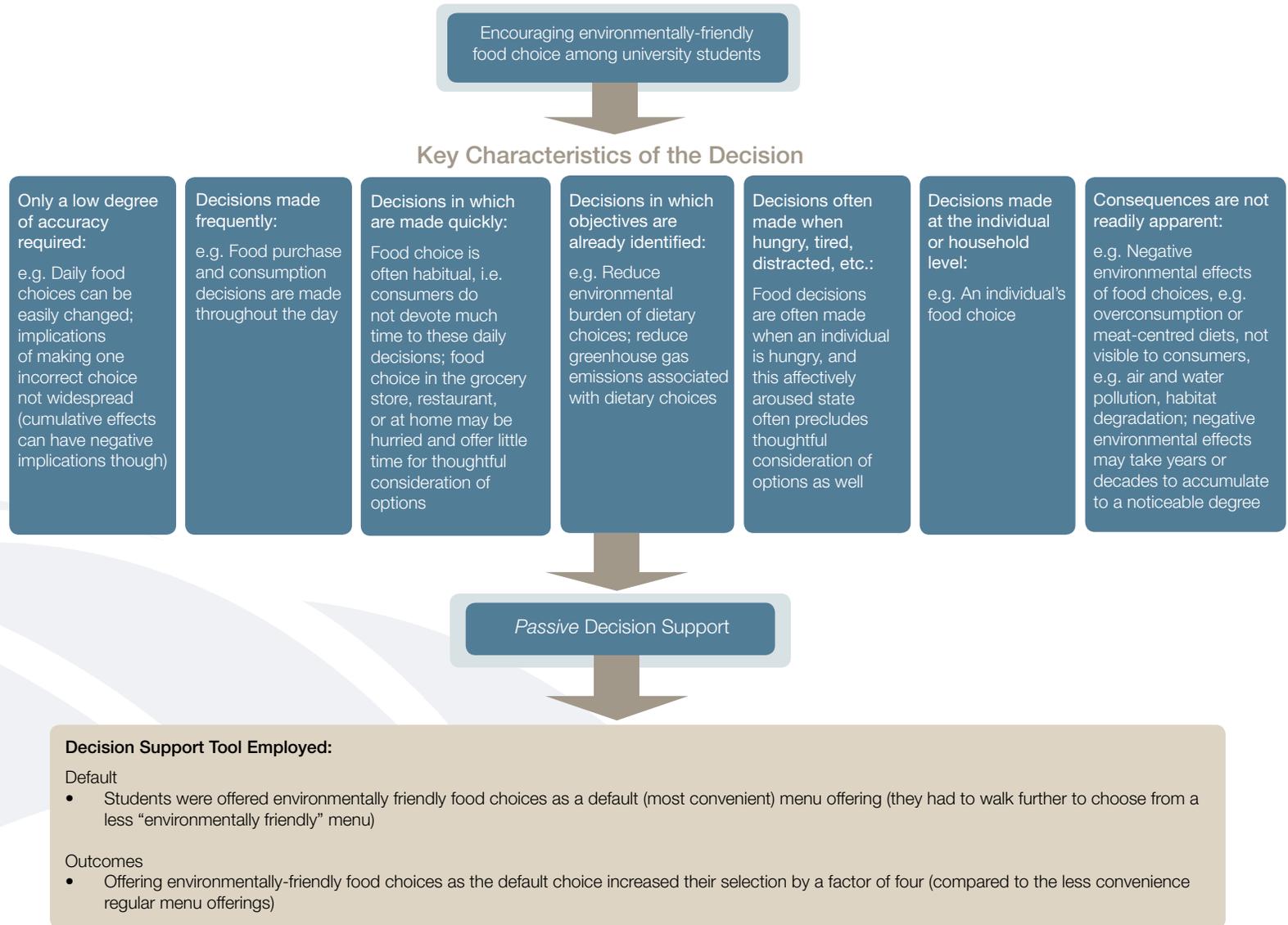
2008) (4) encouraging organ donation (Johnson & Goldstein 2003) and (5) increasing employee savings and enrolment into employer-sponsored retirement programs (Thaler & Benartzi 2004). An example of the application of defaults to a specific sustainability scenario is presented in Model 5.

Defaults are most commonly encountered in opt-out programs. Energy conservation programs that require participants to opt in (i.e. make an active choice to participate) tend to be much less successful than programs where people are automatically enrolled (and must actively opt out to decline participation) (Franklin Energy 2009). Ultimately, defaults have proven to be a powerful decision-support tool because they (1) provide a low-effort option (acknowledging that decisions often require effortful trade-offs), (2) represent an implied recommendation by another person or entity and (3) account for the reluctance of individuals to give up the status quo option (capitalizing on the endowment effect and an individual's aversion to loss). The caveat with the use of defaults is that they can come across as coercive and manipulative if the public is not consulted in their implementation. Nonetheless, providing, for example, energy-saving appliances and HVAC (heating, ventilation, air-conditioning) systems as the default choice in new or renovated homes can be an effective way of ensuring these technologies are more widely adopted.

### *Using “Other” Nudges*

The shape and form that passive decision-support techniques will take in the future is limited only by technology and our imagination. Indeed numerous

**EXAMPLE APPLICATION OF A DECISION SUPPORT TOOL (2): “ENVIRONMENTALLY-FRIENDLY” FOOD CHOICE (Adapted from Arvai and Campbell-Arvai in review)**



examples are available that, although not the subject of a published report, do merit inclusion in this review. These examples are included here because, similar to the interventions described previously, they are at least in part inspired by the principles of behavioural decision research.

- The Nissan “EcoPedal” provides feedback to drivers through the gas pedal. When drivers accelerate too hard or otherwise drive in a fuel-*inefficient* manner, the gas pedal provides increasing resistance to the driver prompting him or her to resume a more energy-efficient driving style ([http://www.nissan-global.com/EN/NEWS/2008/\\_STORY/080804-02-e.html](http://www.nissan-global.com/EN/NEWS/2008/_STORY/080804-02-e.html)).
- California Edison’s “Energy Orb” and the “Wattson” out of the United Kingdom are devices that glow different colours to reflect household energy use. These devices differ from the home digital-display devices previously discussed in that they provide feedback in terms of a simple and easy-to-understand colour change (e.g. Wattson glows blue when home energy usage is low and red when energy use is high), as opposed to attending to digital display readouts or monthly energy bills. Wattson also provides a digital readout of energy used and costs accrued (<http://www.ambientdevices.com/cat/orb/PGE.html>; <http://www.diykyoto.com/uk>).

Both of these examples build on the idea that the effectiveness of digital and dashboard displays of energy and gas usage may be hindered if the user has insufficient time and motivation to scrutinize and

respond to the numeric information. Instead, these behavioural interventions transform the feedback data so that consumers can respond much more quickly, utilizing the affective or intuitive system of information processing (as opposed to cognitively processing the information). Indeed, governments in Europe are piloting the implementation of meters in cars to track mileage and charge fees to those drivers who are logging extra miles. These in-car meters are effective because they provide instantaneous negative feedback on inefficient driving habits (Rosenthal 2011).

Trash can design also has been tackled using these same principles. Researchers found that specially designed lids that mimicked the shape of the item to be recycled (i.e. aluminum cans, glass bottles and paper) increased rates of recycling and reduced contamination (Duffy & Verges 2009). The authors attribute these results to the lack of attention that people direct to recycling activities, and thus any intervention that makes sorting and recycling easier or more obvious will help to increase compliance rates. Readers should note that municipal programs that offer *commingled* recyclables collection also increase compliance rates. This is related to the underlying principle of defaults in that recycling participation can be expected to increase as a consequence of making the decision to recycle much easier—or making improper recycling practices more difficult.

#### *Concluding Comments on Passive Techniques*

Passive decision-support techniques take advantage of the predictable biases in our decision-making (e.g. status quo bias, discounting or overreliance on

the affect heuristic) to help us make decisions that benefit society and the environment. While the specific circumstances under which these techniques can be applied have no hard and fast rules, we can draw some general conclusions.

In general, commitment devices and defaults tend to be used in situations where the sustainable option or course of action is overlooked because of the immediate costs or the immediate negative aspects of the option, or because the decision-maker is distracted, tired or hungry. Feedback, on the other hand, is best applied in situations where the decision context does not provide strong signals in terms of long-term negative effects of a choice or behaviour. Ultimately, these approaches all address similar decision-making errors and biases, their specific employment depends on where and how the decision is made (e.g. in a home, in a cafeteria or in a car) by one individual or many; or the technology and resources available. The specific decision-support techniques available to use are limited only by our imagination. Unfortunately, we had insufficient data to draw conclusions about the long-term effectiveness of these interventions (i.e. will their effectiveness decline over time as people lose interest or begin to challenge what is offered as a “default”).

In addition, while the focus of this section of the report is supporting sustainable decision-making, care should still be taken in carefully outlining decision objectives prior to employing these passive decision-support techniques (utilizing a structured decision-making technique). Otherwise, the use of defaults and in-home feedback devices may be perceived as manipulative (i.e. advancing someone else’s cause). Finally, the choice and deployment of passive decision-

support techniques does require advance planning, in terms of both identifying the goals to be achieved and deciding which technique will be most effective given the particular decision-making circumstances.

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# conclusions

The first step in deciding which decision-support intervention to use is to characterize the decision itself (i.e. is it a high- or low-stakes decision?).

Literature on decision-making spans well over 60 years, but only relatively recently have researchers and practitioners begun to apply the principles of behavioural decision research to understanding and supporting sustainable decision-making. In this review we have summarized what we know about how people actually make decisions (the descriptive component) and the tools that are available to help us make better decisions (the prescriptive component), particularly in the context of sustainability. The sections on normative and descriptive models of decision-making served as a primer on decision-making, describing the ideal normative model of decision-making and then outlining the key features of how we actually make decisions (the descriptive models of decision-making). It is hoped this background information will help practitioners, managers and executives to understand why we may have difficulty with decisions that have implications for the environment (no matter how large or small).

Building on these normative and descriptive models, the prescriptive models of decision-making section identified several decision-support interventions that have been shown to be effective (or have the potential to be effective) in motivating and supporting decision-making for sustainability. The model we developed (Model 2), which represents these prescriptive approaches to decision-making, helps to identify the circumstances under which these different approaches are best applied. Thus, the first step in deciding which decision-support intervention to use is to characterize the decision itself (i.e. is it a high- or low-stakes decision). Is the decision performed frequently and with little conscious thought or is the decision part of a long-term consultation and learning process? Once you have ascertained whether an active or a passive approach is more appropriate, you simply choose the technique best suited to the specific requirements of the decision at hand.

A need remains, however, for further application of behavioural decision research to sustainability problems. Scholars and practitioners alike, having begun to appreciate the unique perspective prescriptive approaches can bring, are applying these principles to a variety of circumstances related to sustainability. Even intervention techniques that have been in use since the energy crisis of the 1970s (i.e. goal setting and feedback) have benefitted from this fresh perspective. More work is still required, however, to determine the long-term efficacy of these interventions and to more clearly delineate when (and why) a particular intervention is most appropriate. In addition, efforts to automate key parts of the SDM process (e.g. the consequences table and trade-off techniques) may help to make this type of active decision support more accessible (both to groups and individuals). Indeed, there have been a number of attempts to create a smartphone application that follows an SDM protocol to assist individual decision makers.

Ultimately, the recognition that behavioural nudges (passive decision-support techniques) are an effective and acceptable means of facilitating sustainable behaviour change will, we hope, translate to a proliferation of intervention techniques designed in response to specific decision-making problems (as illustrated by examples provided in the “Other Nudges” section of this report). It is in this sense that practitioners are actually leading research, applying ingenuity and an entrepreneurial spirit to solve the vexing sustainability dilemmas of today. Their ultimate success, however, will come from recognizing the predictable errors and biases in everyday decision-making and then applying this insight to make sustainability interventions more meaningful, effective and widespread.

# Appendix A

## Summary of Methodology

### SYSTEMATIC REVIEW

Few existing reviews examine decision-making for sustainability in a substantive way. Dwyer et al. (1993) conducted a systematic review of behavioural interventions to preserve the environment, although this review focussed solely on social psychological and consumer research (i.e. did not explicitly deal with decision-making behaviour) and included only those studies published between 1980 and the early 1990s. Steg and Vlek (2009) conducted a more recent integrative review of efforts to encourage pro-environmental behaviour, although again their review drew mainly on literature from social and environmental psychology, consumer and marketing studies.

Similar in focus to our systematic review, Ratner et al. (2008) compiled a more recent overview of research on behavioural interventions to promote consumer welfare; however, they did not focus on pro-social and pro-environmental decision contexts and utilized only a select subset of the available literature. Our research differed from these existing reviews in the following ways: (i) we systematically drew on literature from the interdisciplinary field of behavioural decision research, in addition to relevant work from social and environmental psychology, marketing and business (ii) we included, whenever appropriate, examples from

practitioner literature, and (iii) the scope of our review encompassed more recent (to 2011) research.

Ultimately, we utilized the systematic review methodology, as opposed to the more common narrative reviews and meta-analyses for two reasons. First, a key feature of the systematic review is to adopt a review process that is transparent, exhaustive and replicable (Tranfield et al. 2003). While numerous different approaches can be used to conduct a systematic review (Rousseau et al. 2008), these approaches have in common a detailed and well-documented process of identifying, assessing and interpreting sources for inclusion in the review, with the ultimate aim of avoiding bias and ensuring the validity of the emergent themes and interpretation. Second, our aim was not to conduct an overarching statistical analysis of existing quantitative data, but to instead *integrate* highly theoretical works, field and laboratory experiments, and applied research and case studies for the purpose of determining both the mechanisms behind, and the efficacy of, decision-support interventions to promote decision-making for sustainability (Rousseau et al. 2008).

Briner and Denyer (2010) provide a succinct overview of the key features of a systematic review: (i) the review is systematic, meaning both that the methods employed are designed to answer the research question(s) at hand *and* that these methods are followed rigorously (ii) the review is transparent and replicable, meaning the methods are described in detail sufficient to allow other researchers and practitioners to replicate the process and (iii) the review results in a synthesis, meaning data from identified sources is organized and coded so that the research question(s) can be addressed. In general, following this systematic review process allows researchers to establish the current state of knowledge on a particular topic, as reflected in available literature (academic, government and practitioner sources alike).

## **SUMMARY OF RESEARCH PROCESS**

A broad initial search of the literature using relevant keywords identified well over 22,000 articles, books and practitioner reports; approximately 5,900 of these were identified using the search terms related to how people actually make decisions and 16,100 through the use of search terms that tapped into research on decision support.

We trimmed this list down to the most relevant 2,224 articles, books and practitioner reports. This literature was then reviewed in more detail to assess whether it met the criteria for relevance and quality to be included in this systematic review. Ultimately, 207 sources were identified for inclusion in this systematic review: 174 academic articles, 22 books and 11 government and private industry reports. These sources originated from a wide variety of disciplinary

and interdisciplinary academic journals, e.g. from psychology, economics, marketing and decision analysis, and from government and private industry reports.

These sources were systematically analyzed to identify key insights into human decision-making (particularly as they relate to incorporating concerns about sustainability) and key interventions to support sustainable and defensible decision-making. We further summarized this information in several models throughout this report, both as a visual representation of how we have synthesized the data but also to help other researchers, practitioners and managers to navigate this complex topic.

These methods are presented in greater detail in the following sections.

## **SELECTION OF RESEARCH QUESTIONS AND KEYWORDS**

The research questions that provided the framework for this systematic review were developed through discussions among the three project researchers and with the NBS Guidance Committee. Given that we were investigating both how people make decisions and the interventions available to support more sustainable decision-making, these research questions were organized into two sections to reflect these different foci. An additional set of questions guided our presentation of normative models of decision-making. These research questions can be found on the following page.

The research team also developed a list of keywords to identify the academic journals, books and practitioner reports that would help to address these research questions. These keywords were reviewed by the NBS Guidance Committee and are included alongside the two categories of research questions.

### (I) Setting the stage: Normative models of judgment and decision-making

Note that this section is not part of the systematic review, but was included to provide context for the sections that follow. Thus, no keywords were generated for this section.

Q1a What do normative models of individual decision-making look like?

Q1b What are the implications of this “idealized” perspective for sustainable decision-making?

### (II) Explaining behaviour: *Descriptive* models of decision-making

Q2a What *actually* drives people’s decisions? In other words, what challenges do people face during decision-making (e.g. insufficient time, cognitive limitations, difficult trade-offs, the role of affect/dual process theory, the construction of preference)?

Q2b What are commonly applied coping strategies for dealing with complexity in decision-making (e.g. heuristics, judgmental strategies, norm-based rules, etc.)?

<sup>6</sup> Each keyword was separated by ‘OR’ when entered into the database search engine.

Q2c Is decision-making for sustainability different from other kinds of decision-making?

Q2d Do differences exist for different categories of decision-makers (e.g. expert vs. lay decision-making, consumers, managers, the general public)?

Keywords<sup>6</sup>: Construal theory, Construction of Preference, Discounting, Heuristics and Biases, Affect, Endowment Effect and Loss Aversion, Preference Reversal, Prospect Theory, Present-biased Preferences

### (III) Improving the quality of decision-making in sustainability contexts: *Prescriptive* models of decision-making

Q3a What kinds decision-support tools are readily available for managers, policy makers and practitioners to enhance individual decision-making (i.e. account for potentially biasing short-cuts, heuristics and other decision errors)?

Q3b What kinds of decision-support tools have been applied to decisions relating to sustainability issues?

Keywords: Asymmetric Paternalism, Behavioural Economics, Behavioural Decision Research, Behavioural Interventions, Decision Analysis, Defaults, Education, Feedback, Framing, Goal-setting, Information, Nudges, Commitment, Social Marketing, Social Norms, Structured Decision-Making

## INITIAL SEARCH OF THE LITERATURE

To search for articles in academic journals, academic books and book chapters, the keywords listed above were entered into the following databases: Academic Onefile, JSTOR, Web of Science, EBSCO (Business Communications and Environmental Science) and SAGE. We restricted our search to peer-reviewed English-language publications; we did not place any restrictions on the articles' publication dates.

Practitioner reports were identified using the keywords listed in Part III above, tapping into the following information clearinghouses: Resources for the Future, CBSM (Community-Based Social Marketing), GreenBiz, Business in Society Gateway, SustainAbility, LexisNexis, ECCH (European Case Study Clearinghouse), CSIRO (Commonwealth Scientific and Industrial Research Organization) and Google (the first five pages of results only).

Requests for additional sources and examples of practice were made through our affiliated research networks, including (but not limited to) IRIS and ISEEE at the University of Calgary, the Decision Science Research Institute (Eugene, OR), Columbia University's Center for Research on Environmental Decisions (New York, NY), Climate Decision Making Center (Carnegie Mellon University), Harvard Business School and the Fuqua School of Business at Duke University. We did not use keywords in these requests, but instead queried after articles, books and, in particular, practitioner reports related to decision-making (both

descriptive and prescriptive models) and environmental sustainability.

This broad initial search identified well over 22,000 articles, books and reports; approximately 5,900 of these were identified using the search terms identified in Part II, and 16,100 for Part III above. To pare these lists down to a more manageable size, the following additional terms were included in the search<sup>7</sup>: *pro-environmental, climate change, consumer behaviour, energy use, energy conservation, recycling and sustainable behaviour*. These additional search terms were identified through a review of articles and books in our own databases, i.e. papers, books and reports that explicitly address pro-environmental and pro-social decision-making and behaviour.

Ultimately, this initial search gave us a list of 2,224 articles, reports and books on which to conduct the secondary (eligibility) screening.

## SECONDARY SCREENING

These 2,224 articles, reports and books were screened for eligibility following a procedure developed by the research team and reviewed by the NBS Guidance Committee. In secondary screening, articles, books and reports were read<sup>8</sup> to determine the following: (i) *Do the study findings relate to the research questions?* (ii) *Do the study findings contribute to our understanding of shortcuts in human judgment and decision-making or the efficacy of related behavioural interventions?* and (iii) *Does the study make specific reference to behaviour*

<sup>7</sup> These additional search terms were added to the keyword search using "AND" (to differentiate them from the keywords used in the original search) and 'OR' operators (to differentiate them from each other).

<sup>8</sup> Eligibility was assessed on the basis of a review of the abstract, introduction, and methods as necessary; for many studies, however, the abstract contained sufficient detail on which to judge eligibility. Books and reports that were not organized as such were reviewed in their entirety (or until an assessment of inclusion/exclusion was made).

*change (not just changes in attitudes or intentions)?* Two researchers conducted this secondary screening for eligibility; any disagreements as to eligibility were resolved through discussion.

Note that while our original eligibility criterion was to include studies that were based on controlled laboratory or field-based experiments, many review articles, discussion pieces and books were also worthy of inclusion; thus, we did not use controlled experimentation as an eligibility criterion. Instead, this information (type of study) was included as part of the data collected from eligible publications. However, to keep the scope of this report manageable, we eliminated studies that did not directly relate to judgment and decision-making, e.g. studies that described individual characteristics, e.g. values,

worldviews and demographics, or where framing was included as part of a study on attitudes, perceptions or knowledge of environmental or social issues. Notes were kept to account for all excluded studies, indicating the reason for exclusion.

Thus, from our preliminary list of 2,224 articles, books and practitioner reports, we developed a list of 207 eligible sources: 174 articles, 22 books/book chapters and 11 practitioner reports (for the full list of citations, see page 82). Tables 5 and 6 summarize how these totals were arrived at; list the keywords that were used (both descriptive or prescriptive) to identify the articles, books and reports; and note whether they were sourced through academic databases, practitioner databases or our professional network.

Table 5  
**KEYWORD SEARCH AND SCREENING PROCESS**

SOURCE:	SECTION II (DESCRIPTIVE MODELS) OR SECTION III (PRESCRIPTIVE MODELS) KEYWORD SEARCH:	INITIAL SEARCH	PRELIMINARY SCREENING	FINAL SCREENING
Academic Journal Articles	Section II	5,900	907	81
	Section III	16,100	1,284	93
Books and Book Chapters	Section II	7	7	4
	Section III	19	19	18
Practitioner Reports	Section III only	33	12	11
	TOTALS	22,059	2229	207

Table 6

**BREAKDOWN OF HOW SOURCES WERE IDENTIFIED**

	JOURNAL ARTICLES		BOOK AND BOOK CHAPTERS		PRACTITIONER REPORTS	TOTALS
	<i>Descriptive</i>	<i>Prescriptive</i>	<i>Descriptive</i>	<i>Prescriptive</i>	<i>Prescriptive</i>	
Academic Titles Databases	77	82	4	14	-	177
Information Clearinghouses	-	-	-	2	9	11
Professional Network	4	11	-	2	2	19
TOTALS	81	93	4	18	11	207

These 207 sources were identified via a process of eliminating the following:

- Duplicates (which eliminated close to half of the list of titles)
- Studies that focussed only on perceptions, attitudes or behavioural intentions
- Studies that otherwise did not directly relate to judgment and decision-making
- Studies that were insufficiently detailed (overall length or in description of methods and results)
- Studies that focussed exclusively on theory development and that did not expand our understanding of an issue beyond sources we had already identified
- Studies that did not directly relate to the research questions relating to descriptive and prescriptive models of decision-making (particularly as they relate to decision-making for sustainability)

These articles, books and practitioner reports were entered into an EndNote file and PDFs of each file (where appropriate) were saved.

**DATA EXTRACTION**

Key concepts, and the relationships between them, were identified from the data sources (journal articles, books and practitioner reports) using a combination of inductive and deductive methods (Bernard & Ryan 2010); while we had no *a priori* expectation as to what might emerge from the data, a set of well-established themes and relationships associated with work on descriptive and prescriptive models of decision-making emerged, e.g. specific heuristics and biases, relationships between time stress and decision-making. Thus, our goal was to code the data in such a way to both reflect existing themes and relationships (which

had been established through extensive research on this subject) and acknowledge, through new codes, the emerging themes and relationships that reflect the specific research needs of this review. Coding was a highly iterative process; journal articles, book summaries and practitioner reports were read and reread several times during the course of the data extraction period.

The coding process was terminated when we felt we had an exhaustive list of themes and relationships (i.e. no new codes emerged from the data sources). Notes on themes, the relationship between them and their associated codes were shared between two members of the research team (Campbell-Arvai and Arvai). Any discrepancies and disagreements as to coding and theme identification were resolved through discussion; a summary of this data was recorded in an Excel file and is available on the NBS website.

While the research questions listed in Section A3 provided an overarching guide for this process, we identified themes and the relationships among them by asking the following specific questions as we worked through the data:

1. **What decision-support tools are best suited to decisions relating to environmental, social and economic sustainability?** We identified and coded all decision-support tools that were used in sustainability contexts, e.g. feedback, structured decision-making.
2. **Why were these decision-support tools developed?** In other words, what specific decision-needs were being met, e.g. does the decision-maker have the right information? What decision-specific challenges were being addressed, e.g. is the decision-maker distracted? What decision errors and biases were being mitigated, e.g. status quo bias? In answering these questions, we drew connections between the decision-support tool and one or more of these issues.
3. **What are the differences and similarities among the different decision-support tools?** In answering this question, we began to develop the grouping of decision-support tools on the basis of whether they were *active* (i.e. breaking the decision down into more manageable parts, often with the help of a facilitator) or *passive* (i.e. presenting decision options in such a way as to make sustainable choices easier).<sup>9</sup>
4. **What are the differences and similarities in the circumstances under which these different types of support tools are applied?** In other words, what are the characteristics of decisions in which *active* decision-support tools should be applied? Do these differ from the circumstances under which *passive* decision-support tools are best applied? In developing codes to reflect these different decision-making scenarios and techniques, we constantly asked ourselves whether this differentiation corresponded with what was known about decision-making, i.e. did it accurately reflect the current state of knowledge on decision-making and decision-support techniques?
5. **Do the identified themes and associated codes serve the needs of the intended audience of this report?** Because this review is to serve as a decision-support “toolbox” for managers, practitioners and researchers alike, we constantly

<sup>9</sup> For a more detailed definition of active and passive decision support, please see page 44.

asked ourselves whether our classification and coding system was producing a useful and user-friendly representation of the data (while, again, not violating the conclusions of the existing body of research).

Answering these questions was an iterative process, our understanding of how the different themes fit together changed as we worked our way through the data. Our ultimate goal was to ensure that our coding scheme was exhaustive (i.e. that all themes and relationships between themes were accounted for) and valid (i.e. did not misrepresent the data).

## DATA CODING AND SYNTHESIS

A list of codes relating to descriptive models of decision-making can be found in Table 7. Note that we included in this report only those descriptive models that related directly (e.g. provided an underlying mechanism for a particular decision-support tool) or indirectly (e.g. provided an explanation as to why individuals and organizations may find decision-making for sustainability difficult) to the prescriptive models mentioned below. We ultimately identified five descriptive models. Within each of these main categories were several related concepts and models (i.e. these concepts and models were often referred to together in the literature included in this systematic review).

Table 7

### CODING TABLE (DESCRIPTIVE MODELS OF DECISION-MAKING)

MAIN DESCRIPTIVE MODEL	ASSOCIATED CONCEPTS
Prospect theory	Framing effects Endowment effect Loss aversion Status quo bias
Heuristics and Biases	Availability Anchoring and Adjustment Evaluability
Affect and Dual Processing Perspectives	Affect heuristic
Want/should and Present/future Conflicts	Discounting Construal level theory Present-biased preferences
Construction of Preference	

Through this iterative process of identifying both themes and relationships between themes (both emerging and pre-existing), we were also able to develop models that reflected the data we gathered on prescriptive models of decision-making. These models were further refined and modified through extensive discussions among the co-investigators and through on-going consultations with the data to ensure that the models were a complete and accurate representation of that data.

More specifically, the process of building models from the data began by identifying the decision-support tools and techniques that adhere to the principles of behavioural decision research, which we did by recognizing (1) that most decision-making does not adhere to the principles of rationality (2) that decision-makers typically have difficulty balancing (unaided) social, economic and environmental considerations and (3) that decision-making has predictable biases and errors that should be avoided (or taken advantage of) to support decision-making for sustainability. As noted on page 11 of this report, we also focussed exclusively on approaches to decision-support that made reference to changes in behaviour, not just changes in attitudes or intentions.

Once we were satisfied with our list of different decision-support tools, we then examined the circumstances under which they were commonly applied (which we referred to as “Key Decision Characteristics”). Through this effort we were able to differentiate decisions according to — for example — how many people were involved in the decision process, the amount of information to wade through, whether difficult trade-offs were necessary or whether the decision-maker was distracted or otherwise occupied (please see the Prescriptive Models of Decision-making section beginning on page 40 for a

more detailed treatment of these tools and decision characteristics)

Ultimately, our review revealed two general categories of decision-support tools, which we labelled as *active* and *passive*. The active decision-support techniques identified in this report break decisions into manageable parts and employ specific methods to mitigate and avoid the systematic and pervasive errors and shortcuts described previously. Often a facilitator was present to help guide this process; ultimately, however, the focus was on the process of decision-making and not necessarily on any specific outcome. On the other hand, the passive decision-support techniques included in this report take advantage of known errors and biases, exploiting them to help people make decisions that are in their own self-interest or, as is the focus of this review, to make decisions that have sustainability outcomes. The codes we generated during this iterative process of data synthesis can be found in Table 8.

In all, we developed five models from the data:

- Model 1 is a summary of the relationship between normative, descriptive and prescriptive approaches to decision-making.
- Models 2a and 2b presents a decision-support toolbox, which outlines the two main approaches to decision support that emerged out of the data (active and passive), the specific decision-support tools associated with each of these approaches and the decision characteristics that define the circumstances under which these different decision-support approaches are applied.
- Models 3 to 5 represent real-world examples of why and how these different decision-support techniques have been applied.

Table 8

**CODING TABLE (DESCRIPTIVE MODELS OF DECISION-MAKING)**

ACTIVE OR PASSIVE DECISION SUPPORT?	DECISION-SUPPORT TOOLS	KEY DECISION CHARACTERISTICS
Passive	Commitment e.g. public commitment, commitment to peers, commitment devices  Goal-setting e.g. self-imposed, imposed by researcher, imposed by utility company  Feedback e.g. digital displays, interactive displays, computer interfaces, energy and water bills, usage alarms  Defaults e.g. making sustainable choices more obvious or easier, making unsustainable choices more difficult  Other “Nudges” e.g. unique, context-specific decision-support tools	Low stakes Frequent Quick Individual or household level Objectives already defined Consequences not always known Decision-maker hungry, tired, distracted, etc.
Active	Structured Decision-Making  Multi-criteria Decision Analysis e.g. MAUT, AHP  Adaptive Management	High stakes Multiple stakeholders Multiple objectives Objectives not clearly defined Large amount of information Value judgments Technical assessments Uncertainty

**CRITICAL APPRAISAL OF THE DATA**

To provide readers of this report with an assessment of the potential of each decision-support tool in supporting decision-making for sustainability, we included a brief description of the state of research on each of these decision-support tools. For each decision-support tool we noted: (i) whether it has not yet been put into

practice or empirically tested (or only to a limited extent) (ii) whether it has been used to support other types of decision-making, e.g. financial, food or health-related, but has yet to be applied within an sustainability context or (iii) whether it has been extensively tested and reported on (in decision contexts with implications for sustainability) in both academic literature and practitioner reports (adapted from Bertels et al. 2010).

We also made note, wherever possible, of any criticisms levelled at a specific decision-support technique, but only when those criticisms appeared in one of the journal articles, books or practitioner reports included in this study.

We note that we had originally planned to critically assess the data in terms of the methodological quality of the article or report. We had planned to gauge methodological quality in terms of such standard metrics as sample size, appropriate treatments, controls and analysis. However, we quickly concluded that this original characterization of “methodological quality” was too restrictive, i.e. it only applies to controlled experimental studies (some case studies and all review papers do not meet this criteria). In addition, once we had eliminated inappropriate papers during the eligibility-screening process, very little differentiated the remaining studies in terms of their methodological quality, i.e. all papers and reports ultimately included in this review had sample sizes, treatments, controls and statistical analysis appropriate for their particular study objectives.

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# Appendix B

## The Scope of the Data

Of the 207 sources that form the basis of this report, more than 80 percent (174) are from peer-reviewed journals. The remainder of the sources are books (22) and practitioner reports (11). The publication dates of these sources span more than 60 years, with the earliest publication originating in the 1950s and the latest from 2011 (see Figure 3). The majority of sources, however, were published in the 1990s (21 studies based on descriptive models, 18 studies based on prescriptive models) and the 2000s (44 studies based on descriptive models, 51 studies based on prescriptive models).

The disciplinary origins of these sources<sup>10</sup> are also varied (see Table 9), but the majority of sources originate from psychology, economics and interdisciplinary studies. The remaining sources originate from marketing, business, management, social marketing, law, engineering and public policy. When the disciplinary origins of studies are divided into descriptive models vs. prescriptive studies, many more of the prescriptive studies are the result of interdisciplinary work.<sup>11</sup>

<sup>10</sup> The disciplinary origin of practitioner reports was not assessed, because this characteristic is germane only to academic publications.  
<sup>11</sup> We define *interdisciplinary* as either (i) papers that were the collaboration of individuals from a variety of disciplinary backgrounds or (ii) papers that were written for an interdisciplinary audience, i.e. published in an interdisciplinary journal such as *Climatic Change*.

Figure 3

### DISTRIBUTION OF PUBLICATION DATES FOR SOURCES USED IN THIS REPORT

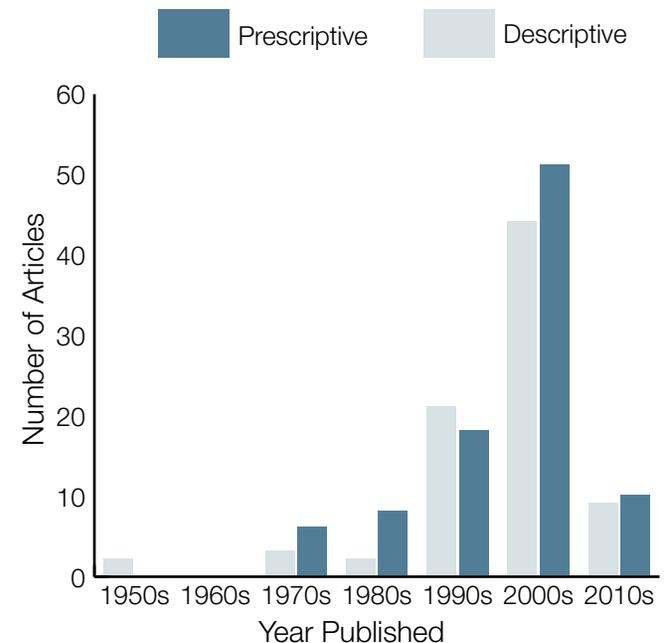


Table 9

### DISCIPLINARY ORIGINS OF SOURCES USED IN THIS REPORT

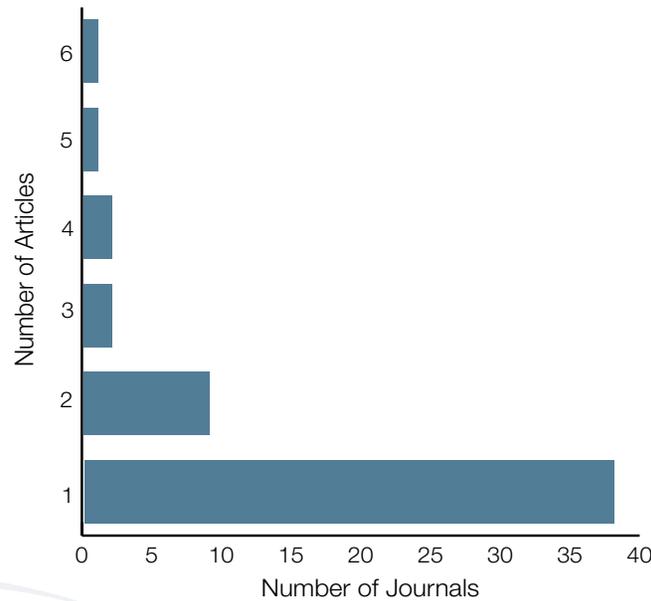
DISCIPLINARY ORIGIN	DESCRIPTIVE	PRESCRIPTIVE
Psychology	42	41
Interdisciplinary	10	37
Economics	15	8
Marketing	4	5
Business	7	–
Management	1	1
Law	1	–
Engineering	–	1
Public Policy	1	–
<b>TOTAL</b>	<b>81</b>	<b>93</b>

Studies that were based on descriptive models were sourced from 53 different peer-reviewed academic journals, the majority of which contributed one or two articles each (see Figure 4). The most frequently cited journals were *Organizational Behavior and Human Decision Processes* (from which six articles were sourced), *Climatic Change* (from which five articles were sourced), *Psychological Science* and *The Quarterly Journal of Economics* (contributing four articles each). *Organizational Behavior and Human Decision Processes* is a leading publisher on basic research into human judgment and decision-making; *Climatic Change* is an interdisciplinary journal; the latter two journals are top publications in their respective disciplines. The remaining journals are similarly diverse, covering a wide range of disciplinary and interdisciplinary research areas.

Similarly, studies based on prescriptive models were sourced from 58 different peer-reviewed academic journals, the majority of which contributed one or two articles each (see Figure 5). The journal titles that contributed the greatest number of articles to this report were *Environment and Behavior* (nine articles), *The Journal of Environmental Psychology* (seven articles), *Risk Analysis* (five articles) and *The Journal of Applied Behavior Analysis* (four articles). *Environment and Behavior* and *Risk Analysis* are both frequently cited interdisciplinary journals. *Environment and Behavior* examines the relationship between humans and the environment, and *Risk Analysis* examines risk (including environmental risks) from a variety of perspectives. *The Journal of Environmental Psychology* and *Journal of Applied Behavior Analysis* publish theoretical and applied studies of the psychology of human behaviour as it relates to environmental and other applied issues.

Figure 4

**SUMMARY OF THE NUMBER OF ARTICLES CONTRIBUTED BY PEER-REVIEWED JOURNALS (DESCRIPTIVE STUDIES)**

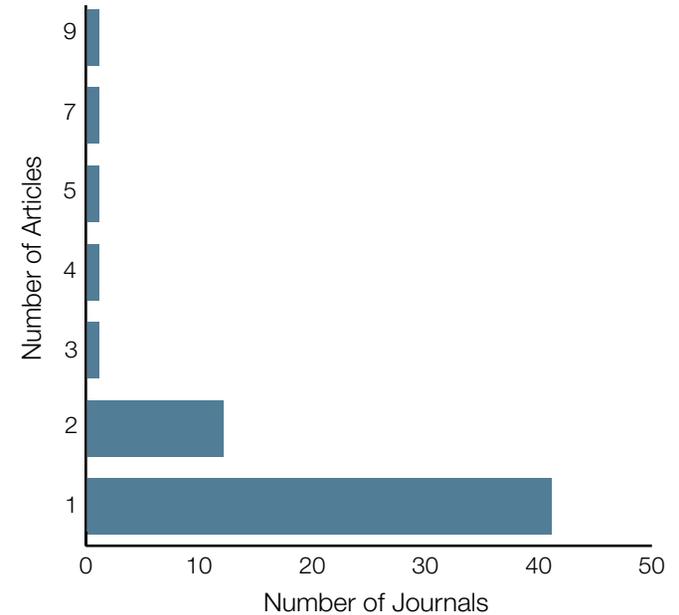


The remaining journals are similarly diverse. The studies (both journal articles and practitioner reports<sup>12</sup>) on which this report is based utilized a wide variety of methods. For studies that were based on descriptive models of decision-making, the most popular methods for examining issues related to judgment and decision-making were lab-based experiments (“pen and paper” or computer-based scenarios) and literature reviews (see Table 10). Note that a “discussion piece” articulates an opinion

<sup>12</sup> Books were not included in these calculations as they are summaries of other, pre-existing studies (although they share characteristics with literature reviews and opinion pieces).

Figure 5

**SUMMARY OF THE NUMBER OF ARTICLES CONTRIBUTED BY PEER-REVIEWED JOURNALS (PRESCRIPTIVE STUDIES)**



about—or new way of looking at—a particular topic but does not refer to the literature to the same extent as a literature review. For prescriptive studies, *in situ* experiments (experiments conducted in the field, in real-life contexts) were the most common method employed to study prescriptive approaches to judgment and decision-making, followed by the literature review (see Table 11). Almost exclusively associated with practitioner reports were case studies, which describe the application of a decision-support tool within a

Table 10

**STUDY TYPE (METHOD USED) – DESCRIPTIVE STUDIES**

LAB-BASED EXPERIMENT	LITERATURE REVIEW	DISCUSSION PIECE	ECONOMIC MODEL DEVELOPMENT	IN SITU EXPERIMENT
42	23	10	5	1

Table 11

**STUDY TYPE (METHOD USED) – PRESCRIPTIVE STUDIES**

IN SITU EXPERIMENT	LITERATURE REVIEW	CASE STUDY	DISCUSSION PIECE	LAB-BASED EXPERIMENT	META-ANALYSIS <sup>13</sup>
37	25	17	6	7	1

single real-life scenario, and pilot studies, in which an experimental design with limited sample size is employed in a preliminary test of a particular method. Finally, the keywords that best represent these studies are summarized in Table 12. This list differs from the original set of keywords used to find these articles (noted on page 10) for two reasons: (i) some keywords were dropped because they weren't associated with any article or report that was ultimately included in this review, e.g. *labels*, *behavioural economics* and

*education* or (ii) they did not uncover additional unique studies beyond what had already been found, e.g. *information*, *dynamic inconsistency* or *asymmetric paternalism*. In addition, a few new keywords are included in these lists. These new additions (e.g. *adaptive management*, *discounting* and *prospect theory*), were added throughout the search and synthesis process to better locate and represent studies that could contribute to this synthesis.

<sup>13</sup> Meta-analytic studies statistically summarize the data from known studies on a particular topic to determine the overall effect of a particular experimental manipulation or relationship.

Table 12

**SUMMARY OF KEYWORDS USED TO IDENTIFY ARTICLES, BOOKS AND REPORTS**

KEYWORDS	# ARTICLES
<b>Section II: Descriptive Models of Decision-making</b>	
Affect	13
Preference Reversal	11
Availability Bias	9
Anchoring	8
Discounting	8
Evaluability	8
Endowment Effect	6
Construal Level Theory	5
Heuristics and Biases	5
Prospect Theory	5
Construction of Preference	4
Loss Aversion	4
Status Quo Bias	4
Affect Heuristic	3
Framing	3
Present Bias Preferences	1
<b>Section III: Prescriptive Models of Decision-making</b>	
Feedback	47
Commitment/Commitment devices	16
Behavioural Interventions	14
Social Norms	14
Decision Analysis	12
Structured Decision-Making	12
Goal-setting	11
Value-focussed Thinking	9
Multi-attribute Utility Theory	5
Multi-criteria Decision Analysis	5
Social Marketing	5
Defaults	4
Adaptive Management	4
Nudges	1

Ultimately, our review of the literature identified the following key issues:

1. The application of decision analysis and behavioural decision research, particularly in the realm of individual decision-making, to issues relating to environmental sustainability and the health of the environment is relatively a new—but rapidly growing—area of research.
2. Our understanding of decision-making behaviour, and decision-making for sustainability in particular, comes from a variety of disciplinary and interdisciplinary areas of research, e.g. psychology, economics, marketing and organizational behaviour.
3. Promising decision-support techniques have been developed as a result of collaborations between academic researchers, government and private industry.
4. Research on health, obesity and saving for retirement yields many insights into decision-support techniques best suited for an individual's daily, sustainability-related decisions.
5. More research is needed on the efficacy of existing decision-support techniques as they pertain to decision-making for sustainability and to identifying and testing new approaches specifically geared to the environmental, social and economic issues faced by individuals, governments and corporations.

# Appendix C

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