Consumer Behaviour

A modelling perspective in the context of integrated assessment of global change

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SUMMARY

Various interrelated processes in the social and environmental systems, such as global warming, economic development and population change, are commonly denoted as 'global change'. In order to develop comprehensive projections of global change, the ideas and findings of various scientific disciplines have to be integrated. Integrated assessment models such as IMAGE 1.0 (Rotmans, 1990), IMAGE 2.0 (Alcamo, 1994), ESCAPE 1.0 (Rotmans, Hulme & Downing, 1994), MARKAL (Fishbone *et al.*, 1983) and TARGETS 1.0 (Rotmans *et al.*, 1994; Rotmans *et al*, 1995, Rotmans & De Vries, in press) provide modelling frameworks that allow for such integration. In 1992 the National Institute of Public Health and the Environment (RIVM) launched the research programme 'Global Dynamics and Sustainable Development' (Rotmans *et al.*, 1994), aimed at developing an integrated modelling framework for global change and sustainable development. Currently, the first version of this framework, called TARGETS (**T**ool to **A**ssess **R**egional and **G**lobal **E**nvironmental and Health **T**argets for **S**ustainability) is available (Rotmans & De Vries, in press). TARGETS adopts an integrated dynamic perspective on global change and sustainable development. In TARGETS several fully linked mathematical simulation models are referring to the human system (e.g. population and health) and to the environmental system (e.g. land use, biochemical cycles). As TARGETS enables one to develop projections of possible futures, it may be a useful tool for both policy decision makers and scientists.

Human consumption of goods and services is a major factor in the process of global change. The effects of many different consumer behaviours jointly intensify global changes, thereby influencing both human habitats and environmental systems. Therefore, various policy strategies for sustainable development are aimed at changing consumer behaviour. So far, integrated assessment models implicitly incorporate the behaviour of consumers. Two main reasons for modelling consumer behaviour explicitly, however, are: (1) to enhance and validate future projections generated by integrated assessment models, and (2) to offer decision-makers points of application in setting priorities and developing effective (behavioural) strategies for sustainable development. Moreover, a behavioural model to be developed should be generic, allowing for its application to different domains of consumer behaviour.

In studying the relevant behaviours, social scientists have developed various models to conceptualise the processes underlying environmentally detrimental behaviour and to provide a perspective on possible effective strategies for behavioural change (see Appendix 1 for examples). However, these existing models are less suitable for integrated assessment modelling for several reasons. Firstly, these models usually do not account for the full range of processes involved in 'real-life' consumer behaviours. Secondly, the relationships between the various model components are rarely quantified. As such, these models lack the mathematical structure that is required to formulate possible projections of future behaviour. Thirdly, domain-specific behavioural models that do quantify such relationships are developed using regression techniques, thus resulting in non-causal static models, in which processes of feedback, adaptation and learning cannot be accounted for. As such, static models only allow for the explanation of present behaviour and are, in principle, unsuitable for developing projections of future behaviour. Fourthly, because these models describe human behaviour for a specific domain, e.g. domestic energy consumption, they lack a generic perspective that would allow for the modelling of behaviour in different domains. Hence, no existing behavioural model meets the requirements as imposed by the context of integrated assessment of global change. Therefore the present project is developing a conceptual model of consumer behaviour that will guide the development of a computer-programmed behaviour simulation module. This behaviour module will be incorporated into integrated assessment models, in particular TARGETS (Rotmans *et al.*, 1994; Rotmans *et al.*, 1995; Rotmans & De Vries, in press).

The conceptual model of consumer behaviour comprises consumer motivation, the opportunities (products and services) they might consume, and consumer abilities (MOA-model, e.g. Batra & Ray, 1986; Robben & Poiesz, 1992; Ölander &

Thøgerson, 1994; Gatersleben & Vlek, 1996). Moreover, the conceptual model provides a taxonomy of major theories on behavioural processes, differentiating between reasoned versus automatic behaviour, and between individual versus social information processing.

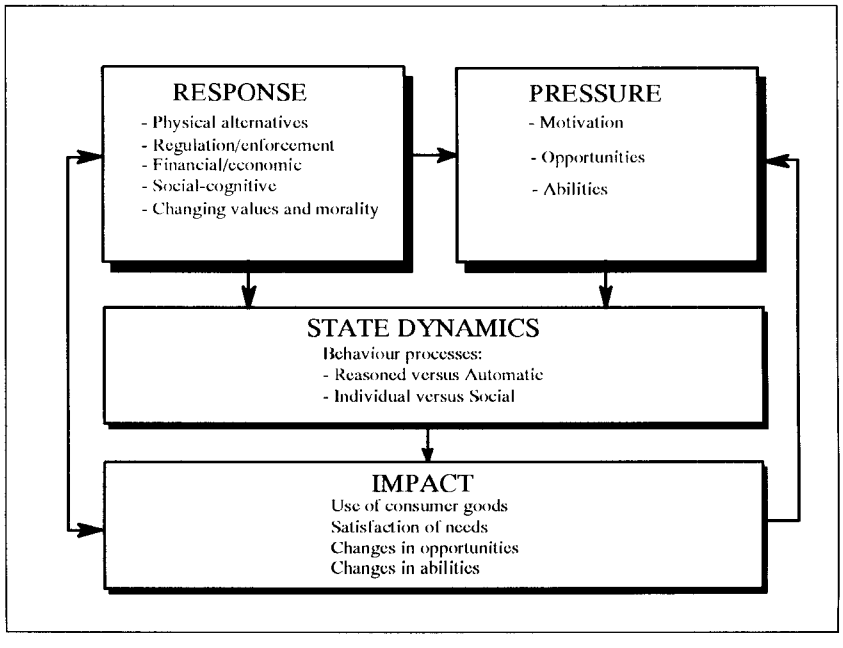
To incorporate processes of feedback in a behavioural model, a system dynamics approach is followed in accordance with the TARGETS philosophy. This implies that consumer behaviour is modelled in terms of *Pressure*, *State*, *Impact* and *Response* systems (P-S-I-R approach). The *Pressure system* describes the driving forces behind consumer behaviour, while distinguishing between consumer motivation, consumption opportunities and consumer abilities (MOA-model). Some of these pressure variables will be imported from other models (e.g. GNP, population). The *State system* simulates the cognitive and behavioural processes preceding consumption using a comprehensive theoretical framework concerning behaviour. The *Impact system* describes the various outcomes of the behavioural process, such as the level of consumption, changes in abilities and opportunities, and the satisfaction of various needs (in relation to quality of life). The level of consumption is a key variable that will be exported to other models within TARGETS. In the *Response system*, different policy strategies, instruments and policy measures to influence consumer behaviour will be represented. The general picture of the conceptual behavioural model is schematically depicted in *Figure 1*.

A preliminary behavioural model, built according to this P-S-I-R approach, was developed for the domain of domestic fresh-water consumption (see Appendix 2). Although the structure of this model is fairly rudimentary due to its illustrative purposes, experiments with this model yielded sophisticated projections on future water use. As such, it was concluded that the general approach would offer a promising perspective for modelling consumer behaviour in the context of integrated assessment.

To develop a more sophisticated model of consumer behaviour, focus is placed on modelling social interaction, learning and adaptation processes in a more comprehensive way. Theories of complex adaptive systems (cas) have offered the modelling tool of 'cellular automata'. This approach allows for the modelling of several distinct consumers (here called *'consumats'*) and their opportunities for consumption in a single programming environment. The basic design of a consumat comprises a set of rules which are rooted in theories of human behaviour. However, the consumats differ with respect to their abilities (e.g. income) and motivation (e.g. cultural perspective), thus representing various types of consumers.

Consumats will be confronted with a set of various opportunities for consumption, analogous to real-world consumption opportunities. Each time-step in the behaviour simulation comprises a full P-S-I-R cycle. In other words, the driving forces behind consumat behaviour will be represented in the Pressure system; the resulting (cognitive) behavioural process in the State system; the outcomes of the consumat behaviour in the Impact system and policy instruments will be represented in the Response system. The next time-step in the simulation starts with the assessment of the new Pressure system. This new Pressure system includes feedback on the impacts generated by other consumats. Because of the comprehensive design of consumats, this feedback will yield the simulation of various social processes, e.g. status-related consumption, the dispersion of new consumer

Figure 1: Schematic representation of the behavioural model



opportunities ('trickling down') and the manifestation of scarcity.

Experiments with the behaviour simulation module will provide insights into the dynamics of consumer behaviour. Moreover, experiments controlling the force and sequences of various types and combinations of policy measures will elucidate the interactions between such measures and the dynamics of consumer behaviour. Consequent, a behaviour simulation model within the context of integrated assessment is expected to improve projections of global change and to provide a perspective on the efficacy of policy strategies to change consumer behaviour.

Organisational structure of the behaviour project

This project of developing a behaviour module within integrated assessment models forms a cooperative effort between the National Institute of Public Health and the Environment (RIVM) and the Department of Psychology of the University of Groningen. The project leader, prof.dr.ir. Jan Rotmans of RIVM, and ir. Marjolein Van Asselt are contributors to this project through expertise in integrated assessment modelling, particularly with respect to the development of TARGETS. Drs. Petra Costerman Boodt has offered expertise through her knowledge and expertise in the field of environmentally sensitive behaviour. From the University of Groningen, prof.dr. Charles A.J. Vlek and drs. Wander Jager have contributed to the development of the behaviour module by offering theoretical state-of-the-art knowledge on social and behavioural processes, and strategies of behaviour change, and by conceptualising such knowledge in system-dynamic terms.

The first part of the behavioural modelling study will be reported here. The aim of this study was to elucidate a generic behavioural model and sketch a perspective on the development and operationalisation of a computer-programmed behaviour simulation model that can be integrated into TARGETS. A subsequent report, intended for publication in 1997, will describe the operationalisation of the behaviour module and present simulation results for a particular domain of consumer behaviour.

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1. INTRODUCTION

One of the main issues of the United Nations Agenda 21 (Dooge *et al.*, 1992) is how to control and reduce human consumption and associated production patterns in order to reduce their impacts on the Earth system. The growing awareness of both scientists and policy-makers of global changes has evoked increased attention for the underlying mechanisms and effective response strategies (United Nations, 1996). Generally, the main driving forces behind human-induced global changes are long-term technological, economic, demographic, institutional and cultural developments (United Nations, 1996; Opschoor, 1989; Stern, 1992; Vlek, 1994; 1995; and Rotmans *et al.*, 1994). In order to develop effective policy strategies for changing these driving forces, it is necessary to identify and understand the underlying socio-behavioural processes. Therefore to fully cope with the causes and mechanisms of global change, the relevant scientific disciplines should cooperate, developing a common language and collaborative methodological tools.

So-called integrated assessment addresses the interdisciplinary process of combining, interpreting and communicating knowledge from diverse scientific disciplines such that the whole cause–effect chain of global change can be evaluated from a synoptic perspective (Rotmans & Dowlatabadi, 1997). Integrated assessment can help to foster understanding of the causal and mutual relationships of processes taking place in the human and environmental systems. Within integrated assessment, computer models are used primarily as a tool to integrate knowledge on a wide variety of disciplines. Integrated assessment models can be used as tools to project specific future processes in global change and to assess the effectiveness of different management policies.

In integrated assessment models, such as IMAGE 1.0 (Rotmans, 1990), IMAGE 2.0 (Alcamo, 1994), ESCAPE 1.0 (Rotmans *et al.*, 1994), MARKAL (Fishbone *et al.*, 1983) and TARGETS 1.0 (Rotmans *et al.*, 1994; 1995; Rotmans & De Vries, in press), consumer behaviour has so far usually been modelled implicitly. However, the behaviour of humans can be considered a dynamic system. Behaviour dynamics are particularly important with respect to human consumption because they determine the use of raw materials, production processes, emissions and the production of waste. For example, in the second half of this century there was a sharp increase in the use of private cars (particularly in the industrialised countries), which generated increasing levels of energy consumption, emissions, waste, and land use for infrastructure (Steg, 1996). The effects of many different accumulated consumer behaviours intensify global changes, thereby affecting both human habitats and environmental systems. Consequently, various policy strategies for sustainable development are aimed at changes in human behaviour, in particular consumer behaviour. Two main reasons for modelling behaviour patterns explicitly are: (1) to enrich the future projections generated by integrated assessment models and make these more valid, and (2) to offer decision-makers points of application in setting priorities and developing effective behavioural strategies for sustainable development.

In studying the relevant behaviours, social scientists have developed various descriptive models to conceptualise the processes underlying environmentally detrimental behaviour and possible strategies for behaviour change e.g., Midden *et al.*, 1982; Van Raaij & Verhallen, 1983; Costanzo *et al.*, 1986; Rosendaal & Poiesz, 1987; Foxall, 1994; SCP, 1996 (For a schematic presentation and short description of these models; see Appendix 1). These models can be conceived as problem-oriented applications of general theories of behaviour, representing the behaviour-determining factors as discerned in field research on energy conservation and other environmentally relevant behaviour. The models thus provide useful knowledge about the behavioural processes underlying consumption patterns, energy-savings, and the reduction of waste. However, because the relationships between the various model components are not quantified, these models do not (yet) offer the mathematical basis needed to formulate possible projections of future behaviours (Jager *et al.*, 1996). Also, because these models aim to describe behaviour in specific domains, they do not offer a generic perspective on behaviour. Therefore, a behavioural model is being developed, integrating available theories and models of human behaviours as much as possible. This behavioural *model* will guide the design of a

computer behaviour *module*. Such a behaviour module allows for the simulation of consumer behaviours, and thus offers a tool that can be incorporated into integrated assessment models, particularly TARGETS (Rotmans *et al.*, 1994; 1995).

TARGETS is an integrated assessment model for global change and sustainable development being developed at the National Institute of Public Health and the Environment (RIVM). TARGETS is an acronym for **T**ool to **A**ssess **R**egional and **G**lobal **E**nvironmental and health **T**argets for **S**ustainability. At present, a first version of this model is currently available (TARGETS 1.0, Rotmans *et al.*, 1994; 1995; Rotmans & De Vries, in press). To explicitly model consumer behaviour in TARGETS, a generic behaviour module is being developed for the TARGETS framework. Such a behaviour module should (1) project developments of consumer behaviours to enrich future projections of global change, and (2) explain the potential of various response strategies for changing consumer behaviour. In this report, we will attempt to position a behaviour simulation model in the TARGETS framework, whilst incorporating theoretical concepts and models from social psychology, sociology and (micro-) economic theory.

Overview of the report

Chapter 2 discusses a behavioural perspective on global change, the integrated assessment model TARGETS, and the need for explicitly modelling human behaviour in integrated assessment models. We particularly emphasise the need for a behaviour module to be incorporated in TARGETS. Chapter 3 delineates the behaviour concept and subsequently outlines a behaviour model on the basis of a multi-theoretical framework for understanding a diversity of behavioural processes. Chapter 4 provides a perspective on the operationalisation of a behaviour module on the basis of the conceptual behaviour model of Chapter 3 is also provided. A perspective on the operationalisation of the variables as presented in Chapter 3. This behaviour module will guide the development of a computer-programmed behaviour module. Chapter 5 presents the conclusions, discusses the preliminary results and pinpoints the most important research issues and corresponding future research.

2. SCOPE OF THE STUDY

2.1 Behavioural dimensions of global environmental change

Past and present civilisations have been more-or-less successful in combatting human poverty, ignorance, discomfort and disease. However, several ancient cultures, like the Mesopotamians (± 2000 BC), the Mayas (800 AD) and the Polynesians on Easter Island (16th century), collapsed because population growth and increase of affluence implied an overexploitation of the natural environment (Ponting, 1992). Currently, various processes causing environmental overexploitation may be recognised on a global scale (e.g. IPCC, 1990; 1996). During the last decades a general awareness has emerged that the environmental impacts of our (Western) economic system not only affect the regional or national levels, but that they also have an impact on the world as a whole. Globalisation of production, trade, culture and so forth has its counterpart in the globalisation of environmental changes, such as global warming, the thinning of the stratospheric ozone layer and large-scale deforestation.

In order to develop effective policies for influencing environmentally harmful behaviours, it is necessary to identify the basic social and behavioural processes that determine global change. Referring to the human causes of global change, Ehrlich & Holdren (1971) propose to explain the environmental impact of a particular society as: I = P x A x T. Here, environmental **I**mpact equals the product of **P**opulation size, the degree of **A**ffluence per person and the environmental damage from the **T**echnology used to produce one unit of affluence. According to this formula, reducing environmental degradation is a battle on three fronts: (1) limiting population growth, (2) limiting affluence and consumption growth, and (3) reducing the environmental impact of production and consumption technology (Goodland *et al.*, 1994). Because of the mutually compensatory character of P, A and T, fighting this battle on just one front may not be sufficient to reach sustainable development. For example, just increasing the level of 'clean' technology (T), while ignoring the growth of population (P) and affluence level (A), may still result in a significant growth of total environmental impact (I).

If we start investigating the socio-behavioural causes of population growth, increasing affluence and the growing power of technology, two other driving forces behind environmental overexploitation can be recognised, i.e. *institutions* as vehicles for constituting and governing human societies, and *culture* as the conglomerate of socially shared beliefs, values and attitudes. On this basis, Opschoor (1989), Stern (1992) and Vlek (1995) consider environmental overexploitation as being driven by technological, economic, demographic, institutional and cultural developments (abbreviated as the T.E.D.I.C. complex). Especially in the 20th century the T.E.D.I.C. complex has propelled an acceleration in environmental over exploitation. From left to right in the T.E.D.I.C. complex, it seems that we are dealing with forces varying from easy-to-change to hard-to-change, or, from modifiable to 'given'. Therefore the more fundamental the determinants addressed by an environmental policy aimed at reducing environmental overexploitation are, the more politically sensitive and harder to implement this policy becomes. This explains the popularity of technical solutions to environmental problems, which may, however, in fact only scratch the surface of a much deeper-rooted set of problems (Vlek, 1995).

As regards the harder-to-change forces, it should be acknowledged that these have their roots in a complex socioeconomic system (Vermeersch, 1988; Opschoor, 1989; Vlek, 1995). The environmental impacts of this socioeconomic system seem to be a natural consequence of the inclination of individual consumers (at the micro-level), and industries and organisations (at the meso-level) to continually optimise their own gains whilst minimising their losses. As long as gains and losses are defined in financial and material (economic) terms, this micro- and meso-level outcome rationality will yield a host of financial and material externalities (costs, waste, overexploitation of common resources) which are transferred to the collective, accumulating into threatening conditions at the macro-level of society as a whole.

However, depending on one's perspective, gains and losses can also be defined within a broader concept of human welfare, including, for example, international equity, the needs of future generations and/or the carrying capacity of supporting

ecosystems. Such a broader perspective could also incorporate collective gains and losses, and thus include various environmental qualities. According to different branches of social science there is no unequivocal definition of particular 'gains' and 'losses' (or 'costs' and 'benefits'). Which micro-, meso- and macro-outcomes associated with a particular behavioural pattern are taken into account is considered to be perspective-dependent. In line with the theory of 'social dilemmas' (Vlek & Keren, 1992), which addresses four types of weighting processes, the comparison of gains and losses is seen to differ with consumer perspectives. The dimensions, described below, are commons dilemmas, cultural theory, policy strategies, and impact assessment and behavioural diagnosis.

Commons dilemmas

A situation in which private interests are at odds with collective qualities can be described as a *social dilemma* (Dawes, 1980; Liebrand *et al.*, 1992). Such a dilemma arises when all or most members of a group act in accordance with their private micro- and/or meso-level interests, whilst shifting off negative external effects to the collective level. Thus, collective outcomes accumulate, (eventually) causing individuals to be worse off than had they all acted in accordance with the collective interests. Depending on his/her perspective, the relative weighing of micro- and meso-level outcomes versus macro-level outcomes will confront a consumer to a greater or lesser extent with the dilemma. Four types of elementary or survival dilemmas are recognised (Vlek & Keren, 1992), in which one-sided overweighting may lead to environmentally detrimental impacts. The following paragraphs, delineating these four 'survival dilemmas', are based on Vlek & Keren (1992).

The first is the everyday *benefit–risk dilemma*: if security, comfort and wealth are primary human desires, then to what extent should the level of achievable benefits be restricted to keep associated risks acceptably low? It is assumed here that benefit and risk levels across sets of human activities are correlated so that optimal benefit-risk combinations must be identified (Coombs & Avrunin, 1977).

The second is a *temporal survival dilemma*: if the principal task of individuals, groups and organisations is to survive 'now', to what degree should current security, comfort and wealth be restrained in order to safeguard future survival conditions (which one may not live to see)? Or, in other words, how much attention and effort could best be devoted to short-term survival and how much is worth allocating to long-term survival?

Third, a *spatial survival dilemma* underlies environmental degradation: if it is our principal task to survive here (in this time and place), to what extent should our local security, comfort and wealth be limited so as to secure more general survival conditions, such as quality of seas and forest areas?

Fourth, environmental degradation can bring about a *social survival dilemma*: if one's principal task is to survive as an individual, then to what extent should individual security, comfort and wealth be restricted in order to maintain collective survival conditions such as public utilities, education, transport and health care?

These four survival dilemmas are combined into a *commons dilemma*. This complex dilemma addresses the balancing of short-term local outcomes (mostly benefits) at the individual level with long-term global outcomes (mostly costs) at the collective level. The latter result from the combined externalities of independently acting individuals. Assuming that consumers assign greater importance to financial and material benefits, and to present, local, and individual outcomes, the dilemmas will work as *traps*, tempting consumers to maximise their own short-term and local benefits whilst ignoring collective, long-term and global risks (Hardin, 1968; Dawes, 1980; Vlek, 1996).

Cultural theory

The perception and awareness of being in a commons dilemma will largely depend on one's values, beliefs and habits. Cultural theory (Douglas & Wildavsky, 1982; Thompson et al., 1990; Schwarz & Thompson, 1990; Rayner, 1991, 1992; O'Riordan & Rayner, 1991) is an organising framework which claims that distinctive sets of values, beliefs and habits are reducible to only a few cultural biases and preferences. Notwithstanding the (operational) limitations of cultural theory, it provides a useful typology to characterise different viewpoints towards a commons dilemma (Van Asselt & Rotmans, 1996). Because the variance in consumer preferences can be partly attributed to differences in consumers' cultural perspectives[1], the typology of

[1] Another part of variance can be attributed to the consumers personality. However, the relation between personality structure and consumer preferences was found to specific to our modelling purposes.

cultural perspectives is useful to understand consumer behaviour and to explain differences among diverse groups of consumers.

Cultural theory discerns two common social dimensions (Douglas & Wildavsky, 1982; Hofstede, 1984; 1994; Rayner, 1991): (1) one which reflects social restrictions placed on individual autonomy ('grid') and: (2) one which contrasts solidarity with egocentrism ('group'). Contrasting high and low values on the 'grid' and 'group' dimensions results in four cultural perspectives, namely: the *Hierarchist* (high 'grid' and high 'group'), the *Egalitarian* (low 'grid' and high 'group'), the *Individualist* (low 'grid' and low 'group') and the *Fatalist*[2] (high 'grid' and low 'group'). These perspectives partly determine the way in which people perceive the world and behave in it. However, the four perspectives are considered to be extreme archetypes, because most consumers exhibit biases and preferences that belong to more than one perspective. In line with this, we can identify a survival strategy for each type fitting the four elementary dilemmas described above.

The Individualist tends to estimate achievable benefits in financial and material terms. In line with the Individualist's risk-seeking strategy, his/her perception of financial and material gains will result in a positive attitude towards a given behaviour pattern, even if appreciable risks are involved. With regard to the social survival dilemma, the Individualist evaluates outcomes in terms of benefits and risks for him/herself. Also, the Individualist emphasises present outcomes over future gains and losses, while in the spatial survival dilemma, the Individualist assigns a higher value to local benefits whilst ignoring outcomes elsewhere.

Egalitarians, however, who are characterised here as being risk-aversive, tend to stress the risk side of behaviour, instead of the benefits. Benefits are also expressed in terms of quality of life, in which material gains are subordinate. Egalitarians tend to feel responsible for humanity everywhere at any time. Therefore, with regard to the temporal and spatial survival dilemmas they take serious account of future and global consequences. In line with the Egalitarian definition of solidarity with others, which ascribes a higher value to the collective as a whole than to separate individuals, in the evaluation of behaviour collective outcomes are emphasised.

The Hierarchist, for whom social stability is the primary driving force, aims to maintain a reasonable balance between benefits and risks, present and future outcomes, local and global impacts, and collective and individual gains and losses.

The Fatalist has no predefined position with respect to three of the four dilemmas. The Fatalist will not evaluate behaviour in the terms described above, but is merely trying to cope with the circumstances, which are regarded as beyond human control. This implies that he/she focuses on individual rather than collective outcomes of behaviour.

The main foci associated with the various cultural perspectives are summarized in Table 1 (page 12).

The perspective an individual has determines his/her perception of any survival dilemma. Firstly, individuals having either an extreme individual or collective perspective on human welfare are not confronted with any dilemma at all. For them, either there is no collective risk or it is automatically kept within acceptable limits. This applies to the Individualist and the Egalitarian, respectively. Secondly, one may be unaware of the collective outcomes that exacerbate global change. Thus, Egalitarians, being unaware of a particular collective risk, would not perceive a social survival dilemma. Thirdly, one may underestimate the impact of collective outcomes on global change. Fourthly, one may feel that the collective negative outcomes do not (yet) outweigh the benefits at the individual level. And finally, people may be well aware of collective negative outcomes, but feel that they can't do anything against it without seriously endangering their own quality of life.

Policy strategies

Several policy strategies may be used to change the individual and the collective outcomes in social dilemmas or to change one's awareness of these outcomes (Dawes, 1980; Messick & Brewer, 1983; Wilke, 1989). These strategies may be directed at the individual or at the collective level. Strategies directed at the individual level may be aimed at increasing dilemma awareness by informing people about collective outcomes that exacerbate global change and by stressing their impacts. The strategies also may be used to inform individuals about and to

[2] Thompson *et al.* (1990) admit the *Hermit* as a fifth perspective. The *Hermit* withdraws from coercive or manipulative social involvement altogether, detaching him/herself from what happens in the world. Because the rare adherents to this perspective are not engaged in either scientific or policy debates, this perspective is not considered.

Table 1: Main foci of the four perspectives for the four types of dilemmas

	Benefit-risk dilemma	Temporal survival dilemma	Spatial survival dilemma	Social survival dilemma
Hierarchist	benefits versus risks	present versus future outcomes	local versus global outcomes	individual versus collective outcomes
Egalitarian	risks	future "	global	collective "
Individualist	benefits	present "	local "	individual "
Fatalist	ad hoc	ad hoc "	ad hoc "	individual "

stimulate them to have trust in the (collectively oriented) behaviour of others. Finally, individuals may be challenged on their social values, responsibilities and group identity. Measures directed at the collective level involve a more structural management of the dilemma, e.g., through privatisation of collective resources, reducing group size and the introduction of a controlling authority. In general these measures are based on (a combination of) five general strategies for behaviour change: (1) provision of physical alternatives and (re)arrangements, (2) regulation-and-enforcement, (3) financial-economic stimulation, (4) social and cognitive stimulation and (5) changing values and morality. With respect to changing behaviour two main questions arise. First, which factors are the main determinants of behaviour? This involves an adequate diagnosis. Second, which strategies would be effective in changing these main determinants? This pertains to designing appropriate interventions.

Impact assessment and behavioural diagnosis

Before changing behaviour, it is essential to assess the detrimental effects of a particular consumer behaviour. This is necessary to set goals for policy and to assess the importance of a behaviour change. For this, data ascertaining the environmental impacts of behaviour are required. Life Cycle Analysis (LCA) of material products and services offers an appropriate methodology to acquire such data. This implies that the processes of global change and the role of consumer behaviour in these processes have to be identified. If the detrimental effects of a given kind of behaviour are apparent, goals can be set for a behavioural change. Dependent on the type of behaviour and the most important behavioural determinants, custom-tailored measures can be developed, in which the four general strategies may be combined. The development of effective policy measures thus requires the cooperation of both the physical and the behavioural sciences.

Models that are solely based on the description of physical (environmental) processes of global change lack a comprehensive perspective on the behavioural origins of environmental degradation, and are therefore incomplete as a basis for policy making. On the other hand, models that only describe the human (behavioural) processes underlying environmental degradation lack a perspective on the role of technology and on the environmental impacts of behaviour and behavioural change. Consequently, these models are also incomplete as a basis for policy making. Integrated assessment models that include both social and environmental system processes may offer the appropriate means to describe environmental degradation and to develop and evaluate policy measures aiming at sustainable consumption patterns.

2.2 TARGETS, an integrated assessment model for global change

In 1992 the Dutch National Institute of Public Health and Environmental Protection (RIVM) launched its research programme Global Dynamics and Sustainable Development. The main objective of this programme was to operationalise, and to render applicable, the concept of sustainable development from a global perspective (Rotmans *et al.*, 1994). Furthermore, this research project aimed to improve communication processes among scientists from various disciplines, and between scientists and policy-makers. In order to achieve this, a generic integrated assessment model entitled TARGETS

(**T**ool to **A**ssess **R**egional and **G**lobal **E**nvironmental and health **T**argets for **S**ustainability) is being developed. The global issues covered in TARGETS are human health and population dynamics, energy resources, global cycles (transformation and movements of chemical substances in the global environment), and land-use and water resources.

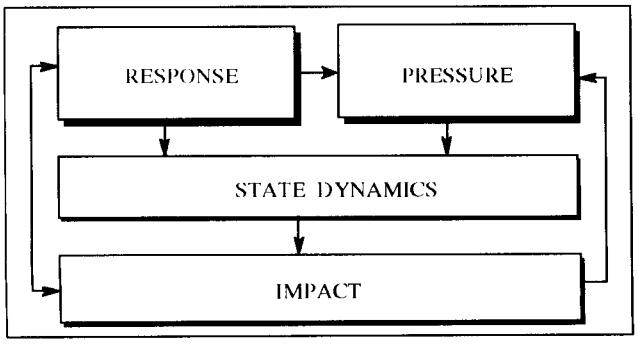
In the TARGETS research project, a systems approach is advocated. This concentrates on the interactions and feedback mechanisms between the different subsystems of cause-effect chains of global change, rather than focusing on each subsystem in isolation. Using a systems approach, the anthropogenic disturbance of the biosphere on a global scale, denoted as global change, can be represented by a set of interrelated cause–effect chains. Together, these cause effect chains provide a conceptual framework that considers the Earth as a system of human and environmental reservoirs, and of natural and societal processes connecting these reservoirs. A general division of any cause–effect chain into subsystems on a global scale is denoted in Figure 1.

The **PRESSURE subsystems** describe continuously changing pressures on the human and the environmental system, along with their driving forces.

The **STATE DYNAMICS subsystems** describe changes in the physical, chemical and biological state of environmental systems, as well as changes in human population and in environmental resources and capital.

The **IMPACT subsystems** describe human behaviour impacts on aquatic and land ecosystems, impacts on the atmosphere, and the consequences for human health and socio-economic effects for various sectors of society.

Figure 1: Systems diagram of the general Pressure-State-Impact-Response (P-S-I-R) system of global change (Source: Rotmans et al., 1994).



The **RESPONSE systems** describe a users' possibilities to influence either human activities and/or environmental states, the latter including human responses to societal and ecological impacts.

All of these subsystems have their own characteristics which, may change as a result of anthropogenic or evolutionary processes.

Within the TARGETS framework, the major issues on a global scale are translated in terms of Pressure, State, Impact and Response. A series of highly aggregated submodels has been built, for the various subsystems of the global system, i.e. a population/health submodel (Niessen *et al.*, 1996), an energy/economics submodel (De Vries *et al.*, 1995), CYCLES (Den Elzen, 1995b), TERRA (a land submodel; Den Elzen *et al.*, 1995a) and AQUA (a water submodel; Hoekstra, 1995). These submodels are interlinked and integrated within the overall TARGETS framework. The several submodels reflect the integrated cause effect chain in *Figure 1* (*vertical integration*). Horizontal integration is achieved by linking a specific part of a submodel (e.g., Pressure system) to the corresponding (Pressure) parts of the other submodels. For example, the overall pressure system (see Figure 2) describes the complex of interrelated developments in human population, resources/economy, biophysical processes, land-use and water use (*horizontal integration*). The TARGETS model can be represented as a two-dimensional integration matrix, as conceptually represented in Figure 2.

The complexity of the TARGETS model arises from the many relationships and feedback loops between the various submodels. The TARGETS model serves to explore the long-term dynamics of global change, using a time horizon that spans about two centuries, from 1900 up to 2100. The integrated systems approach deals with the complexity and the dynamic nature of the mutual interdependencies between different subsystems. As such, integrated assessment can help to foster understanding of the causal and mutual relationships between processes within the human and the environmental systems. As TARGETS adopts a generic approach, it is applicable irrespective of the level of analysis. This implies that the submodels can be applied on a global as well as on a regional scale. Following a top-down approach, analysis may start at the highest aggregation level, i.e. global level, considering the

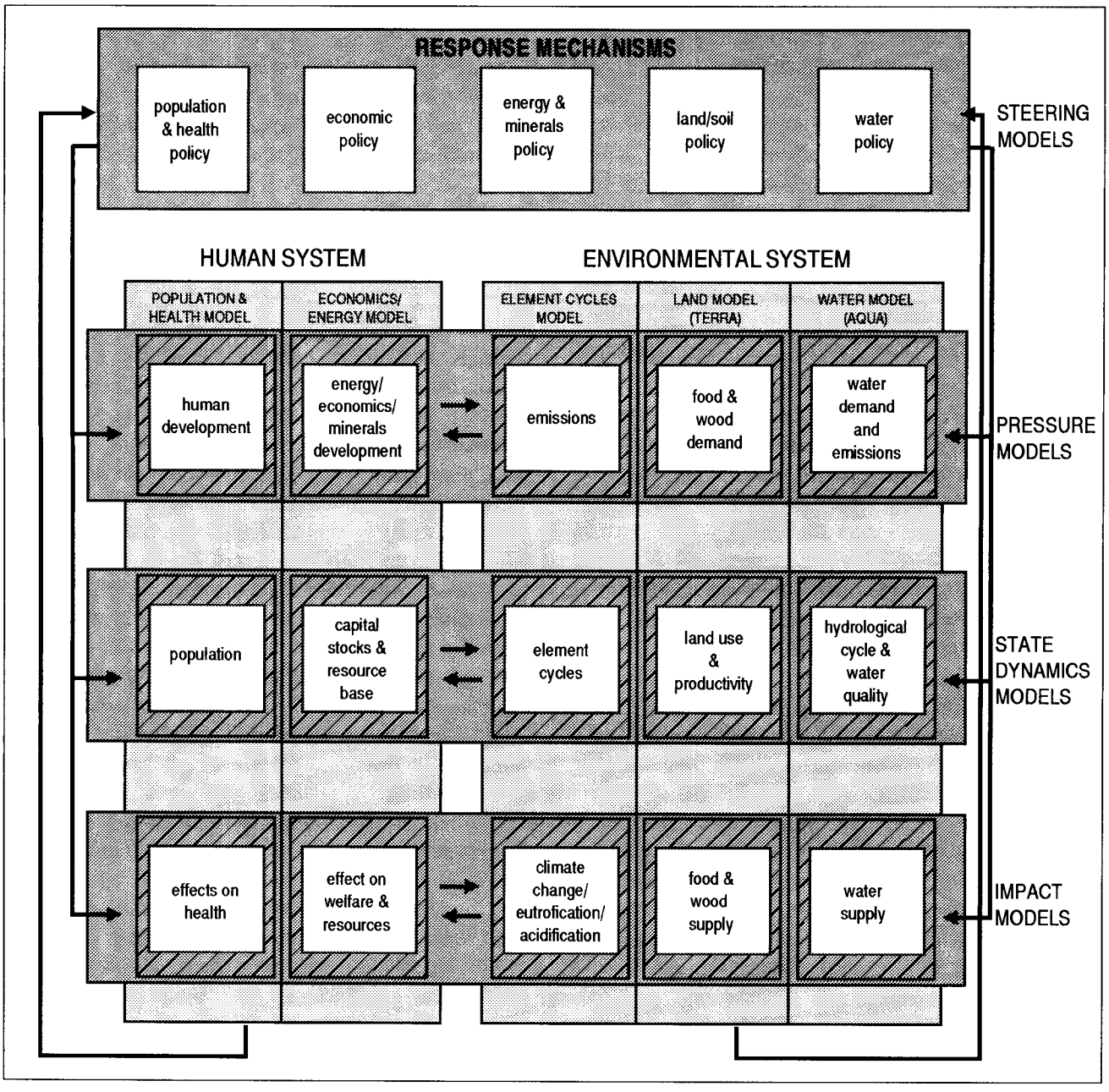


Figure 2: TARGETS model diagram (source: Rotmans et al., 1994)

Earth as a whole. Eventually TARGETS will be disaggregated to the level of economic world regions, river basins and ecosystems, using regional data sets. This implies that reasonably specific case studies will be carried out, for example, the modelling of the Zambesi River Basin using AQUA (Hoekstra & Vis, 1996). Although TARGETS is still under development, its major constituents have been integrated in TARGETS 1.0 (Rotmans *et al.*, 1995; Rotmans & De Vries, in press).

An evaluation of TARGETS 1.0 has led to the conclusion that the model does not explicitly address consumer behaviour. However, as recognised in the introductory chapter, the dynamics of human consumption determine, to a large extent, the use of raw materials, processes of production, emissions and the production of waste. Therefore various policy strategies for sustainable development are aimed at behaviour changes, in particular consumer behaviour. The modelling of consumer behaviour would allow for a more comprehensive assessment of developments in human consumption and the effectiveness of policy strategies aimed at a behavioural change. Including a model of consumptive behaviour within the context of

integrated assessment modelling would significantly improve the development of valid projections of future global change, and the development and evaluation of policy measures aimed at behavioural changes. In line with the highly aggregated level of the submodels within TARGETS, a behavioural model should generically address the processes of behaviour and behaviour change, i.e. irrespective of regional and temporal differences. This implies that a 'meta-consumers' category should be defined, representing certain types of consumers corresponding with the level of modelling. For example, if a modelling exercise contrasts the northern with the southern hemisphere, two types of meta-consumers will be used, representing consumers in the north and in the south. Further disaggregation of TARGETS modelling would also necessitate a more differentiated modelling of meta-consumers.

The incorporation of a model of consumer behaviour in TARGETS is one of the issues in its further development. The goal of this further development is to improve the projections of global change developed using TARGETS. As such, the improvement of the TARGETS model facilitates the communication processes among scientists from various disciplines, and between science and policy-making. With respect to the inclusion of a model of consumer behaviour, this implies developing a framework to facilitate the communication among the various disciplines already involved in integrated assessment, and between them and the social sciences. Because the inclusion of a social scientific perspective in TARGETS involves a more comprehensive view on changing consumptive behaviours, this also would facilitate the communication between policy-makers and the scientific disciplines involved in integrated assessment.

2.3 Modelling consumer behaviour as part of integrated assessment

To incorporate conceptions of consumer behaviour in models for integrated assessment of global change, first it is necessary to examine the 'state of the art' in the social sciences for theoretical perspectives and behaviour models that could be used in such a context. If no suitable behaviour models are available, the requirements for developing a comprehensive behaviour model that integrates various relevant theoretical perspectives, need to be known.

The growing awareness of the fact that environmental quality substantially depends on the (consumer) behaviours of human populations has stimulated the social sciences to develop multi-theoretical models describing various environmentally detrimental behaviours. These models conceptualise the processes underlying such behaviour and they identify possible strategies for behavioural change (e.g., Midden *et al.*, 1982; Van Raaij & Verhallen, 1984; Costanzo *et al.*, 1986; Rosendaal & Poiesz, 1987; for a schematic presentation of several models see Appendix 1). These models can be considered as problem-oriented applications of general behaviour theories; they represent the behaviour determining factors as identified in field research on energy conservation and other environmentally relevant behaviours. Several problems however seriously limit the suitability of these models within the context of integrated assessment.

A major problem refers to the mathematical relationships to be postulated between the various model variables. In social science models, often the relationships between various model components can not easily be quantified. As such, such models do not (yet) offer the mathematical basis needed to formulate projections of future behaviours. However, if empirical data are used to assess the mathematical relations between variables in behaviour models, such calculations are usually based on *multiple regression analysis*. This reveals the correlations between a set of (predictor) variables and a criterion variable. For example, the Social and Cultural Planning Office (SCP) of the Netherlands is currently developing an operational model of environmental-relevant behaviour based upon regression analysis, thereby using different databases with information on the behaviour and the socio-cultural status of the Dutch people (Hoevenagel *et al.*, 1996). In such a model of behaviour, data on people's transport behaviour (criterion variable) and age, social status and income (predictor variables) can be represented in a (linear or non-linear) regression equation. The smaller the average difference between the predicted and the observed values of the criterion variable, the better the fit of the regression equation is. As such, regression analysis is a valuable technique to explore the correlational structure between multiple predictor variables and a criterion variable. As such, these conceptual models are useful for the post-hoc explanation of environmental relevant behaviours; they also indicate strategies that might be effective in

changing such behaviour. For example, the SCP model (Hoevenagel *et al.*, 1996) can be used to assess the influence of family size on personal transport and to estimate the effects of family downsizing on personal transport volumes.

However, because regression analysis is a multiple-correlational technique, a multiple-regression equation does not infer causality between predictor and criterion variables, no matter how accurate a regression equation may be. Moreover, the selection of predictor variables may be arbitrary. Also, the use of the 'predictor variable' concept is somewhat misleading because regression analysis requires *a priori* scores on the 'to be predicted' criterion variable. As such, a regression analysis is not predictive but merely reveals a correlational structure. However, a causal relationship between selected 'predictor variables' and the criterion variable is often (implicitly) inferred. As such, regression equations are used to make inferences on future behaviour. However, by definition, processes of feedback (positive or negative), such as learning, habit formation and adaptation cannot be accounted for in regression equations. Consequently, a static multiple-regression model is not capable of simulating the dynamics of consumer behaviour. Despite the fact that multiple-regression equations may have a limited predictive value for, in particular, short-term developments in relatively stable environments, this technique is not suitable for predicting or simulating future behaviour. For example, a multiple-regression analysis might reveal a significant increase in car-use as a result from family downsizing. However, feedback processes, such as increasing traffic congestion pushing people towards the use of transport alternatives, cannot be taken into account. As such, models of behaviour that are based on multiple-regression analysis lack the system-dynamic approach which is required to translate observed and/or predicted behavioural processes into mathematical models of behaviour. Such mathematical modelling of behaviour is a prerequisite for modelling consumer behaviour in the framework of integrated assessment of global change.

A subsequent problem refers to the domain-specific character of many behaviour models. Because they were developed to describe the behaviour in a specific context (for example energy conservation, e.g., Midden *et al.*, 1982; Van Raaij & Verhallen, 1984; Costanzo *et al.*, 1986), they lack a generic perspective that allows for their valid application to other domains. Because a behaviour model to be used within the context of integrated assessment should be applicable regardless of the level of analysis, existing models should be carefully considered for their general application.

Next to multi-theoretical frameworks for understanding environmentally harmful behaviours (see Appendix 1), there are several more restricted, basic theories of human behaviour. These pertain to specific types of behavioural processes, such as learning, decision-making, social comparisons and intentional behaviour. In the sections to follow, we will use a number of well-known behaviour theories in an attempt to formulate a fairly comprehensive *conceptual behaviour model.* The latter should function as the theoretical basis for designing an operational *behaviour module* to be incorporated in TARGETS.

A system-dynamics approach towards behaviour modelling

Human consumption is influenced by various processes of learning, habit formation, decision-making, social comparison, adaptation to changing situations, et cetera. These processes include different types of feedback. As such, human consumption can be understood as a complex dynamic system. Such systems imply that small differences in feedback (positive or negative) may yield large differences in behaviour at a later time. To envision the range of possible behaviour developments, it is necessary to run a series of behaviour simulations, each starting with different initial settings and involving different types of feedback. However, as complex dynamic behaviour is hard to predict by nature, the projections resulting from dynamic model simulations should be interpreted with caution, while explicitly acknowledging their uncertainty. Sensitivity analysis may be utilised to explore ranges of possible consumer behaviour variables as a function of changes in inputs and feedbacks.

A behavioural model to be used within the framework of integrated assessment should enable us to develop projections of future behaviour. Behaviour simulation deals with complex dynamic interactions between various actors and their environment. Because in real life a vast number of variables affects behavioural processes, such a simulation would have a limited scope, in which the 'real world' is considerably simplified. However, because feedback processes such as learning, habit

formation and adaptation are explicitly modelled, the simulated behavioural process would be more 'life-resembling' than is the case in simpler basic theories of behaviour. Such a behaviour simulation model would therefore provide means to generate possible answers to the following central questions:

- How do various kinds of consumer behaviour interact with projected developments in various domains? (e.g., economic developments, population changes, land-use). In line with the environmental issues modelled in TARGETS, the behavioural model can firstly be connected with the domains of population dynamics, and of water, food and energy resources. Future research could be directed at other domains relevant to the context of global change, e.g. motorised transport, and tourism and recreation.
- Which policy response strategies would provide effective means to change particular kinds of environmentally detrimental consumptive behaviour in the context of sustainable development?

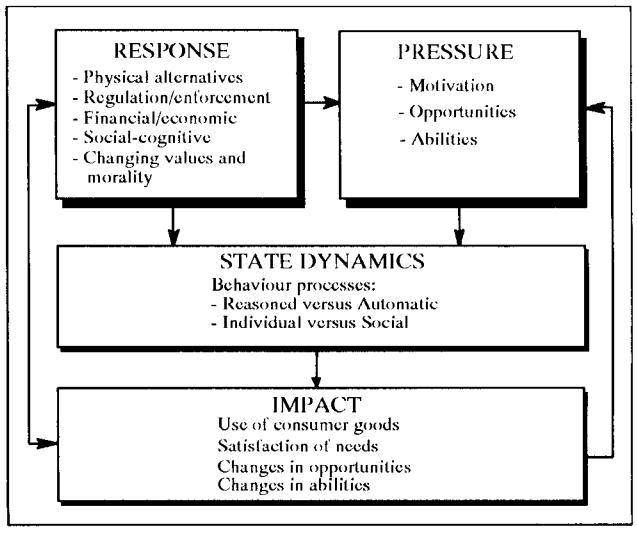
In order to be able to answer these questions, the dynamics of behavioural processes have to be modelled in a formal quantitative way. Since the P-S-I-R approach (see Section 2.2) will be followed in line with the TARGETS philosophy, the following questions need to be answered:

- What are the main *pressures* on diverse consumer behaviours?
- Which (*state-dynamic*) mechanisms underly various consumer behaviours?
- What are the *impacts* of various types of consumer behaviour on human and environmental systems?
- What is the influence of different policy *response* strategies on consumer behaviour?

Adopting the P-S-I-R approach implies that the conceptual behaviour model (and, later, the operational behaviour module) will include a Pressure system, describing the driving forces of consumptive behaviour, a State-dynamics system, describing the behavioural mechanisms involved, an Impact system, describing the outcomes of the behavioural process (e.g., consumption levels as a critical variable to incorporate in other submodels), and a Response system, describing the policy strategies aimed at changing behaviour patterns. *Note that the whole P-S-I-R-chain of the behavioural model can be conceived as being part of the Pressure system of other submodels.* In this way projections of consumer behaviour can be incorporated in Pressure systems of other submodels, e.g., concerning resource use or waste production. For example, the consumption of various types of food, as simulated by a behavioural model, could be included in the Pressure system of the land-use model TERRA. As such, an increase in meat consumption, as projected by the behavioural model (under Impact), would serve as a Pressure variable for TERRA. Within the scope of this paper, however, the concepts of Pressure, State, Impact and Response exclusively address human consumer behaviour. Figure 3 schematically depicts the conceptual behaviour model.

Whereas the various feedback processes which co-determine consumer behaviour necessitate a system-dynamic type of modelling, a system-dynamic model does not simulate processes of active learning and adaptation. However, the consumer is not a cork drifting on a sea of feedbacks, but beholds and interprets his/her environment (including other consumers), gazes back on past experiences, formulates goals and can take course on this information. As such, the active, constructive role that consumers can play, has to be modelled as well in order to gain sufficient insight in the full dynamics of the behavioural system, to assess the role of specific determining factors, and to explore the possible paths and patterns of future development. Theories on *complexity* provide a framework for the conceptual understanding of the processes of active learning and purposeful adaptation. Moreover, theories on complexity form the theoretical root of several simulation techniques.

Figure 3: Schematic representation of the conceptual behaviour model



Aggregate behaviour simulation: theories on complex adaptive systems

Many systems, such as the immune system, food chains and the economy, change and reorganise their component parts to adapt to the problems of their surroundings (Holland, 1992). As these systems can be conceived as 'moving targets', they are difficult to understand and to control. However, despite the fact that these systems show large differences at first glance, the mechanisms that underlie them are similar with respect to three characteristics: evolution, aggregate behaviour and anticipation, all three further elaborated below. As such, these systems can be grouped under the name of *complex adaptive systems* (Holland, 1992; Trisoglio, 1995). Theories on complex adaptive systems confront us with the fundamental limits to our ability to understand, control and manage social behaviour, and force us to deal with unpredictability.

Firstly, with respect to consumptive behaviour, the *evolution of behaviour* refers to the ability of individual consumers to learn. Because consumers differ with respect to their abilities and their perceptions of what constitutes a 'good outcome', this adaptive process is complex. This implies that changed or new environments will provoke exploration, thereby yielding a diversity of consumer behaviours, even in relatively stable environments. The diversity between consumers allows for quick adaptation within consumers if the environment should change. The emphasis on active learning and adaptation implies that only using a system-dynamic approach without including processes of learning will not suffice (e.g. Trisoglio, 1995).

Secondly, the numerous individual consumers often interact, thus generating *aggregate consumer behaviour*. This can be seen as a complex network of interactions between supply and demand, existing and changing lifestyles, and varying responses to policy measures. Such aggregate behaviour in a complex adaptive system cannot be simply derived from the behaviour of individual consumers, but it is an aspect of the system as a whole. Within the current project we are interested in understanding and developing projections of aggregate consumer behaviour, and the efficacy of various policy response strategies. Therefore, it is necessary to understand and simulate the way in which aggregate consumer behaviour emerges from the interactions between individual consumers and other parts of the system, such as environmental quality and availability of various resources.

Thirdly, consumers *anticipate* (more or less) the future outcomes of their present behaviour. Such anticipation is reflected in the beliefs and expectations consumers have with respect to the outcomes of certain consumer behaviours. For example, they may believe that the use of a certain product (e.g. a car) may have certain outcomes (e.g. comfort and status). Processes of anticipation may result in considerable changes in aggregate behaviour. For example, according to the economic laws of supply and demand, people are willing to pay more for scarce goods. Thus, if many consumers anticipate an oil shortage, this may - via increase in demand - cause a rise in oil prices and an increase in alternative energy use, even if the oil shortage actually never occurs (Holland, 1992).

Because most individual consumers are constantly changing and adapting their behaviour, they are also confronted with a constantly evolving (socioeconomic) environment. As a result, the aggregate behaviour of a socio-economic system is usually far from optimal, provided that such an optimum can be defined (Holland, 1992). Because of this constant evolution, it is the 'process of becoming' that needs to be studied to gain insights in consumer behaviour. A model of consumer behaviour that incorporates the principles of complex adaptive systems would offer a useful perspective on 'processes of becoming' and its susceptibility to intended (policy) and unintended changes.

In Chapter 3, a conceptual behaviour model will be developed that is to guide the development of an operational behaviour module. Chapter 4 is devoted to the operationalisation of a computer-programmed behaviour module. In the following stage of the research project, this computer-module will be used to develop projections of future behaviour in one or more domains of human consumption. The final chapter offers a perspective on the main topics for further research.

3. TOWARDS A CONCEPTUAL MODEL OF CONSUMER BEHAVIOUR

In developing a conceptual behaviour model it is first necessary to elucidate the concept of behaviour. In light of our interest in the effects of consumer behaviour on the environment, a specific definition will be developed. Subsequently, we will categorise the main driving forces of consumer behaviour as motivation (M), opportunities (O) and abilities (A). Following this, we will consider eight specific theories of human behaviour, the latter to be characterised as either reasoned or automatic, and as either individual or social. Subsequently, the various outcomes of consumer behaviour will be identified. Following this, a perspective regarding strategies for behaviour change will be sketched. Finally, a conceptual behavioural model will be outlined by integrating the various theories of behaviour in a comprehensive model to depict the causal chains in behavioural processes in terms of Pressures, State, Impacts and Response systems. This behavioural model is to guide the programming of a behaviour simulation programme, referred to as the 'behaviour module', to be incorporated in TARGETS.

3.1 Consumer behaviour

In economics consumer behaviour is defined as: 'all the actions of individuals which are directly involved with the purchase, use and disposal of products and services in order to satisfy one's needs' (Wierenga & Van Raaij, 1987, p. 3). With respect to *products and services*, a distinction can be made between material and immaterial goods (Schermer, 1991). The consumption of material goods or products is of special importance in considering the impact on the environment due to consumer behaviour patterns. The impact which a product has on the environment depends firstly on an individual's decision to (or not to) use the product. Secondly, the intensity of product use and the impact per unit of product use will determine the degree of impact. And thirdly, the disposal (when and how) of a product will also determine the environmental impact. Thus, the total environmental impact of a product is dependant upon the purchasing, use and disposal phases in the consumer's behaviour (Van Raaij & Antonides, 1994).

The consumption of products is aimed at fulfilling consumer *needs*. According to McDougall (1932), Maslow (1954) and Max-Neef (1992), different types of needs can be identified, ranging from biological or subsistence needs to the need for self-actualisation or freedom. These different needs can be seen as the main motivating factors underlying consumer behaviour. Thus, in understanding consumer behaviour, it is necessary to elucidate the types of needs that underlie the purchase, use and disposal of various products. In section 3.2 the need concept will be further outlined.

Environmentally relevant consumer behaviour

A variety of definitions exists among social scientists of environmentally relevant behaviour. In general, this notion refers to 'human actions in a broad sense, which cause a change in the physical environment of humans, influencing human well-being in a positive or negative way, on the short or on the long-term' (Rosendaal & Poiesz, 1987; Nelissen *et al.*, 1987; Breemhaar & Midden, 1992). This definition is typically formulated from an anthropocentric perspective. Groenen *et al.* (1995) use a more eco-centric definition of environmentally relevant behaviour, namely, 'all human actions, particularly the behaviour of consumers, influencing the environment'. In order to offer decision-makers points of departure for developing effective strategies for sustainable development, the above definition of environmentally relevant behaviour needs to be specified. In particular consumer behaviour with significant negative or detrimental consequences for the human-environmental system needs to be considered. Therefore we define environmentally relevant consumer behaviour as: 'All the actions of individuals, which are directly involved with the purchase, use and disposal of products in order to satisfy one's needs, which have a significant detrimental impact on the environment'. Equivalent to the previously mentioned definitions, this definition includes a variety of behaviours, ranging from reasoned actions to habitual or automatic behaviours. Depending on the type of behavioural an actor performs, different strategies for behaviour change may be more-or-less effective. To diagnose a given type of behaviour and to identify the most viable strategies for behavioural change, a conceptual model of behaviour has to be formulated. This model will provide the theoretical justification of the rules, formulas and equations that will be used in a computer programmed behaviour

module. The next sections, which end with a conceptual framework on behaviour and behaviour change, are aimed at providing this justification.

3.2 Driving forces underlying consumer behaviour (Pressures)

In identifying the driving forces of consumer behaviour, it is useful to make a distinction between *individual* and *societal driving forces*. With respect to individual driving forces, *motivation to consume* is the first driving force to be identified. Motivation is concerned with the expected satisfaction of certain needs by means of consumption. But motivation alone is not sufficient, because one must also have the *opportunity* to apply the consumer behaviour. Opportunity is concerned with the types of products or services that are available for consumption. A consumer may perceive or imagine opportunities that would satisfy his or her needs. Finally, one also has to have the *ability* to apply the consumer behaviour. Ability is concerned with the skills and capacities one may utilise. This Motivation-Opportunity-Ability perspective on consumer behaviour (see Batra & Ray, 1986; Robben & Poiesz, 1992; Ölander & Thøgerson, 1994; Gatersleben & Vlek, 1996) addresses three types of pressures on consumer behaviour. The collection of motivation, opportunities and abilities determines the behavioural process and the resulting consumer behaviour. As far as the societal driving forces of consumer behaviour are concerned, it is supposed that *macro-level variables*, such as technology, economy, demography, institutions and culture (the T.E.D.I.C.-complex) in part determine the individual motivation, opportunities and abilities (Gatersleben & Vlek, 1996). Below, we will go more deeply into the three main components of the MOA-model of consumer behaviour.

Motivation

The motivation to consume is determined by the needs that consumers have and the (perceived) need-satisfying potential of an (real or imaginary) opportunity. The concept of need has many connotations (e.g. Douglas, *et al.*, 1995). First, it can be used both as a verb and a noun. The verb 'need' usually refers to wanting a certain item as a prerequisite for a certain behaviour, without referring to the deeper source of that wanting. For example, one may need a car to travel to work. The noun 'need' has many meanings, which can be grouped in three generic categories (Douglas *et al.*, 1995). The first refers to needs as related to wants or desires. Theories in this realm posit needs as underlying internal forces that drive our actions, e.g. the theories of McDougall (1932), Maslow (1954) and Max-Neef (1992). The second refers to needs as an external requirement for achieving an end. Theories in this area analyse satisfaction and try to identify what makes people fulfilled, happy or content (e.g. Scitovsky, 1992; Argyle, 1987). The third refers to needs as justified requirements for performing behaviour. Corresponding theory is concerned with normative and ethical aspects of need and arguments, about which prerequisites have a priority status (e.g., Doyal & Gough, 1991). We will henceforth adopt the 'verb' meaning of needs, in conjunction with the first 'noun' meaning, referring to forces which drive our actions, as an appropriate perspective for our modelling exercise. As such, the theories of McDougall (1932), Maslow (1954) and Max-Neef (1992) offer a starting point to model needs as motivation-determining factors.

McDougall (1932) identified eighteen human needs (innate propensities or instincts). These needs are:

1. To seek (and perhaps to store) food;
2. To rejects and avoid certain noxious substances;
3. To court and to mate;
4. To flee to cover in response to violent impressions that inflict or threaten pain or injury;
5. To explore strange places or things;
6. To feed, protect, and shelter the young;
7. To remain in company with fellows and, if isolated, to seek that company;
8. To domineer, to lead, to assert oneself over, or to display oneself before one's fellows;
9. To defer, to obey, to follow, to submit in the presence of others who display superior powers;
10. To resent and forcibly to break down any thwarting or resistance offered to the free exercise of any other tendency;
11. To cry aloud for assistance when our efforts are utterly baffled;
12. To construct shelters and implements;
13. To acquire, possess, and defend whatever is found useful or otherwise attractive;
14. To laugh at the defects and failures of our fellow-creatures;
15. To remove, ore to remove oneself from, whatever produces discomfort, as by scratching or by change of positionand location;
16. To lie down, rest and sleep when tired;
17. To wander to new scenes;
18. A group of very simple propensities subserving bodily needs such as coughing, sneezing, breathing, evacuation.

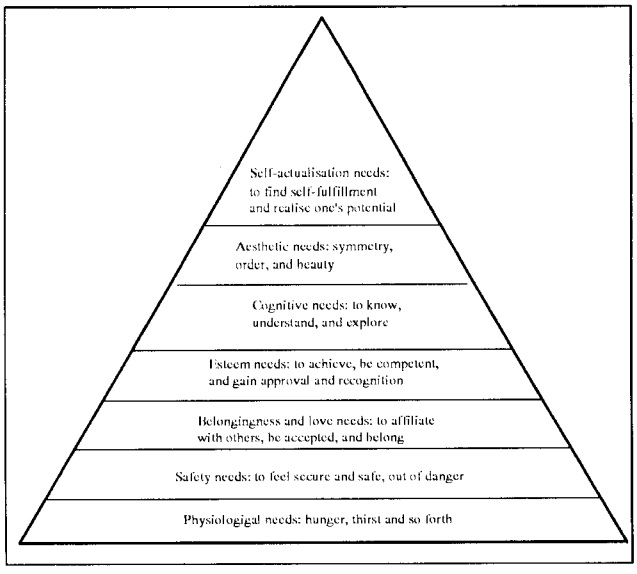


Figure 4: Maslow's hierarchy of needs

This listing of what people need represents an early attempt to state universal properties of people. However, this listing lacks a theoretical perspective on the relationships between the various needs.

Maslow (1954) has presented a hierarchical ordering of needs, assuming that needs low in the hierarchy must be at least partially satisfied before needs that are higher in the hierarchy may become important sources of motivation. From the top to bottom of this need-pyramid, Maslow (1954) discerns Physiological and Safety needs, needs to Belong and Be loved, and Esteem, Cognitive, Aesthetic and Self-actualisation needs.

A more sophisticated description and classification of human needs is postulated by Max-Neef (1992). This author identifies nine fundamental needs: Subsistence, Protection, Affection, Understanding, Participation, Leisure, Creation, Identity and Freedom. Whereas the first seven needs have existed since the origins of *homo habilis*, and, undoubted, since the appearance of *homo sapiens*, the latter two are assumed to have been developed later in the evolutionary process. Furthermore, Max-Neef (1992) hypothesises that needs nowadays felt by some people, e.g. the need for Transcendence, may somewhere in the future evolve into a universal need. According to Max-Neef (1992), needs can be fulfilled by satisfiers, which are defined as '...everything which, by virtue of representative forms of Being, Having, Doing and Interacting, contributes to the actualization of human needs'. Thus, the above-mentioned needs are related to four types of existential categories, respectively Being, Having, Doing and Interacting. Linking the 9 types of needs to the 4 types of existential categories yields a matrix as represented by Table 2, in which specific satisfiers can be categorised.

The satisfaction or dissatisfaction of needs will result in experiencing feelings or emotions. As the concept of emotion is associated with a general arousal of the Sympathetic Nervous System (Schachter, 1964), and the satisfaction of a need may actually decrease one's level of arousal, we prefer to relate the (dis)satisfaction of needs to the concept of *feelings*. However, (un)pleasant feelings about something can be conceived as one of the constituting parts of emotion (Frijda & Mesquita, 1992). Feelings may be positive or negative (e.g. McDougall, 1928: pleasure and pain, and Siminov, 1970: positive and negative emotions). It is assumed here that the satisfaction of a need will yield positive feelings, whereas the dissatisfaction of needs will yield negative feelings. Extending the typology of needs as presented by Max-Neef (1992) with positive and negative feelings yields the following list of feelings (*Table 3*):

If a need is not satisfied, the relating negative feeling will arouse a *drive* to satisfy this need. For example, if the need for subsistence is not satisfied because of a lack of food, the negative feeling will be hunger, arousing the drive to eat. If confronted with an (real or imagined) opportunity that is perceived to be able to satisfy the needs in question, this drive will result in a motivation to use that opportunity. Often there are several opportunities for satisfying one's needs. For example, if one is hungry, one could eat a tuna sandwich, a banana, and an almost infinite number of other foods. As such, a consumer may be motivated to use many different opportunities. The satisfaction of a need will evoke positive feelings. If a need is fully satisfied, no drive will emerge and the motivation to use any opportunity will be low.

After a need is satisfied, it will take some time before the need fulfilment decreases to an unsatisfactory level. This so-called depletion time may differ significantly for different needs. For example, the need for subsistence can be satisfied quickly (by eating), but after a relatively short period of time the fulfilment decreases and hunger emerges again. On the other hand, the need for identity, once satisfied, may remain satisfied for a long period of time.

If the motivation to use a particular opportunity is low, then a consumer does not want to use that

Table 2: A categorisation of satisfiers according to Max-Neef (1992). Along the rows, nine basic needs are listed. Along the columns, four existential categories are ordered.

	Being	*Having*	*Doing*	*Interacting*
Subsistence	1/ Physical health, mental health, equilibrium, sense of humour, adaptability	2/ Food, shelter, work	3/ Feed, procreate, rest, work	4/ Living environment, social setting
Protection	5/ Care, adaptability, autonomy, equilibrium, solidarity	6/ Insurance systems, savings, social security, health systems, rights, family, work	7/ Co-operate, prevent, plan, take care of, cure, help	8/ Living space, social environment, dwelling
Affection	9/ Self-esteem, solidarity, respect, tolerance, generosity, receptiveness, passion, determination, sensuality, sense of humour	10/ Friendships, family, partnerships, relationships with nature	11/ Make love, caress, express emotions, share, take care of, cultivate, appreciate	12/ Privacy, intimacy, home, spaces of togetherness
Understanding	13/ Critical conscience, receptiveness, curiosity, astonishment, discipline, intuition, rationality	14/ Literature, teachers, method, educational policies, communication policies	15/ Investigate, study, experiment, educate, analyse, meditate	16/ Settings of formative interaction, schools, universities, academies, groups, communities, family
Participation	17/ Adaptability, receptiveness, solidarity, willingness, determination, dedication, respect, passion, sense of humour	18/ Rights, responsibilities, duties, privileges, work	19/ Become affiliated, co-operate, propose, share, dissent, obey, interact, agree on, express opinions	20/ Settings of participative interactions, parties, associations, churches, communities, neighbourhoods, family
Leisure	21/ Curiosity, receptiveness, imagination, recklessness, sense of humour, tranquillity, sensuality	22/ Games, spectacles, clubs, parties, peace of mind	23/ Day-dream, brood, dream, recall old times, give way to fantasies, remember, relax, have fun, play	24/ Privacy, intimacy, spaces of closeness, free-time, surroundings, landscapes
Creation	25/ Passion, determination, intuition, imagination, boldness, rationality, autonomy, inventiveness, curiosity	26/ Abilities, skills, method, work	27/ Work, invent, build, design, compose, interpret	28/ Productive and feedback settings, workshops, culturalgroups, audiences, spaces for expression, temporal freedom
Identity	29/ Sense of belonging, consistency, differentiation, self-esteem, assertiveness	30/ Symbols, language, religions, habits, customs, reference groups, sexuality, values, norms, historical memory, work	31/ Commit oneself, integrate oneself, confront, decide on, get to know oneself, recognise oneself, actualise oneself, grow	32/ Social rhythms, everyday settings, settings which one belongs to, maturation stages
Freedom	33/ Autonomy, self-esteem, determination, passion, assertiveness, open-mindedness, boldness, rebelliousness, tolerance	34/ Equal rights	35/ Dissent, choose, be different from, run risks, develop awareness, commit oneself, disobey	36/ Temporal/spatial plasticity

Table 3: A categorisation of feelings according to the typology of needs (Max-Neef, 1992).

Type of need	*Satisfaction of needs: positive feelings*	*Dissatisfaction of needs: negative feelings*
Subsistence	satiated, repleted	hungry
Protection	safe	in danger, anxiety
Affection	love/being loved	hate/indifference
Understanding	intellectual well-being, smart, clever	intellectual frustration, dumb, stupid
Participation	belonging, related, involved	lonesome, isolated, forsaken
Leisure	playful, relaxation	boredom/bored, weary, stressed
Creation	creative, inspired	uninspired
Identity	self-assured, confident, positive self-image	uncertain, insecure, negative self-image
Freedom	free, independent	entangled, chained, bounded, captured, tied

opportunity at that moment in time. However, this does not mean that the consumer never wants to use that opportunity. If the level of need fulfilment decreases, and using a particular opportunity will satisfy that need, it may well be that the relevant motivation rises. For example, if one is well fed (satiated), the motivation to eat will be low. However, after some time appetite starts to rise again and one's motivation to eat will increase accordingly.

The satisfaction of different needs is interrelated. For example, the need for subsistence should be satisfied to a certain minimum level to be able to satisfy the need for understanding. As such, the use of certain need-satisfying opportunities may form a prerequisite for the satisfaction of other needs.

Whereas the lower needs are, to a certain extent, equal for all humans, the higher needs show considerable variety across different cultures. For example, depending on one's values and beliefs, esteem can be gained by material consumption or by abandoning material consumption. To develop a cultural perspective on the varying needs of consumers, we will attempt to link the typology of needs according to Max-Neef (1992), to the perspectives as recognised by Cultural Theory (e.g. Douglas & Wildavsky, 1982; Thompson *et al.*, 1990; Schwarz & Thompson, 1990; Rayner, 1991, 1992; O'Riordan & Rayner, 1991).

Cultural Theory discerns four cultural perspectives, viz. the *Individualist*, the *Hierarchist*, the *Egalitarian* and the *Fatalist* (see also section 2.1). With respect to the perception and management of needs and resources, the four perspectives can be described as follows (Van Asselt & Rotmans, 1996):

Hierarchist: rational allocation of resources, can manage resources but not needs;
Individualist: expands resource base, can manage resources and needs;
Egalitarian: need-reducing strategy, can manage needs but not resources;
Fatalist: resources unpredictable, can manage neither needs nor resources.

The type of satisfiers that one employs is, for instance, dependent on historical and cultural conditions (Max-Neef, 1992). As such, consumers in one culture may prefer different opportunities to satisfy their needs than consumers in another culture. To operationalise this, the needs as depicted by Max-Neef are conceptually connected to the cultural perspectives. It is asserted here that a given cultural perspective is characterised by a preferred mode of need fulfilment. For example, Individualists would focus on satisfying their needs using opportunities that involve material consumption. Contrarily, Egalitarians would prefer opportunities of a more spiritual nature. Thus, cultural perspectives can be conceived as biasing consumers' perception of opportunities with respect to their need-satisfying capacities. Hence, an individualistic perspective would overestimate the degree of need fulfilment via material consumption, and would underestimate need impairments resulting from material consumption. The linking of needs to cultural perspectives allows for the description of meta-consumer motivation in terms of (1) the types of needs that guide consumer behaviour, and (2) the orientation of the needs with respect to consumption and management of natural resources and the manageability of the needs for these.

Opportunity

As previously stated, opportunities depend on the

availability of products and services one can use to satisfy his/her needs. Thus, in line with Max-Neef (1992), an opportunity can be conceived as a potential satisfier. A single opportunity may satisfy several needs. For example, eating caviar may fulfil the need to eat (Subsistence), to relax (Leisure) and to demonstrate one's prosperity (Identity). However, the less fulfilled a particular need is, the more it will dominate the evaluation of available opportunities. As such, a consumer with real hunger will tend to evaluate food with respect to its nutrient capacities only.

Also, a single need may be fulfilled using several opportunities. For example, the need for Leisure may be fulfilled by playing, watching television, taking a holiday, practising sports, and so forth. Thus, the relation between opportunities and needs is a complex one, as some opportunities may, in fulfilling a specific need, simultaneously either fulfil or impair other needs. In exploring the relation between needs and opportunities, Max-Neef (1992) discerns five types of satisfiers:

1: *Violators and destructors*: these supposedly satisfy a need (usually protection) but in fact often annihilate the possibility of satisfying a need and impair the satisfaction of other needs. For example, a strong government bureaucracy aims to offer protection, but often annihilates it, along with understanding, affection, participation, creation, identity and freedom (cf. Table 2).
2: *Pseudo-satisfiers* stimulate a false sensation of satisfying a certain need, but they may in fact impair the fulfilment of that need. For example, status symbols may be used to fulfil the need for identity, but a preoccupation with the acquisition of status symbols may actually impair one's identity.
3: *Inhibiting satisfiers* satisfy one need, but inhibit other needs in the process. For example, obsessive economic competitiveness may satisfy the need for (economic) freedom, but may impair the needs for subsistence, protection, affection, participation and leisure.
4: *Singular satisfiers* satisfy one need without interfering with others. For example, insurance systems satisfy the need for protection without inhibiting the satisfaction of other needs.
5: *Synergic satisfiers* satisfy a certain need, and they simultaneously stimulate and contribute to the satisfaction of other needs. For example, popular education satisfies the need for understanding, but also the need for protection, participation, creation, identity and freedom.

The more an individual perceives an opportunity as potentially need-satisfying, the more he or she will be motivated to use this opportunity. This motivation, combining both consumer needs and perceptions of opportunities, is a typical reflection of an internal trait of the consumer. However, the consumers' perception is susceptible for external information on the supposed need-satisfying capacities of opportunities, as, for example, provided by advertisements and the consumptive behaviour of other persons.

Besides perceived need-satisfying attributes of opportunities, which relate to someone's internal motivation, external factors also constitute an opportunity. These external factors have to do with the availability of consumer goods, the publicity (advertisement) for them, the prices that have to be paid, the places where they can be bought, and the like. In general, such external factors pertain to the feasibility of opportunity use. Opportunities differ with respect to resources required to use the opportunity, e.g., required monetary investments, permits and knowledge. The more constraints the use of an opportunity imposes on a consumer, the higher the opportunity's *resource demands*. General strategies aimed at a behavioural change often involve a change of resources. As such, a typology of general strategies is useful in developing a typology of resources for the use of opportunities. In line with general strategies for behavioural change (e.g., Sheth & Frazier, 1982; Cook & Berrenberg, 1981; Stern, 1992) we discern four general types of resources: (1) physical resources, (2) juridical and regulatory resources, (3) financial-economic resources, and (4) social and cognitive resources. As such, important practical aspects of opportunity use refer to *physical characteristics*, *laws and rules*, *prices*, and *social & cognitive constraints*.

Physical characteristics refer, in the first place, to the availability of certain products and services. This availability largely depends on the developmental stage a given society is in. For example, in Western society, the availability of coal and wood as a heating fuel is very low because the availability of natural gas and electricity allows for a much more convenient way of home-heating. Due to the low demands for coal, the market mechanism has reduced this opportunity to almost zero[3]. However,

[3] Wood-fuelled fireplaces and stoves have recently experienced increased popularity, but mostly for reasons of homely comfort (cosiness).

in regions where the availability of natural gas and electricity is low, people are more dependent on coal and wood (e.g. Gatersleben & Vlek, 1996). If available, coal and wood form the major home-heating opportunities in those regions. Secondly, physical availability refers to the places where certain products can be obtained. As such, both the infrastructure (e.g. for the distribution of gas, water and electricity) and the location of shops and service centres determine the physical availability of products. Other physical characteristics refer to, for example, the distance travelled and the amount of energy (e.g. physical strength) needed for consumption, and the quantity that can be consumed at one time.

Laws and rules refer to the legal constraints associated to the use of certain products. As such, some products are not allowed to be sold in a given region (country) because they do not conform to given product standards (e.g. ingredients, energy use, or environmental effects) or trade-agreements (origins of the product). Some may only be used with a permit or allowance (e.g. driver's licence, residential permits).

Prices refer to the amount of money products cost. Developments in mass production have resulted in the decreasing price of consumer goods, especially in the Northern regions (Gatersleben & Vlek, 1996). This in itself has led to an increased consumption. Furthermore, the development of consumer credits (loans) also allows for the consumption of products, even if people lack a sufficient amount of cash.

Social and cognitive constraints refer to the skills, knowledge, cognitive capacity and social support required to use a particular opportunity. Some opportunities require training (education) before one can use them, e.g., using a computer and driving a car. Moreover, some opportunities are not widely used and therefore relatively unknown. To find these opportunities requires a certain amount of cognitive effort. Furthermore, the amount of publicity (advertisement and information) that is associated with the marketing of a given product plays a significant role. Advertising usually tries to persuade consumers to buy the product. Along with the development of the media (newspapers, radio, television, Internet), advertising has grown into a huge industry, stimulating people to consume whatever is being produced. Information is commonly more neutral in presenting both the pros and the cons of a given product. As such, information is often provided by consumer organisations. Besides the formally defined rules, such as laid down in official laws, informal cultural rules also determine the opportunity to consume a certain product. For example, the consumption of pork and alcohol is restricted in Islamic countries (often also according to the law), and the smoking of cigarettes is socially restricted in the USA

The more opportunities are alike with respect to their need-satisfying attributes, the more they are interchangeable. This interchangeability functions in processes of *substitution*. For example, for medium-distance travelling, the train is a better substitute for the car than the bike. If an opportunity is not attainable, a consumer may look for alternatives which satisfy his/her needs as much as possible in the same way. Sometimes substitution processes cross the borders of different activity domains. For example, a consumer may decide to travel longer in order to achieve better living conditions (e.g. housing). In this situation the satisfaction of needs in one domain (good housing: Protection, Identity, Freedom) is increased at the cost of the satisfaction of needs in other domains (less spare time: Leisure and Freedom).

Ability

The concept of ability refers to the set of capacities and/or skills an actor (individual, or household) has for actually using an opportunity. In line with the resources demanded, as depicted in the section on opportunities, abilities can be conceived as the resources a consumer has available. Important aspects of ability refer to physical means and skills, permits and licences, financial means, and social and cognitive abilities to buy and use consumer goods.

Physical resources refer firstly to one's personal health, fitness and strength. These physical capacities allow for the use of certain opportunities, such as cycling, working on the land, carrying water, and the like. Secondly, also the physical tools and circumstances one has available are conceived as physical abilities. As such, owning a car, a house, and having (storage) space are regarded as physical abilities. For example, owning a car allows one to consume farther away and a larger house provides more room for useful appliances (washing machine, cooling equipment, etc.). The physical resources a consumer has available are variable by nature, that is, they can increase and decrease as a function of aspects like age, satisfaction level of certain needs (e.g. subsistence) and consumption of certain opportunities (e.g. owning a car).

Permitted and licensed resources refer to the permits and licences one has so as to use certain opportunities. Examples of such abilities are having a driver's licence, a necessary educational grade and a permit to install solar energy devices on top of the roof. Besides permitted and licensed abilities as provided by governments, the sociocultural environment also provides abilities. For example, the (officially) abandoned caste system in Indian society allows certain opportunities only to members of a given caste, and cultures more or less accept the consumption of alcoholic beverages and pork. Internalisation of rules and norms as imposed by a government may be reflected in the cultural norms and beliefs of a given society. The permitted and licensed resources are variable, that is, they may be granted or denied as a function of, for example, age, gender, identity and culture.

Financial resources refer to the income a consumer has. The higher the income of a consumer, the higher his/her ability to buy more and more expensive consumer goods. Especially in the Northern hemisphere the combination of increasing mean annual income and decreasing prices of consumer goods has led towards a strong increase in consumption (Gatersleben & Vlek, 1996). The financial resources a consumer has are variable, depending on income and spending patterns.

Social and cognitive resources refer, firstly, to one's knowledge, cognitive capacities/skills, attitudes, values and norms. These factors determine one's ability to understand the outcomes associated with opportunity use. This may lead to the perception of a low behavioural control, viz. the physical or social feasibility of a particular opportunity use. Secondly, the ability to elaborate on outcomes and the available time to consume are determined by the time one has available. The less time one spends working, the more time one has to consume (e.g., during leisure-time, holidays). Finally, one's social status (a social resource) may also allow the use of certain opportunities. A high social status is generally associated with easier access to information, a larger social network providing one with information, and more social support then with a low status. Social status can be seen as a function of one's physical, permitted and financial resources, as well as the level of one's needs satisfaction. Cognitive resources may be conceived as a function of educational level and heredity. Knowledge is a resource that hardly decreases. However, new opportunities often demand more or new cognitive resources, as the introduction of the computer illustrates.

Macro-level factors

In section 2.1 it was stated that environmental overexploitation is propelled by developments in technology, the economy, demography (population), institutions and culture (Opschoor, 1989; Stern, 1992; Vlek, 1995). In section 3.2 it was stated that the development of T.E.D.I.C. factors influence consumer behaviour by affecting the motivation, the characteristics of opportunities and abilities of the consumer (Gatersleben & Vlek, 1996). The following sections, derived from Gatersleben and Vlek (1996), describe the developments in The Netherlands with respect to macro-level factors in terms of technological, economic, demographic, institutional and cultural developments.

Technological developments. In current Western society many goods, services and materials are available now that 50 years ago did not exist. For example in 1950 the washing machine came on the market. The first machine only made mechanic movements and it had no supply- or drain-pipe. Nowadays, the washing machine does everything for us; we merely have to put in the laundry and the soap and push the button. We can choose the temperature, whether we want our laundry pre-washed or if we want an after-treatment. Goods like the washing machine or other household goods such as the micro-wave oven deliver a service that was also delivered before the good was available, but then by other means such as the launderette or the gas oven. There are, however, also many goods that deliver new services, such as a TV set, or the personal computer. Apart from a growing availability of goods and services there are also more different goods that deliver the same service. The number of brand options is enormous and they often differ only slightly in the service they deliver. Technological developments also indirectly influence household consumer behaviour because it makes goods and services available that people need in order to be able to use other goods, such as roads to drive a car, or pipe-connections to the gas-, water-, or electricity distribution systems.

Economic developments. While technological developments led to many new goods, economic developments led to an increasing amount of money to consume and produce these goods. Of course these two go hand in hand; goods that are developed in technology are sold and profits are used for further development. Not only is there more money to produce; there is also more money to consume. Since 1950 the purchasing power of individual

households may have increased even more then their income. Because of mass production, prices have decreased and more people were able to afford a particular good. Furthermore, for some goods, the prices per service unit have decreased. Household goods such as a washing machine have become more efficient and therefore use less energy, which makes the service they deliver relatively cheaper.

Demographic developments. Demographic developments can be seen as a multiplier, because when there are more people more goods and materials are needed and may be consumed. From 1950 to 1990 the Dutch population has grown by a factor of 1.5 (from about 10 to 15 million) and is estimated to grow by another 0.6% towards 2010. The number of households has increased even more, due to a decreasing average household size. The average number of people living in one house was 4.4 in 1956, in 1989 this was 2.6 and it is estimated that this will be 2.2 by the year 2010. Furthermore, the number of one-person households has strongly increased (from 285.000 in 1947 to 1.829.000 in 1990).

Institutional developments. Striving for economic and technological growth can also be found in the way in which society is organized in social structures and institutions. According to Opschoor (1989), today's industrial capitalism originates not only in technological and scientific developments, but also in the development of the free-market system, which is aimed at increasing the material well-being of individuals and society by focusing on efficiency expressed in market values. Natural resources used for industrial production generally do not have a market value and therefore are not seen as contributing to the economic value of goods. Galbraith (1984) noted about this that firms and industrial systems in the free-market mechanism seek to maximize stability and growth by focusing on increased production and consumption, and by creating motives in consumers to buy the goods firms most want to produce.

Cultural developments. Consumption and consumption growth have penetrated into cultural norms and values as well: well-being these days seems to depend largely on how much people earn and possess; and how one is perceived by others is influenced by one's material possessions. The importance of nature tends to be reduced to the extent to which it is able to serve human needs. This stems from a traditional Christian belief in human domination over nature (or anthropocentrism: man as the measure for everything; White, 1967), a belief in material prosperity, the free-market mechanism, and a materialistic culture in which norms and values are expressed in quantifiable units (Opschoor, 1989).

Especially technological, economic and demographic developments are projected by other submodels of TARGETS. Such projections, with respect to e.g. developments in population, GNP, food availability and the like, are considered as external determinants, which partially determine the motivation, opportunities and abilities of the meta-consumer. For example, rapid population growth might, all other factors being equal, lead towards scarcity of certain goods, thus affecting the opportunities available to a consumer. To address these processes in the behaviour module, developments, as projected by other TARGETS submodels, have to be evaluated on their impacts on consumer motivation, opportunities and abilities. With respect to institutional and cultural developments other sources of information have to be consulted.

3.3 The behavioural process (State)

More or less cognitive elaboration

If a consumer is highly motivated, he or she wants to use a relevant opportunity to satisfy his or her needs. However, the feasibility of consumption depends on the discrepancy between the resources demanded for using the opportunity and the consumer's abilities (or resources) to do so. This implies that a consumer may have more or fewer resources than are demanded by an opportunity. This discrepancy, defined as the available minus the demanded resources, is referred to as *behavioural control* (BC). If BC over a certain opportunity is high, it is relatively easy to use that opportunity. This implies that the consumer can consume without searching or elaborating alternative opportunities, or increasing his/her consumption ability. However, the lower BC gets, the more difficult it will be to use that particular opportunity. As such, the lower the BC for a given opportunity, the more the consumer will elaborate on alternative strategies to satisfy his or her needs. Thus, the higher the motivation, and the lower the behavioural control, the more a consumer is inclined to elaborate and the more a consumer engages in cognitive processing. This cognitive processing can be geared to two strategies to satisfy one's needs. First, a consumer may elaborate on alternative

opportunities that satisfy the same needs, yet do not demand that number of resources. Such opportunities will yield a higher behavioural control, and be used more easily. Second, a consumer may elaborate on strategies to increase his or her abilities. An increase in abilities would also yield a higher behavioural control, thus facilitating the use of the relevant opportunity. The degree to which either process is followed depends largely on the number of suitable opportunities the consumer perceives and the perceived potential of increasing one's own abilities.

Depending on the opportunities a consumer already uses, and on his or her abilities, the consumer can realise a higher level of over-all need satisfaction through substitutions. Such substitutions arise when the use of one opportunity is terminated or restricted, and the resources that are consequently disengaged may be employed to consume another opportunity. For example, an actor may curtail his/her expenses on clothing in order to buy a refrigerator. A consumer is likely to substitute if he or she perceives the potential for an increase in the overall need satisfaction.

These varying degrees of cognitive processing provide a major perspective to distinguishing between different behavioural processes, ranging from extensive elaboration of all opportunities and strategies to increase abilities, to automatic performance of a given behaviour, involving minor cognitive activity, if any at all. In the behavioural sciences this perspective has led to the emergence of two important paradigms, i.e. cognitivistic and the behaviouristic approaches towards behaviour. Each paradigm involves a variety of theories addressing the dynamics of different types of behaviour.

Besides distinguishing as to the extent of cognitive processing, a second distinction can be made with respect to the processing of individual versus social information. Individual-information processing refers to the situation where a consumer only elaborates on his or her own preferences with respect to need-satisfying opportunities. Information on the preferences and behaviours of other consumers is excluded from this type of processing. On the other hand, consumers can also elaborate on the preferences and behaviours of other consumers. This social information processing refers to the elaboration of preferences and behaviours from family, friends, neighbours, prominent spokespersons, and the like. In behavioural theories this perspective has led to the distinction between theories on individual and social behaviour. Some important factors that determine the relative importance of individual versus social information processing are:

- Uncertainty about the need-satisfying aspects of opportunities, which may be partly due to a low level of ability or inclination to elaborate. The more uncertain a consumer is, the more he or she will compare his or her behaviour with that of others similar to him/herself;
- Visibility of opportunity use. The more public an opportunity use is, the more information on other people's behaviour is available, and the more prevalent the norms on proper opportunity use will be;
- The cultural perspective of a consumer. For example, an individualist will be more inclined towards individual information processing, whilst an egalitarian will be more inclined to social information processing;
- The types of needs prevailing in a certain behavioural processing situation. More individually relevant needs, e.g. the need for subsistence, will entail a more individual style of information processing. More socially relevant needs, e.g. the need for identity, will entail more social information processing.

Both individual and social information processing can be more or less extensive, or automatic. Moreover, they usually coincide. As such, a behavioural process is rarely purely individual and reasoned, or social and automatic. For example, a consumer may reason extensively on his or her individual preferences, whilst 'automatically' including the preferences and behaviour of other people. The two distinct dimensions of behavioural processes yield a fourfold perspective on existing behavioural theories, as presented in *Table 4*.

This framework provides a comprehensive theoretical perspective on a basic variety of behavioural processes. In the following sections, the theories as referred to in Table 4 are briefly presented.

Theories of individually reasoned behaviour *(block 1 of Table 4)*

Theories of individually reasoned behaviour apply mainly to situations where consumers have a relatively highly motivation, but a relatively low behavioural control. Thus, consumers are forced to elaborate on alternative opportunities and/or on

Table 4: A classification of eight major theories on human behaviour, with: M = Motivation, BC = Behavioural Control, EL = Elaboration, and CP = Cultural Perspective

	Individually determined *(certainty, private, individualistic CP, personal needs)*	**Social determined** *(uncertainty, public visibility, egalitarian CP, social needs)*
Reasoned *(high M, low BC much EL)*	- Decision and choice theory (1) - Theory of reasoned/planned behaviour (attitude and perceived control)	- Social comparison theory (2) - Relative deprivation theory - Theory of reasoned/planned behaviour (social norm)
Automatic *(low M, high BC,) little EL*	- Classical conditioning theory (3) - Operant conditioning theory	- Social learning theory (4) - Theory of normative conduct

increasing their abilities. These theories apply to situations where outcome-uncertainty is relatively low, opportunity use less publicly visible (i.e. more private), the needs in question more individually relevant, and where the consumers have a more individualistic cultural perspective. An example would be the purchase of a micro-wave oven.

Decision and Choice Theory addresses the process of cognitive elaboration which precedes the making of deliberate choices. Decision theory deals with the question of how people actually decide (descriptive research) and how they should optimally decide (prescriptive research). Because the prescriptive branch of decision theory applies to strategies for behaviour change, this will be discussed in section 3.5 on policy instruments and behavioural change. Within the descriptive branch of decision theory, Janis and Mann (1977) discriminate between an optimising and a satisficing strategy. Optimising refers to a decision strategy leading to maximal (expected) utility. This strategy requires the elaboration of all available information. To apply an optimising strategy, an actor must be highly motivated, have high cognitive abilities and ample decision-making time. Two stages can be identified in the optimising strategy: (1) structuring the decision-making problem and (2) evaluating alternative options (opportunities) and making a choice (Vlek, 1989). *Economic theories* on consumer behaviour typically regard consumers as rational individuals. In this view, consumers try to optimise their utility (welfare), given their *available budget* (Green *et al.*, 1990; Opschoor, 1993).

Often people lack the motivation, cognitive ability and/or time to employ an optimising strategy. Furthermore, people have a limited capacity to store and elaborate information (Newell & Simon, 1972; Shiffrin, 1975). Consequently, people often use a satisficing strategy, which amounts to choosing an option that is 'good enough' for them (Simon, 1976; Janis & Mann, 1977). For instance, one can select the option with the highest score on the most important attribute. If two or more options score equally well, the procedure can be repeated for the second important attribute (*lexicographical heuristic*). A comprehensive listing of decision heuristics is given by Timmermans (1991). These heuristics allow for quick and effective decision-making, albeit through reduced information processing, so that more preferable options may be overlooked. In general, the type of decision process one follows depends on one's information processing motivation (driven by the importance of the related needs), the complexity of the opportunities one has to choose from and one's cognitive and temporal abilities.

The *Theories of Reasoned Action and Planned Behaviour* (Fishbein & Ajzen, 1975; Ajzen, 1985, 1988, 1991; Ajzen & Madden, 1985) are based on the assumption that individuals are rational human beings who make systematic use of the information available to them when choosing between alternative opportunities. The concepts employed in the theory of reasoned action are fundamentally cognitive in nature, i.e. the behaviour is supposed to depend on the intention to perform a given behaviour (White *et al.*, 1994). The stronger a person's *intention*, the

more he/she is willing to try to act in that way, and the greater the likelihood that such behaviour is actually performed. The *Theory of Reasoned Action* (Fishbein & Ajzen, 1975) specifies two conceptually independent determinants of *intention*. The first determinant is a personal factor termed the *attitude toward the behaviour* and refers to the individual's positive or negative evaluation of using an opportunity. This attitude consists of one's *beliefs* that using an opportunity will lead to certain outcomes, weighted by the *evaluations* of these outcomes.

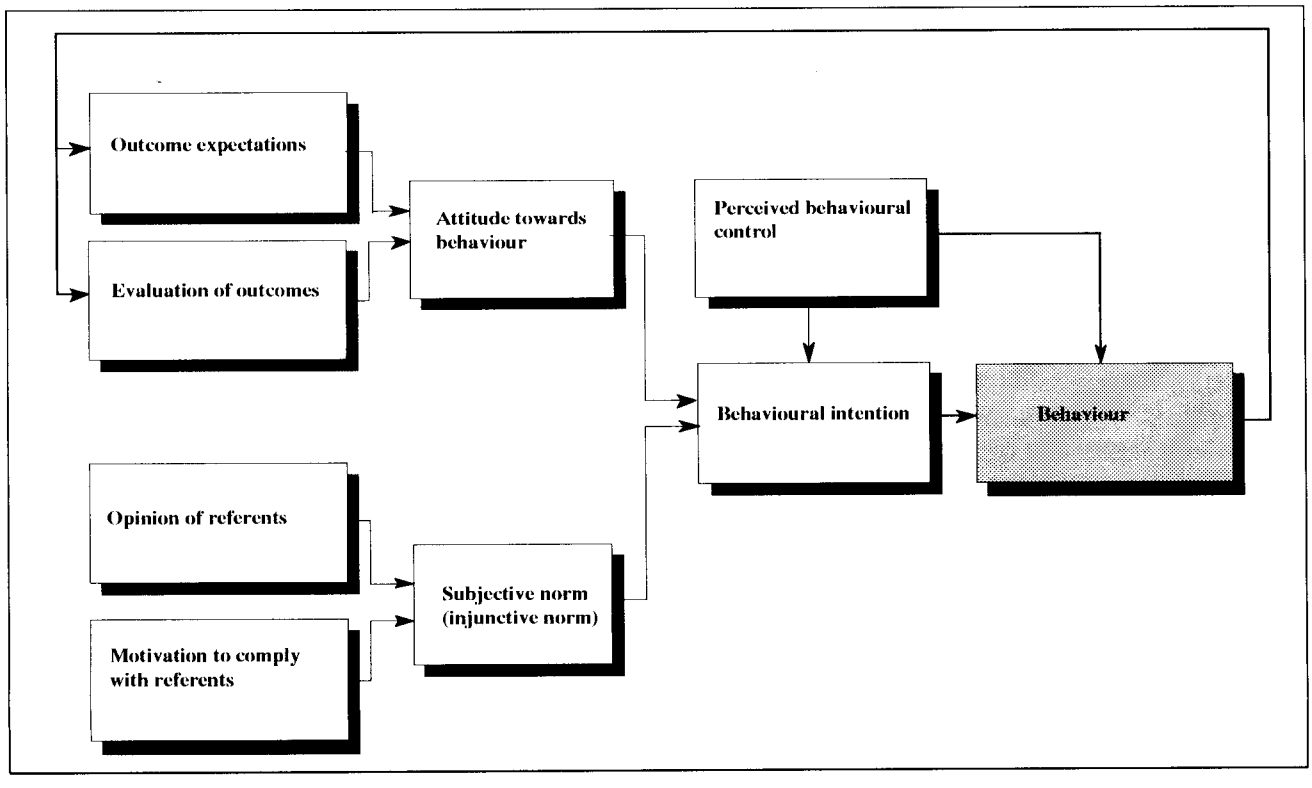
The second determinant of behavioural intention is a social factor, called the *subjective norm*, or one's perception of what other people consider to be appropriate (the 'injunctive norm'), which will be discussed in the section on socially reasoned behaviour, below.

The *Theory of Planned Behaviour* (Ajzen, 1985, 1988; Ajzen & Madden, 1985) is an extension of the *Theory of Reasoned Action* (Fishbein & Ajzen, 1975), which consists of including the concept of *perceived behavioural control*, i.e. the person's belief as to how feasible the use of an opportunity is likely to be. Both abilities and opportunities can interfere with control over the intended behaviour. Examples of abilities are resources like skills, knowledge, financial means and adequate planning, whereas resource demands like financial costs, time and social support (the dependence on the cooperation of other people) may determine the opportunities. The more resources individuals think they possess and the fewer resource demands they anticipate, the greater their perceived behavioural control. Perception of control has an important impact on a person's behavioural motivation (Ajzen & Madden, 1985). Generally, the greater the perceived behavioural control, the stronger is the person's intention to try to perform the relevant behaviour. A low level of behavioural control can backfire towards an adjustment of formerly positive attitudes (Golob, Horowitz & Wachs, 1979). *Figure 5* schematically represents the *Theory of Planned Behaviour*.

Theories of socially reasoned behaviour *(block 2 of Table 4)*

Theories of socially reasoned behaviour apply mainly to situations where consumers are relatively highly motivated, yet have a relatively low behavioural control. Therefore, people are forced to elaborate on alternative opportunities and/or on increasing their abilities. Moreover, these theories apply to situations where outcome-uncertainty is

Figure 5: The Theory of Planned Behaviour (Ajzen, 1985, 1988; Ajzen & Madden, 1985)



relatively high, the opportunity use would be publicly visible, the needs in question are more socially relevant and the consumers have a more egalitarian cultural perspective.

As shown in the previous section, the *Theory of Planned Behaviour* (Ajzen, 1985, 1988; Ajzen & Madden, 1985) also includes a social factor, the *subjective norm*, which refers to the person's perception of the social pressures put on him or her to perform or not to perform the relevant behaviour. The subjective norm is proposed as a function of one's *beliefs* that referents think whether the person should or should not perform the behaviour (called the injunctive norm), weighted by the *motivation to comply* with those referents (see *Figure 5*). Becoming aware of a subjective (social) norm would involve an assessment of relevant others and an appreciation of their behavioural intentions. Specific theories on social norms describe both reasoned and automatic behaviour. As such, the *Theory of Planned Behaviour* overlaps with the *Theory of Normative Conduct* (Cialdini *et al.*, 1991; see the next section on socially automatic behaviour).

Social Comparison Theory (Festinger, 1954) states that people are motivated to consciously compare their opinions and abilities with those of other people. These comparisons follow dimensions such as the possession of material goods, financial means, status, principles, attitudes and skills. With respect to opinions, people have a drive to roughly conform to others. With respect to abilities, people have a drive to be (somewhat) superior to others. Especially in new (unfamiliar) situations, these comparisons provide information about what is proper behaviour and opinions. Social comparison processes not only happen at the individual level, but also at the group level (Faucheux & Moscovici, 1972). Two important factors determine the degree of comparison between persons in a group (Festinger, 1954): the more *similar* group members are, and the more *cohesive* a group is, the more strongly members are motivated to compare themselves with others in the group. More recently, social comparison processes with respect to personal status and achievements have been the focus of research (Buunk & De Vries, 1991). Theories on *relative deprivation* describe social comparison processes in terms of social justification and relative deprivation (e.g. Masters & Smith, 1987). Because people generally prefer a positive outcome of a social comparison, this process appears to stimulate a continuous upward social mobility: a permanent striving towards the improvement of one's own position compared to the position of relevant others.

Theories of individually automatic behaviour *(block 3 of Table 4)*

Theories of individual automatic behaviour apply mainly to situations where consumers are relatively moderately motivated and/or have a relatively high behavioural control. Therefore, elaboration on alternative opportunities and/or on increasing their own abilities is not necessary. Moreover, these theories apply to situations where outcome-uncertainty is relatively low, opportunity use is less publicly visible (more private), the needs in question are more individually relevant, and consumers have a more individualistic cultural perspective.

Cognitivistic theories on reasoned behaviour emphasise the cognitive processes of deliberation and choice before performing a given behaviour, whilst they are more or less presuming that the consumer is a rational actor. In contrast, behaviouristic theories rely more on the *reduction of drives* as pressures towards behaviour, and as such they emphasize the outcomes of a performed behaviour. The dissatisfaction of a need is assumed to lead towards a drive to satisfy that need. If the need is fulfilled, the drive is reduced. For example, ingesting food is a need, whereas hunger is the drive to fulfil that need. People are conceived as being biologically motivated to reduce drives with respect to basic physiological and safety needs (Maslow, 1954; Max-Neef, 1992; see also section 3.2). Behaviours that are successful in reducing those needs are experienced as *rewarding*.

The *Classical Conditioning Theory*, as studied by Pavlov (1927), describes the process of how the performance of behaviours can be linked to stimuli that are indirectly related to the reduction of a drive. Pavlov's most famous experiment showed that, after a light was repeatedly turned on before a dog was fed, the dog salivated already in response to the light itself. Instead of showing the unconditional or natural response: salivating when confronted with food, the dog had learned that the turning on of the light preceded the presentation of food. As a result, the salivating at the light developed as a *conditional* response. This is called *response acquisition*. As long as the conditional stimulus is followed by an unconditioned reward, a conditional response will occur. When the reward is omitted, the conditional response will continue to occur for some time, but it will eventually diminish, thus revealing *extinction* of

the relevant behaviour. Conditional stimulus-response relationships in fact are simple, primitive 'if-then' rules by which behaviour is automatised and cognitive processing is strongly reduced. For example, a popular conditioned stimulus-response mechanism is; *if* you have to travel for more than two kilometres, *then* you take your car, because you 'automatically' expect positive travel experiences with it.

Where classical conditioning is based on linking existing natural responses to new, 'unnatural' stimuli, *Operant Conditioning Theory* (Skinner, 1938; 1953) describes the process of learning new, previously nonexistent responses. If, in a given stimulus situation, an immediate reinforcement or a punishment is experienced after performing a (coincidental) behaviour, the principles of operant conditioning apply. Positive reinforcements or rewards stimulate the repetition of the relevant behaviour. After experiencing a reward, people are motivated to repeat the preceding behaviour. Eventually, even an occasional rewarding of the behaviour (e.g. only 1 out of 10 times) will suffice to let the behaviour to continue. Furthermore, people may try to find out to what extent small changes in behaviour, and/or performing it in more-or-less similar situations, will lead to similar rewards. Following this *Principle of Contingent Reinforcement*, the behaviour can evolve and be performed in comparable situations. Negative reinforcements are concerned with the experience of physically or socially negative outcomes after performing a given behaviour. Thus such behaviour will be unlearned or extinguished. Negative outcomes may be avoided by performing an other behaviour to which they are not associated. The performance of new behaviour may thus be motivated either by the expectation of still higher rewards, or by the desire to avoid negative outcomes associated with current behaviour.

Because classical and operant conditioning theories only apply to situations with a small time interval between behaviour and 'contingent' reinforcement, long-term outcomes can only affect behaviour through explicit cognitive processing (reasoning). Furthermore, one has to experience outcomes that can be clearly attributed to one's individual behaviour. Therefore, classical and operant learning theories imply that time-dispersed and collective outcomes largely occur beyond the scope of (individual) conditioning processes because of: (1) the large time interval between performing behaviour and experiencing the corresponding outcomes, and (2) the impossibility of identifying one's own contribution to collective outcomes. In some cases, where performing a specific behaviour leads to rewards in the short term, but to negative outcomes in the long run, conditioned and cognitive response processes may collide. If one is well aware of the negative long-term outcomes resulting from a behaviour but unable, at the same time, to give up the short-term positive outcomes, we can speak of *addictive behaviour.*

Theories of socially automatic behaviour *(block 4 of Table 4)*

Theories of socially automatic behaviour apply mainly to situations where consumers are relatively moderately motivated and/or have a relatively high behavioural control. Therefore, elaboration on alternative opportunities and/or on increasing abilities is not necessary. Moreover, these theories apply to situations where outcome-uncertainty is relatively high, opportunity use is publicly visible, the needs in question are more socially relevant and consumers have a more egalitarian cultural perspective.

Besides directly experiencing personal reinforcement, seeing someone else being reinforced following his/her behaviour may also affect one's behaviour. Such processes are expressed in *Social Learning Theory* (Bandura, 1977; 1986; Liebert *et al.*, 1973). Social learning may occur directly while seeing someone being reinforced, however also the media (e.g. radio and television) and verbal representations (e.g. stories) may evoke social learning. Teaching new behaviour using exemplary behaviour is called *modelling* (Bandura, 1977). Because one has to be aware of someone else's experiences, social learning theory asserts the occurrence of cognitive processes in addition to plain conditioning processes. From being aware of someone else's (rewarding) behaviour towards performing that behaviour yourself, five steps have to be taken. These are, respectively, being *attentive* to the behaviour of someone else, *understanding* and *remembering* that behaviour, being able to *reproduce* that behaviour, and experiencing *reinforcement* after performing the behaviour yourself. As such, social learning involves the abilities one has (attention, understanding, recollection), the opportunities and skills to reproduce the behaviour, and the motivation as driven by expected reinforcement.

Socially automatic behaviour may also occur in the form of compliance to social norms. According to

the *Theory of Normative Conduct* (Cialdini *et al.*, 1991), three distinct types of norms affect human actions. First, social norms of the *descriptive* kind guide one's behaviour via the perception of how most other people (would) actually behave. Second, social norms of the *injunctive* kind guide one's behaviour via the perception of how most other people would approve or disapprove of one's behaviour. Third, *personal* norms guide one's behaviour via the perception of how one would approve or disapprove of one's own behaviour oneself. The behaviour of people is likely to conform to the norm that is currently in focus, even when the other types of norm dictate contrary behaviour.

When a certain behaviour is repeatedly performed (involving positive outcomes), the behavioural process may be automatised to a certain degree, thereby resulting in a *habit*. However, the origins of a habit may lie in earlier reasoned behaviour of a person. Much consumer behaviour is repetitive in character, e.g., the buying of food, the use of appliances (cars, showers, domestic appliances) and the disposal of rubbish. In order to understand the processes of habit formation, and to develop promising strategies to eventually alter habitual behaviour, it is essential to include processes of habit formation (and habit-undoing) in the behaviour module of TARGETS.

Habit formation and change

Habit formation refers to the automation of behaviour, and it thus relates to the periodic use of the same opportunity without elaborating on alternative opportunities. Habits and automaticities are related concepts (Huizing *et al.*, 1995). Fiske and Taylor (1991) distinguish a continuum of automaticities. The strongest automaticity is a preconscious one (Fiske & Taylor, 1991), i.e., behaviour which can hardly be influenced at all (e.g. as in reflexes). Habits are considered to be weak automaticities which are more susceptible to change. Much consumptive behaviour is embedded in relatively stable consumption patterns, which can be conceived as forms of habitual behaviour.

An important condition for habits to develop is that individuals are able and motivated to repeat their behaviour (Verhallen & Pieters, 1984; Groenen *et al.*, 1995). Regardless of the nature of the behavioural processes that had originally led to the behaviour, frequent repetition leads towards automation of the behaviour, thereby saving limited cognitive capacity (abilities) for other tasks. Stated differently, by means of extensive elaboration on possible opportunities, one may detect an opportunity that both satisfies needs and entails a high behavioural control. If this opportunity is being frequently used because it satisfies needs that are quickly depleted (see also section 3.2 on motivation), the next time a consumer is motivated to use this opportunity, virtually no cognitive elaboration on alternatives will be required. By repeatedly conducting the behaviour, the evaluations of the relevant aspects of the alternative behaviour patterns are saved and stored as a whole within a *script* (Fiske & Taylor, 1991). The minute a given behaviour may be conducted, a person appeals to such a script instead of comparing and elaborating the opportunities over and over again. Thus, individuals do not have to explicitly evaluate all aspects of the available opportunities any more. This implies that fewer resources like cognitive capacity and time have to be used in performing the behaviour, which enables consumers to use their limited abilities in other domains.

Because the use of a behaviour script implies the absence of extensive cognitive elaboration, the principles of classical and operant conditioning are most applicable to the behavioural process. Thus it is assumed that mainly short-term, individual and local (detectable) need-satisfying outcomes will determine a habit. Outcomes that emerge on the long term, and that are collective and more dispersed, will hardly affect the habit, irrespective of the fact that they are positive or negative. As long as the short-term outcomes are positive, the habit is likely to persist, often despite one's *cognitive* awareness of the risk of long-term negative outcomes. As soon as negative outcomes are experienced directly following the behaviour, e.g. the consumer's needs are no longer satisfied by using that opportunity, one is likely to abandon the script and shift toward the cognitive (reasoning) mode of information processing. A cognitive re-evaluation of the habitual behaviour may include the elaboration of long-term, collective and dispersed outcomes. This cognitive elaboration may evoke a behavioural change. Eventually, the new behaviour, if sufficiently repeated and positively reinforced, develops into a new habit of opportunity use.

The relation between reasoned and habitual behaviour was explored and characterised by Triandis (1977), Bentler & Speckart (1979), Ronis *et al.* (1989), Aarts *et al.* (1992), Verplanken & Aarts (1994) and Eagly & Chaiken (1993). They suggest

that with regard to the prediction of behaviour, there is a trade-off between deliberate intention and habit: when habit is strong the intention-behaviour relation is weak and vice versa. Or as Triandis expresses it: "....when a behaviour is new, untried and unlearned, the behavioural-intention component will be solely responsible for the behaviour, while, when the behaviour is old, well-learned, or overlearned and has occurred many times before (..), it is very likely to be under control of the habit component".

3.4 The outcomes of consumptive behaviour (Impacts)

The behavioural process as explicated in section 3.3 results in actual consumer behaviour, whereby an opportunity is being used which may be either material or immaterial. This opportunity use has several outcomes. Four main categories are: (1) satisfaction of needs, (2) changes in abilities, (3) changes in consumption opportunities and (4) various environmental impacts. Each of these will be briefly discussed below.

Satisfaction of needs

The utilisation of opportunities may satisfy (or impair) several consumer needs. If a need is satisfied, a person's immediate motivation to use the relevant need-satisfying opportunity again will decrease, that is, for as long as the need remains satisfied (see also Section 3.2 on the depletion time of needs). If a need is not satisfied by using an opportunity, this would decrease the motivation to use this particular opportunity again. Thus processes of feedback on satisfaction of needs regulate the frequency and intensity of opportunity use, and guide the behavioural process.

The capacity of a given opportunity to satisfy one's needs depends partly on the consumer's preferences. For example, one ('egalitarian') consumer may prefer to conform to the consumptive behaviour of a certain group to satisfy his or her need for identity, whilst another ('individualistic') consumer may be focused on stressing his or her uniqueness to satisfy the same need. Thus the cultural perspective a consumer has (see also sections 2.1 and 3.2) will partly determine consumer's preferences for certain opportunities.

With respect to the need-satisfying outcomes of opportunity use, it can be stated that the more his or her needs are satisfied, the better off the consumer will be. The need satisfaction resulting from a (combined) opportunity use can be conceived as a contribution to one's *quality of life*[3]. The concept of *quality of life* (QoL) is defined here as the extent of multivariate needs satisfaction. For the moment we adopt this definition to operationalise the concept of quality-of-life in a modelling framework. The authors are well aware of the limitations of this multivariate utilitarian approach, but for modelling purposes an overall quality-of-life measure is the best. Furthermore, some empirical basis for this quality-of-life measure based on need satisfaction is provided by Erikson (1987). Erikson's study, based on surveys in Sweden in 1968, 1974 and 1981, found that quality-of-life (or a sense of well-being) is caused by one's capacity to satisfy one's needs or, more generally, 'to control and consciously direct [their] living conditions'.

As previously stated, a consumer's cultural perspective partly determines the level of needs satisfaction by using an opportunity. Consequently, two consumers with an equal opportunity use may experience a different quality-of-life due to their differing cultural perspectives. For example, one consumer may experience a very high quality-of-life in a Buddhist monastery, the same environment may lead another consumer to experience a very low quality-of-life.

The concept of *lifestyle* refers to a coherent consumption pattern that characterises a person. It is postulated that culturally biased needs lead to the motivation to use certain types of opportunities and to refrain from others. As such, lifestyle is considered to be related to the four different cultural perspectives as discussed in sections 2.1 and 3.2. Consequently, Hierarchic, Egalitarian, Individualistic and Fatalist lifestyles may be distinghuised. The attainability of a particular lifestyle is dependent on the relation between one's abilities and opportunities. If one has sufficient abilities to use

[3] The concept of *quality of life* has received a lot of attention from social scientists, in particular by economists in the field of health care and social services. In developing measures for quality of life, a major contrast exists between utilitarian (e.g. Mill, Marx) and existentialist (e.g. Nietsche, Sartre, Kierkegaard, Heidegger) approaches (see Hodge, 1990). Where utilitarians try to develop a single measure of quality of life, existentialists dispute the possibility of such a single measure of what human beings need to flourish (Hodge, 1990). Furthermore, existentialists state that a full account of the problems cannot be given, that a set of principles leading towards a single resolution is not available, and that constructing a set of theoretical criteria for decisions and then proceeding towards decision-making forms a model which postpones the making of decisions indefinitely.

available opportunities, the preferred lifestyle (i.e. consumption pattern) can be easily attained. This lifestyle may be referred to as a *consonant lifestyle*. For example, a consumer who is motivated to adopt a lifestyle favouring material consumption (i.e. the 'individualist') and who has abundant financial abilities can easily adopt his or her preferred lifestyle. However, if someone lacks adequate abilities, he or she may be forced to adopt a lifestyle (consumption pattern) incongruent with one's perspective-ridden motivation. The resulting lifestyle may be called a *dissonant lifestyle*. For example, if the consumer just mentioned lacks sufficient financial abilities, he or she will be forced to adopt a less materialistic (i.e. 'egalitarian') lifestyle. Consonant lifestyles are hypothesised to manifest themselves in stable consumption patterns, whilst dissonant lifestyles go along with unstable consumption patterns. For example, the consumer just mentioned, having abundant financial abilities, may exhibit a stable lifestyle directed at material consumption. However, if the same consumer would lack sufficient financial abilities, he or she would be forced to adopt a less materialistic lifestyle, but, as far as financial abilities allow, he/she would occasionally consume in a more materialistic way.

A change of cultural perspective could evoke a different pattern of opportunity-wanting (desire) and opportunity-using (lifestyle), and could subsequently result in a different level of need fulfilment, thus affecting one's quality of life. Dependent on the nature of a cultural perspective change, one could experience an increase or decrease in overall need fulfilment, and thus a growth or decline in one's *quality of life*. For example, let us suppose that the Chinese society today is a hierarchic one, and individuals there would change their perspective towards individualism. This means that these individuals would be inclined towards increasing their (material) consumption. However, because of their lack of corresponding abilities and/or the unavailability of appropriate (material) opportunities, they are not able to consume the products they perceive as most need-satisfying. Consequently, their needs may not be fulfilled as when they had a hierarchic perspective. For example, the Chinese farmer may have been reasonably happy with his hierarchic consumption style, but the change towards individualism made him buy a refrigerator while leaving him craving for a car (dissonant lifestyle). As such, the perspective a consumer is stated to determine his preferences for opportunities. This implies that everything else being equal a difference in perspective may result in different qualities-of-life.

Changes in consumer abilities

The consumption of an opportunity will also affect the abilities a consumer has. For example, the purchase of a car will have consequences for the consumer's physical abilities (e.g. a higher mobility), financial means and social life. Four kinds of outcomes referring to changing abilities are recognised: (1) physical outcomes, e.g. one's ability to move, (2) regulatory and enforcement outcomes, e.g. the withdrawal or granting of a license, (3) financial-economic outcomes, e.g. one's available budget and (4) social and cognitive outcomes, e.g. changes in knowledge and social support (see also section 3.2 on opportunity and ability). These changes of consumer abilities may be positive (e.g. increasing knowledge) and negative (e.g. financial budget constraints). Also, the consumption of one opportunity may affect the attainability of other opportunities. For example, the purchase of a car may reduce one's financial abilities to afford a proper house. That car, however, may provide the means to develop the skill of running a freight transport business. As such, the use of a certain opportunity will affect one's abilities, and thus one's behavioural control over other opportunities. These feedbacks reflect the process of substitution, and refer to the autonomous or self-regulating processes of behaviour change.

Changes in consumption opportunities

The opportunities may also change as result of their use. Depending on the level of consumption and the type of opportunity (e.g. exhaustible, renewable, recyclable), a scarcity or even a depletion of opportunities may occur. Especially in the case of renewable resources, overconsumption may be understood as the overshooting of the carrying capacity of a certain provision system. Moreover, the type of consumer using an opportunity may also influence the need-satisfying aspects of the opportunity. For example, if only high-status consumers use a particular opportunity, other consumers may subsequently perceive this opportunity as more socially rewarding (e.g. satisfying the need for identity), and they thereby may become more motivated to use this opportunity as well. Societal processes of behavioural change are rooted in such feedback processes.

Various environmental impacts

Environmentally relevant outcomes refer to the observable levels of human consumption. The use of

products, goods and services implies the consumption of energy, water, materials, space and the like as well as the production of waste. This implies that, given a particular distribution of opportunity use, the resulting amount of resource use will have to be estimated. At this stage, information on the physical (environmentally relevant) outcomes of the behaviour is needed. For example, the number of litres of water that a certain type of consumer uses has to be derived from his/her drinking, showering, cleaning, irrigating and other behaviours in using water. As such, such outcomes display the amount of human consumption in terms of litres of water, miles of transportation, kWh electricity, M^3 natural gas and the like.

3.5 Policy instruments and behavioural change (Response)

Changing motivation, opportunity and abilities

Many policy instruments are aimed at deliberate behavioural change. For example, information on environmental effects of behaviour is provided to influence consumers' elaboration of opportunities; taxes are imposed to decrease the affordability of certain opportunities; regulations are set to restrict or enforce certain behaviours. Policy instruments aimed at a behavioural change are directed at the driving forces behind consumptive behaviour, thus changing consumer needs, opportunities and abilities, and thus their motivation and behavioural control.

Motivation is determined by the level of need-satisfaction a consumer experiences and his/her perception of the need-satisfying capacities of an opportunity. Because motivation is an internal state of the consumer, policy measures can only change motivation indirectly by means of changing the consumers' level of need-satisfaction and by changing the (perceived) need-satisfying capacity of opportunities.

The level of need-satisfaction a consumer experiences also refers to an internal state of the consumer. This level of need-satisfaction is partly determined by the cultural perspective a consumer adheres. As such, consumers with an equal type of consumption may experience different levels of need-satisfaction (quality-of-life) due to their differing cultural perspectives (see section 2.3). Consequently, a change in cultural perspective may change one's experienced level of need-satisfaction, thereby changing one's motivation. Moreover, such a change in cultural perspective may also change one's perception of the need-satisfying capacities of opportunities in general, thereby (indirectly) also changing one's motivation to consume certain types of opportunities. Such a change in motivation may pertain to general categories of consumer activities such as eating, transport and holiday-making. Consequently, strategies aimed at a change of cultural perspective might be effective in changing coherent patterns of consumer behaviour, thus changing one's life-style. The cultural perspective a consumer adheres may be changed via modification in people's values, norms and morality underlying people's satisfaction with their current and/or expected future quality-of-life. This may be accomplished through 'value debates', confrontations with others adhering to different cultural perspectives and concomitant life-styles, resulting in a different (not lesser) quality of life.

Besides changing one's general motivation, using strategies to change one's cultural perspective, strategies may also be directed at changing opportunities, thereby changing motivation at a more specific level. These strategies refer to the changing of particular need-satisfying characteristics of specific consumer goods, so that simple preference changes may occur. Therefore, motivational change may be induced in either general or specific terms, depending on the kind of behaviour change one intends to achieve. The following section will discuss the changing of opportunities.

Opportunities can be changed with respect to their sheer availability, their need-satisfying attributes and the consumer abilities they require (resource demands). Changing the need-satisfying attributes of opportunities indirectly affects the consumer's **motivation** to use an opportunity (see above). This motivational change will only occur if one actually perceives the opportunity change. The consumer's perception of opportunity changes may be the result of personal reflection, external information and/or persuasion, own experiences with the need-satisfying characteristics of consumer goods and services, and via the observation of other consumers' behaviour and outcomes.

Increasing need-satisfying aspects is relatively easy to do, and many suppliers of opportunities (e.g. producers) make large efforts to increase the need-satisfying aspects of their products by improving existing products and developing new ones. A decrease in need-satisfying attributes often is harder

to achieve as it requires a fundamental change of an opportunity, e.g. making cars less comfortable, making long-distance holidays less appealing, et cetera.

Governmental policy is usually aimed at changing the ability (resource) demands of an opportunity, using laws, prices, information, et cetera. As such, unpreferred opportunities may be taxed or prohibited, and preferred opportunities may be subsidised or propagated. Changing the ability demands of an opportunity obviously influences the **behavioural control** a consumer has. Increasing the ability demands of an opportunity results in a decrease in consumer's behavioural control. Decreasing the ability demands results in an increase in behavioural control.

Changing consumer **abilities** (consumer resources) involves instruments that increase or decrease consumer abilities. For example, income taxes decrease the financial abilities a consumer has, and education increases the knowledge abilities of a consumer. The changing of consumer abilities also changes the **behavioural control** of consumers. Increasing abilities will result in an increasing behavioural control, whilst decreasing abilities result in a decreasing behavioural control. Thus, as discussed before, consumer abilities (resources) and opportunity resource demands are two sides of the same coin.

Five general strategies to change behaviour

Different strategies can be applied to change consumers' cultural perspective, consumer abilities and opportunity characteristics, thereby indirectly altering consumers' motivation to consume and their behavioural control. The nature and effectiveness of various strategies to change behaviour have been tested in many social dilemma experiments. This research took place in many laboratory and fewer field settings (e.g., Dawes, 1980; Edney, 1980; Messick & Brewer, 1983; Liebrand *et al.*, 1992). Several researchers have categorised strategies for behavioural change: e.g. Sheth & Frazier, 1982; Cook & Berrenberg, 1981; De Young, 1993; and Vlek & Michon, 1992. Whilst acknowledging that more sophisticated categorisations are available, in this report we present a categorisation based upon four general scientific disciplines usually employed in the policy development process, and a fifth discipline that is rarely used in policy. These five disciplines are: technical science, law, economics, psychology/ sociology and moral philosophy/ cultural anthropology. In line with these disciplines, five corresponding types of general strategies for behavioural change are recognised: (1) providing physical alternatives and arrangements, (2) regulation and enforcement, (3) financial-economic stimulation, (4) social and cognitive stimulation, and (5) changing values and morality. The following section delineates the five general strategies for behavioural change, and indicates how they address consumer abilities, opportunity resource demands and cultural perspective.

1. *Provision of physical alternatives and (re)arrangements* may change the consumer's set of opportunities. New behavioural opportunities are shaped or existing opportunities are deleted through changing technology and infrastructure. The basic assumption is that behaviour can be shaped by changing the physical environment in which it takes place. Firstly, this strategy may change the need-satisfying capacity of opportunities. This would subsequently change the consumer's motivation to use opportunities. For example, making public transportation more comfortable may result in an increasing motivation to actually use it. Secondly, this strategy may change the physical resource demands of an opportunity. Hereby the behavioural control a consumer has may change. For example, closing a street down for car-traffic (e.g. during certain hours) will substantially decrease consumers' behavioural control over driving there. If this decrease of behavioural control is significant, consumers cannot drive there by car (as much as they used to) and may be motivated to elaborate on alternative travelling opportunities and strategies to increase ability (substitutions). Some exemplary types of physical alternatives and (re)arrangements are:

- Optimalisation of existing technology (improving efficiency etc.). For example, cars can be made more energy-efficient and more energy-efficient wood-fired cooking stoves can be produced.
- Innovation and development of new technologies refers to the development of new opportunities. For example, new small-scale types of windmills have been developed for the generation of energy and pumping of water. Cars with electric engines have been developed.
- Infrastructural change refers to the change of a system of opportunities or the development of a new system of opportunities. For example, a new railway offers new opportunities to travel, and the development of computer networks (Internet) provides new opportunities for communication.

2. *Regulation-and-enforcement* serves to restrict or extend the set of opportunities one has to behave in a certain way. This strategy is based on the issuing and enforcement of laws, rules, regulations and standards adopted by the government. Their violations - if detected - are met with some kind of punishment, fine or disapproval. This requires an adequate organisation for supervision, monitoring and enforcement. Regulations typically change opportunity demands and/or consumer abilities, thereby altering the behavioural control consumers have. It is assumed that regulations eventually will be internalised, thereby leading to a motivational change, i.e. a change in the perceived need-satisfying capacities of an opportunity. Some exemplary types of regulation-and-enforcement are:

- Civil law determines the rules which apply to interactions between citizens. For example, civil law provides rules for business transactions between citizens and rules concerning private property.
- Constitutional law determines the rules which the government imposes on its citizens. For example, constitutional law determines product characteristics (e.g. rules for additives in food) and maximum speed for traffic.
- International law determines the rules which apply to the interaction between states. For example, governments may take measures like boycotting a country to force it to conform to international civil rights and may regulate the freedom of trade (e.g. NAFTA) and travelling (e.g. Schengen agreement).

3. *Financial-economic stimulation* aims at changes in the pay-off structure of a set of opportunities for consumption. Preferred behaviours may be financially rewarded using subsidies, discounts, etc., while unpreferred behaviours may be financially punished using taxes, fines, etc. The basic assumption is that the behaviour of people is susceptible to the price mechanism, and that the demand-price elasticities involved are reasonably high. Financial-economic stimulation can be directed at specific (types of) opportunities, thereby altering the behavioural control consumers have. Moreover, the financial ability consumers have may be changed, e.g. by changing the tax system. Some exemplary types of financial-economic stimulation are:

- Microeconomic measures making use of the price mechanism. As such, they are directed at changing the financial abilities opportunities require. Examples are taxing luxury goods and subsidising public transportation.
- Macroeconomic measures mainly address the financial abilities of consumers in a country. Examples are measures to change interest rates, budgetary deficits, national debts et cetera.

4. *Social and cognitive stimulation* may be aimed at increasing public problem awareness and to alter problem perception, thereby motivating people towards preferred behaviours. This strategy involves giving information, education, arguments, social rewards, behavioural examples (role-models), prompts and advice. Changes in attitudes and values, seeing rolemodels being rewarded and changes in people's perceptions of their quality-of-life are assumed to change the perception of the need-satisfying capacities that opportunities have, thereby changing consumers' motivation. Also, offering knowledge and advice can increase consumers' ability to change their behaviour. The basic assumption is that specific behaviours are determined by cognitions and by social factors, such as social norms and customs. Some exemplary types of social and cognitive stimulation are:

- Informing consumers about the (dis)advantages of certain opportunities may change their motivation and subsequently their behaviour.
- Social modelling and support may change consumers' motivation. For example, if high-status persons propagate and demonstrate the use of a certain opportunity, consumers may perceive that opportunity as status-increasing (need for identity). Also, exemplary behaviour may facilitate the reproduction of that behaviour, because copying behaviour often requires fewer consumer abilities than extensive elaboration on the outcomes of that behaviour.

5: *Changing values and morality* involves appeals to the conscience of consumers and attempts to enhance their 'altruism' or 'cooperativeness' towards other actors and future generations, e.g., by means of increasing their trust in other consumers behaviour. This strategy may also entail a change in people's conceptions of quality-of-life, particularly in the relative importance they attach to collective and environmentally qualities as components of their notition of human welfare and sustainable development. Assumed is that a change in morality is reflected in a changing cultural perspective, e.g. a consumer may move from a more individualistic perspective towards a more egalitarian perspective. Such a change of values or morality implies that one's perception and motivation to consume

opportunities in general will change. Consequently, this strategy might be effective in changing one's life-style.

The strategy of changing or preserving values and morality is by nature the domain of religious and other ideologic and cultural groups and organisations. Also the government has means to influence existing values and morality, e.g. by means of the educational system, general campaigns and the media. For example, stressing the fact that some behaviours have negative outcomes for other people (or the collective), and appealing to the principle of reciprocity, may motivate people to change their behaviour for reasons of fairness.
The above mentioned general strategies may be directed at individual consumers (the *micro-level* of society), but also at organisations (the *meso-level*) such as industries, special interest groups, public services and so forth, and at the level of countries and international organisations such as the World Bank and the OECD (the *macro-level*). Especially when the behaviour of individuals is embedded in or determined by organisational structures of a higher level, applying the strategies at the meso- and macro-level may indirectly affect the behavioural opportunities one may employ at the micro-level. For example, setting energy-use standards for the appliances produced by an industry (regulation-and-enforcement at the meso-level) may indirectly affect the opportunities a consumer at the micro-level can use, via the (derived) strategy of providing physical alternatives and (re)arrangements. Strategies employed at the macro-level may strongly affect the behavioural processes at the meso- and micro-levels. For example, a free-trade agreement may have effects on both the producers and consumers of goods.

The five strategies just discussed can, alone or in combination, be operationalised in specific policy instruments. The latter are defined as 'all means an actor has decided to use to achieve one or more policy goals' (Klok, 1991). Van der Doelen (1989) discerns three dimensions to categorise policy instruments. The first differentiates between *directing* and *constituting* instruments. Directing instruments are aimed at influencing the behavioural process directly, e.g. by means of information, prices, prohibitions, et cetera. Constituting policy instruments are aimed at creating preconditions for a behavioural change, e.g. by means of education, developing infrastructure, issuing constitutional law, et cetera.

The second dimension differentiates between *collective* and *individual* policy instruments. Collective instruments are aimed at influencing simultaneously many consumers in different situations, e.g. by means of mass-media campaigns, regulating prices, general laws, et cetera. Individual instruments are aimed at influencing specific groups of individuals in specific situations, e.g. by means of advice, levies, licences, et cetera.

The third dimension discerned by Van der Doelen (1989) refers to instruments which either *restrict* or *extend* people's freedom of choice. Restrictive instruments are aimed at decreasing the behavioural control consumers have over an opportunity, e.g. by means of propaganda, raising prices, prohibitions, et cetera. As such, restrictive instruments are usually directed at restricting the use of opportunities not favoured by policy. Extending instruments are aimed at increasing the behavioural control consumers have over an desired opportunity, e.g., by means of information, subsidies, privileges, et cetera. As such, these instruments are usually directed at stimulating the use of opportunities favoured by policy.

A theoretical perspective on behavioural change

The efficacy of policy instruments directed at behavioural change depends on how well a behavioural process is approached. For example, if a consumer is highly motivated to use an opportunity, but is lacking an adequate behavioural control, he or she will be motivated to elaborate on alternative opportunities and/or on strategies to increase behavioural control, and it is likely that new information will be taken into consideration. However, a consumer with a low motivation to elaborate will not consider new information; inducing a behaviour change then requires other (combinations of) instruments. Because the existing situation with respect to motivation, behavioural control and uncertainty of the situation determines the behavioural process a consumer engages in, it is important to relate policy instruments carefully to the relevant type of behavioural process. To provide a theoretical perspective on behavioural change, an inventory of behaviour-change instruments is provided in the sections to follow for each of the four types of behavioural processes as presented in section 3.3: individually reasoned, individually automatic, socially reasoned and socially automatic behaviour; see Table 2.

Changing individually reasoned behaviour

The theoretical frameworks to consider individually

reasoned behaviour are decision theory and the theory of planned behaviour. Decision theory offers two main perspectives on behavioural change. First, one may change a person's decision situation. This implies a change of opportunities to choose from, e.g. offering new opportunities, eliminating existing opportunities and changing the value attributes of opportunities. Such changes may lead to preference shifts, whereby new opportunities come to be chosen over old ones. This perspective utilises the strategies of providing physical alternatives (1), regulation-and-enforcement (2) and financial-economic stimulation (3).

The second perspective, emerging from the prescriptive branch of decision theory, involves methodical decision support. This applies to situations where consumers lack sufficient abilities to apply an optimising strategy and therefore use a satisficing strategy. Procedures, sometimes computer-programmed, are available to assist decision makers in structuring a problem and selecting the most preferred opportunity. See, e.g. the Multi Attribute Utility-model (MAU model, Keeny & Raiffa, 1976; Edwards & Newman, 1982). Such decision support may be helpful in evaluating a set of opportunities on several need-satisfying characteristics. Consequently, the greater use of information in the decision-making process may result in shif-ting preferences. Decision support is a typical social and cognitive stimulation technique (4).

The first perspective on behavioural change offered by the *Theory of Planned Behaviour* (Ajzen, 1985) entails changing attitudes. Attitudes may change as a consequence of providing information on (changed) need-satisfying characteristics of (new) opportunities and/or the resources required for their consumption. If consumers are made aware of an opportunity change, they may subsequently change their beliefs that certain outcomes (satisfaction of needs, required resources) result from using that opportunity. Moreover, if a consumer is aware of an increase in required resources for a specific opportunity use, this would decrease his or her perceived behavioural control. As such, information, communication and education (strategy 4) can be employed to inform consumers about changing opportunities. This strategy mainly addresses the consumer abilities in comprehending the apparent opportunity changes.

Besides changing opportunities, the evaluations of outcomes also can be changed. Stated in terms of decision theory this means the changing of the subjective weighting of attributes. As this subjective weighting partially depends on the predominant values and morality (associated with a cultural perspective), a change in values and/or morality may change a consumers motivation to use an opportunity, thus resulting in a behavioural change. Especially changing values and morality (strategy 5) may be aimed at the changing of values and/or morality.

The second perspective on behavioural change offered by the *Theory of Planned Behaviour* (Ajzen, 1985) entails changing the Subjective Norm, thus addressing socially reasoned behaviour. Consequently, this perspective will be discussed in the corresponding section on socially reasoned behaviour.

The abovementioned perspectives also address the process of attitude change. The *Elaboration Likelihood Model (ELM*; Petty & Cacioppo, 1986) discerns a *central* and a *peripheral route* to attitude change. The central route pertains to the elaboration of pure arguments in a persuasive message and/or new information. The peripheral route is concerned with the elaboration of form aspects or cues of a message such as the number of arguments, the credibility and the attractiveness of the source. The extent to which people follow these two routes depends on their motivation to elaborate (MTE) and/or their ability to process information. If MTE and/or cognitive processing ability is low, people will only elaborate the cues in a message, using simple cognitive schemata (*heuristic process model of persuasion*). If MTE and/or cognitive processing ability is moderate, people will assess the motives of the source to deliver the message (*attribution process model of persuasion*). This combined use of central and peripheral routes requires more cognitive elaboration than the use of heuristics. If MTE and/or cognitive processing ability is high, people will explicitly elaborate the information in the message, relating it to existing knowledge structures (*cognitive response model of persuasion*). Generally spoken, attitude changes resulting from central processing are enduring, while peripheral processing results in temporarily attitude shifts. This implies that if people have a high MTE and/or cognitive processing ability, a persuasive message is most likely to be effective if it entails relevant arguments and new information. If people have a low MTE and/or cognitive processing ability, it is advisable to identify strategies to increase MTE and/or cognitive

processing ability, and subsequently provide arguments and new information.

Changing socially reasoned behaviour

The *Theory of Planned Behaviour* also offers a perspective on changing behaviour by changing one of its three components, viz. the Subjective Norm. Changing the beliefs that a consumer has regarding the appropriateness of a given behaviour involves providing information, communication and education (strategy 4) and changing values and norms (strategy 5). Especially the belief that similar people approve or disapprove of a certain behaviour will be effective. As a result, a consumer may change his or her (social) evaluation of an opportunity.

According to the *Social Comparison Theory* (Festinger, 1954) and the *Theory of Relative Deprivation* (Masters & Smith, 1987), a change in the salient dimensions of comparison would result in a change of behaviour. For example, if status and achievements were defined in a more sustainable way, with lesser emphasis on material consumption as a main focus of comparison, upward social mobility would come to be directed at being more sustainable than others. Such a drastic change of morality, although hard to realise in one generation (e.g. Elias, 1984), would mainly fall under strategy 5 (changing values and norms).

The preceding two perspectives on behavioural change originate from cognitive behaviour theories, and they are directed at changing both the situation (in terms of opportunity characteristics) and the consumer (in terms of motivation and ability) in a direct way. The following two behaviouristic perspectives, however, address only situational changes, implying that this will yield an indirect change in consumer motivation and ability.

Changing individually automatic behaviour

As discussed before, classical and operant conditioning perspectives on behavioural change address changes in opportunities. This implies changing the *reinforcement schedules* associated with the use of opportunities. Two methods can be distinguished, namely *rewarding* the preferred behaviour and *punishing* the unwanted behaviour. Both rewards and punishments can be developed using all five strategies: providing physical alternatives (1), regulation-and-enforcement (2), financial-economic stimulation (3), social/cognitive stimulation (4) and changing values and morality (5). The experiencing of a reward or punishment after employing an opportunity directly affects one's motivation to use that opportunity (again). Indirectly, certain types of rewards and punishments may also imply changes in people's ability to actually use an opportunity.

Rewarding the preferred behaviour can be accomplished in two ways. Firstly, new positive outcomes may be connected to the use of an opportunity. Secondly, existing negative outcomes associated with the opportunity may be removed. *Punishment* may also be administered in two ways, viz. by connecting new negative outcomes to an opportunity or by removing existing positive outcomes. Some guidelines for effective punishment are (Azrin & Holz, 1966):

- The punishment must be unavoidable;
- The punishment stimulus must be immediate at a profound level instead of increasing gradually;
- The punishment should follow immediately after performing the unwanted behaviour;
- The frequency of punishment should be as high as possible;
- Prolonged periods of punishment should be avoided, as one could get accustomed to the punishment, especially when the punishment is moderate;
- Positive reinforcements should be eliminated as far as possible;
- Feasible alternative opportunities must be available;
- If direct punishment is not feasible, a punishment-related stimulus should be used.

When using effective punishment, the unwanted behaviour will be extinguished and, consequently, further punishment will be unnecessary. When using rewards, a minimum level of rewarding should always be guaranteed. A combination of punishing the unwanted behaviour and rewarding the wanted behaviour will be most effective.

Changing socially automatic behaviour

The perspective of the *Social Learning Theory* (Bandura, 1977; Liebert *et al.*, 1973) on behavioural change addresses the use of representative behaviour as performed by role models. This technique, often referred to as *modelling*, comprises the presentation of role models that are rewarded or punished as discussed in the foregoing section on classical and operant conditioning. Role-models may be present in one's direct social surroundings, but they may also be provided via media such as television,

Table 5: Policy instruments for behavioural change classified according to four general theoretical perspectives and strategies for behavioural change.

	Individually determined	**Socially determined**
Reasoned behaviour	**Strategy 1: Physical alternatives** - Offering new opportunities - Changing the need satisfying capacities attributes of opportunities - Changing the required resources for opportunity consumption - Eliminating existing opportunities - Changing consumer abilities **Strategy 2: Regulation and enforcement** - Changing the required resources for opportunity consumption - Changing consumer abilities **Strategy 3: Financial economic stimulation** - Changing the required resources for opportunity consumption - Changing consumer abilities **Strategy 4: Social and cognitive stimulation** - Offering decision support - Providing information and education on existing, new, changed and/or eliminated resources (arguments and/or cues) **Strategy 5: Changing values and morality** - Changing knowledge, attitudes, values and morality	**Strategy 4: Social and cognitive stimulation** - Changing consumer beliefs regarding the appropriateness of behaviour - Changing the salient dimensions of comparison - Stressing personal or injunctive norms - Offering normative information **Strategy 5: Changing values and morality** - Change of morality with respect to the focus of social comparison - Appealing to the conscience of consumers
Automatic behaviour	**Strategy 1: Physical alternatives** **Strategy 2: Regulation and enforcement** **Strategy 3: Financial economic stimulation** **Strategy 4: Social and cognitive stimulation** Rewarding - Providing new short-term positive outcomes - Eliminating existing short-term negative outcomes Punishing - Providing new short-term negative outcomes - Eliminating existing short-term positive outcomes	**Strategy 4: Social and cognitive stimulation** - Showing role models who experience negative short-term outcomes (physical, regulatory, financial-economic, social and cognitive) after performing an unpreferred behaviour. - Showing role models who experience positive short-term outcomes (physical, regulatory, financial-economic, social and cognitive) after performing a preferred behaviour. - Activation of injunctive norms - Activation of descriptive norms

newspapers, magazines etc. As such, modelling falls under strategy 4 (social & cognitive stimulation).

According to the *Theory of Normative Conduct* (Cialdini *et al.*, 1991), the activation of norms to change behaviour may best be directed at *injunctive norms*, thus stressing or changing one's ideas about what other people regard as proper behaviour. The activation of *descriptive norms* will only be effective if most people already behave in a desirable way, and thus offers fewer possibilities for the development of policy instruments. Finally, the activation of *personal norms* will only be effective if these norms are already congruent with the preferred behaviour. This

changing of personal norms is similar to the changing of socially reasoned behaviour as discussed before. The activation of norms falls under strategy 4 (social and cognitive stimulation).

Table 5 presents an overview of policy instruments for behavioural change, following a classification according to the four theoretical perspectives and the four general strategies for behavioural change.

Changing the behavioural process

The preceding sections focussed on changing behaviour from the perspective of one of the four types of behavioural processes as distinghuised in Table 2 and 5. However, it has to be acknowledged that policy measures often cause shifts in the type of behavioural processing. A clear example may be derived from attempts at changing habits. As previously stated (section 3.3), habitual behaviour involves minor or no cognitive processing at all. Only positive direct outcomes will maintain the perseverance of a habit. Policy measures aimed at changing a given habitual behaviour thus require the elimination of direct positive outcomes, and/or the administration of direct negative outcomes. Especially in the case where policy measures may cause a decrease in behavioural control, e.g. by raising the price of an opportunity, will the consumer become more motivated to elaborate on alternative opportunities (thus shifting to reasoned behaviour). If a more need-satisfying opportunity is found, and the consumer has a high behavioural control over that opportunity, a new habit may emerge, which involves a shifting back to (a new) automatic behaviour. At the moment a consumer elaborates (i.e. manifests reasoned behaviour), the provision of information on long-term outcomes may be included, and this may have an effect on the valuation of different alternative opportunities and a corresponding behavioural change. Therefore, often a **combination** of instruments directed at different types of behavioural processes is needed to change behaviour effectively.

3.6 A conceptual behavioural model

In Chapter 2, section 2.3, it was concluded that a behavioural model should incorporate dynamic processes of learning, habit formation and adaptation. Such feedback processes requires system dynamic type of modelling. In line with the TARGETS philosophy (Rotmans *et al.*, 1994; 1995; Rotmans & De Vries, in press), the P-S-I-R approach will be used to model the dynamics of consumptive behaviour. Therefore, a distinction is made between: (a) a Pressure system, describing the driving forces underlying consumptive behaviour, (b) a State dynamics system, describing the behavioural process itself, (c) an Impact system, describing the outcomes of the behavioural process and (d) a Response system, describing the policy strategies aimed at a behavioural change. Thus far, the current chapter has presented an overview of various theories of behaviour and its determinants (section 3.2), types of behavioural processes (section 3.3), the outcomes of consumptive behaviour (section 3.4) and policy instruments for behavioural change (section 3.5). As such, the concepts used in this chapter may be translated into a P-S-I-R-based BEHAVIOUR module. *Figure 6* presents a conceptual behaviour *model*. The next chapter will provide a perspective on the operationalisation of this conceptual behavioural model into a computer-programmable behavioural *module*.

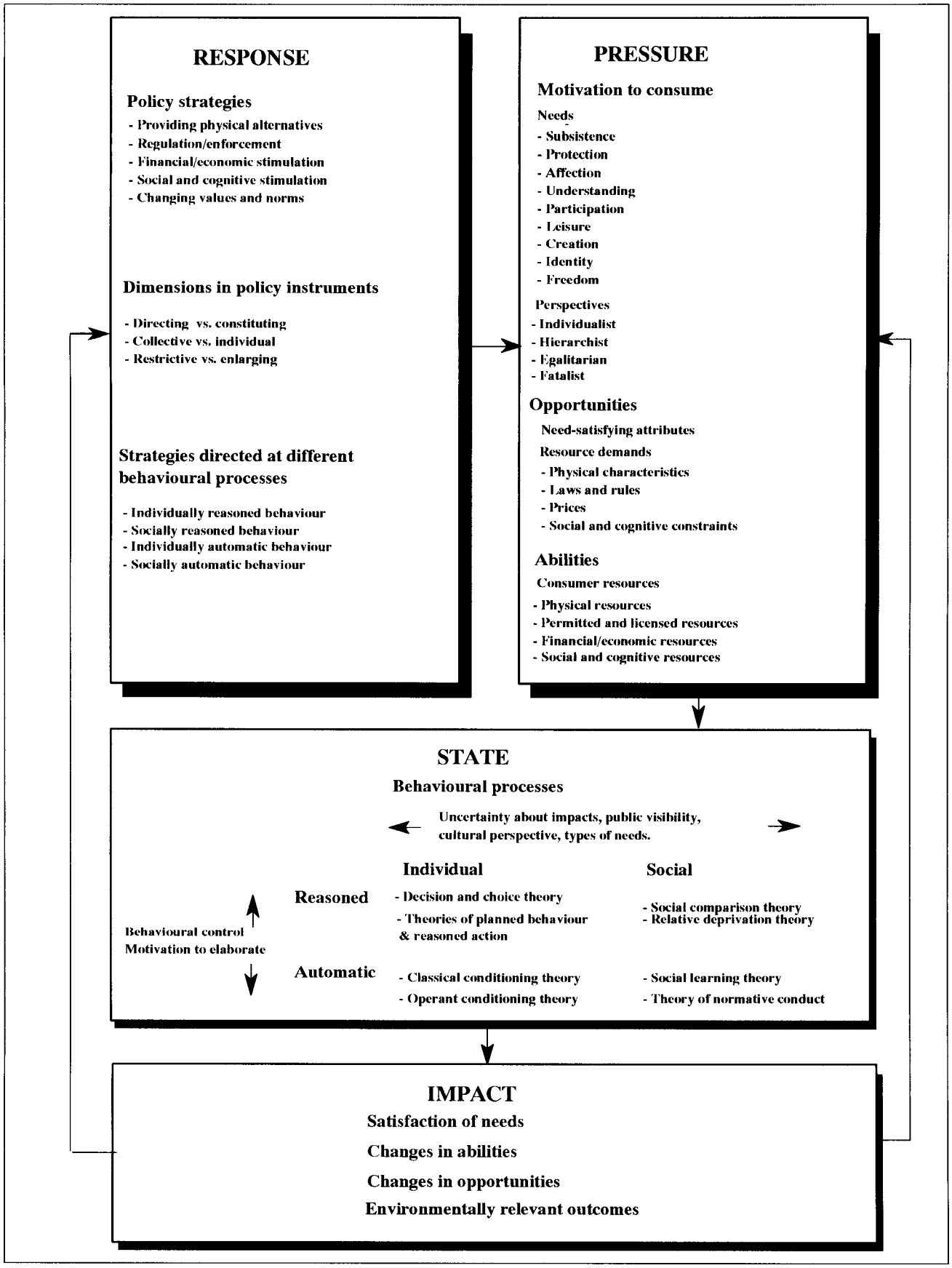


Figure 6: Schematic representation of the most important concepts in the behaviour model

4. TOWARDS A BEHAVIOUR SIMULATION MDULE

4.1 General requirements of the behaviour module

In Chapter 1 and 2 conclusions were drawn on the necessity to explicate behaviour in integrated assessment models, and in particular, the preconditions for developing a behaviour module within the framework of TARGETS. In Chapter 3 various theories of behaviour were combined in one generic behavioural model. This model will guide the development of a computer-programmed behaviour module. To be useful in a context of integrated assessment, such a behaviour module should address the processes of behaviour and behavioural change in a generic manner, e.g. irrespective of aggregational, regional and temporal differences. A generic behaviour module could be applied to many different domains of consumptive behaviour, providing information on possible developments of consumptive behaviour in a particular domain (projections) and offering a tool to experiment with various policy measures aimed at changing consumer behaviour. Consequently, a behaviour module operationalised for a particular domain should simulate the relevant behavioural processes that guide consumption in that domain, and it should provide insights on the interactions between policy measures and behavioural processes. Such a module, allowing subjects (policy-makers) to experiment with the simulation of a complex system, can be seen as a 'microworld' (e.g. Brehmer & Dörner, 1993).

The above-mentioned purposes stress the importance of comprehensive modelling of the processes that guide the developments in consumptive behaviour. Moreover, a behavioural module should also be practical. Especially in the context of integrated assessment should the module be as simple as possible. This simplicity should facilitate its practical use with respect to the incorporation of empirical data (e.g. the use of a few essential data at a high level of aggregation) and would allow for an efficient programming of the module, thus thrifting with computer processing time. However, a behavioural simulation module should capture the most important processes of consumptive behaviour, to provide insights useful for understanding consumptive behaviour and the impacts of policy measures. Stated differently, the tool must reflect the essential aspects of consumptive behaviour in order to enhance the future-projections made with integrated assessment models in a valid way. Consequently, in modelling consumptive behaviour, comprehensiveness and simplicity should be balanced.

4.2 Comprehensive yet simple: the 'meta-consumer' approach

Simulating the aggregate behaviour of consumers implies that the major behavioural processes that determine real-life consumptive behaviour are represented in a simplified form. In the process of operationalising a behavioural simulation module, the first central question pertains to the number of actors who should be modelled to capture the dynamics of consumptive behaviour. Given a specific domain of consumption, an extreme simulation would include as many actors as there are actually present in that domain. Obviously, modelling thousands or even millions of individual actors would be extremely labourious, whereas the benefits of such a fine-grained approach are not evident. Therefore, we propose to aggregate the behaviour of all those individual consumers, using an approach where groups of relatively similar consumers are represented by so-called 'meta-consumers'. A high level of aggregation, thus modelling large groups of people in a single meta-actor, contributes to the simplicity of the module, thus making its practical use more feasible. Too high a level of aggregation, however, may obstruct the simulation of the dynamics of consumptive behaviour validly, thus being unsuitable for the main purposes of the module. The question that arises is at what (high) level of aggregation we can validly model 'meta-consumers', and how many of these 'meta-consumers' we need to model without losing (to much of) the relevant dynamics of consumptive behaviour. As it is in principle possible to represent all consumers in just one meta-consumer, our central question is: 'do we need a multi-actor approach or will a single-actor approach suffice?' A single-actor approach using only one meta-actor is very appealing because of its simplicity. Because the choice between a single- and a multi-actor approach

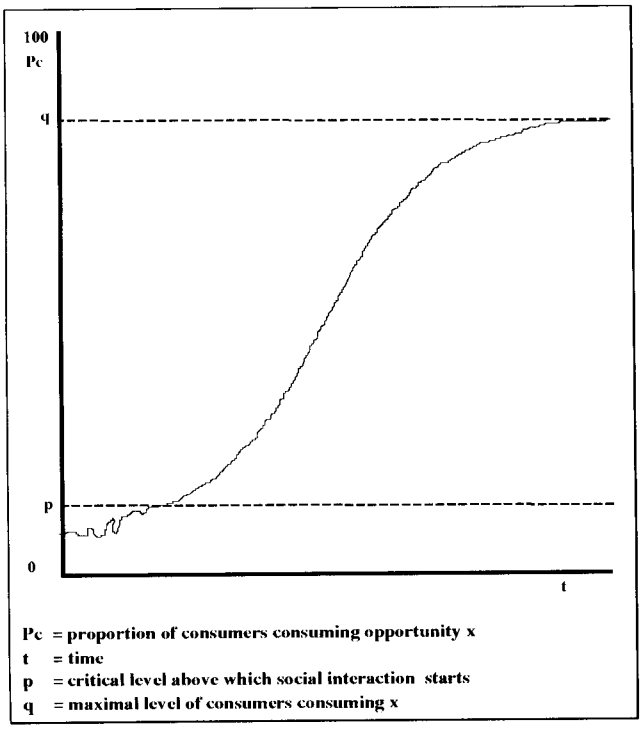
also has serious implications for the modelling techniques to be applied, we will recapitulate the arguments for making this choice. We will first elaborate on the possibilities of using such a single-actor approach in simulating consumptive behaviour.

Is a single-actor approach capable of validly simulating consumptive behaviour?

A single-actor approach, based upon the modelling of only one meta-consumer, implies the impossibility of simulating actual interactions between meta-consumers. Processes of interaction would have to be translated into a function that describes how new consumptive behaviours would spread in time through a population of consumers. As the behavioural simulation model has a generic character, such a function should be generic as well, thus being valid in most situations (domains) independent of aggregational level and time span. This approach can only be used if we may assume that all changes in consumption effectuated by social interaction can be described by the same type of curve. Figure 7 presents the typical shape of such a hypothetical curve.

If such a S-curve is generally capable of representing the social interaction processes that determine the 'trickling down' of new opportunities, three values

Figure 7: Hypothetical curve describing the level of consumption as a function of social interaction.



have to be empirically estimated. Firstly, the critical p value has to be estimated, or stated differently, it has to be estimated which proportion of consumers has to consume opportunity x before the rest will imitate that behaviour. Secondly, the q level has to be made explicit, that is, the maximal proportion of consumers that will or can use opportunity x has to be estimated. Thirdly, it has to be estimated at what speed the consumption of opportunity x will spread through the population. The estimation of each of these three values may depend on several variables, and thus may require the use of several underlying functions. It seems obvious that the p value, for example, depends on variables such as group cohesiveness, visibility of consumption and the universality of the need-satisfying capacity of the opportunity in question. If these p, q, and t values can be validly estimated, it would be possible to use a singe-actor approach in modelling consumptive behaviour.

Such a single-actor approach has some important advantages compared with a multi-actor approach. Firstly, a single-actor approach using such a function is very efficient with respect to the required programme routines and thus will be sparse with computer processing time. Secondly, such a generic function requires a relatively small amount of empirical data to describe the spreading effects of social interaction in a certain domain of consumption which would benefit its practical use. In principle, only the values of p, q and the development of Pc in time have to be estimated. This estimation of these values may involve the use of empirical data. This would also offer a perspective on the efficacy of policy measures. If the variables that determine p, q and the development of Pc are changed, this would also alter the shape of the S-curve representing the process of social interaction.

However, before trying to identify the factors that determine the values of p, q, and the development of Pc, it is necessary to elaborate on the fundamental possibilities of capturing social interaction processes by using such a single-actor approach. If we assume that all (or most) processes referring to the spreading of opportunity consumption throughout a society can be described with a S-shaped curve, the use of a single-actor approach seems justified. However, these processes are not only determined by certain variables, but these variables themselves are subject to change because of the social interaction process. Firstly, the need-satisfying capacities an opportunity has often change as a result of changing

consumption. For example, when some people start using opportunity *x* it still may be exclusive, and thus may satisfy the (individualistic) need for identity. However, the more people start to consume *x*, the less exclusive *x* becomes and the less appealing *x* will be (especially for the innovators who started consuming *x*). As such, the innovators may stop consuming a certain opportunity once it is very popular because for them the need-satisfying capacity of that opportunity has decreased. An example for northern European consumers is spending the holidays in France, which at first was only done by the elite. In more recent years a vast number of vacationers have visited France, whereas the elite have showed a tendency to visit more distant and exclusive destinations.

Secondly, the abilities demanded by an opportunity (its resource demands) often change as a result of the number of people that use that opportunity. For example, if more and more people use the same opportunity, scarcity may emerge, resulting in an increase of the price of that opportunity. On the other hand, the more people consume an opportunity, the more likely it is that suppliers (industry) react with mass production, resulting in a decrease in price. Other resource demands may also change in such processes. For example, the people who started using a new opportunity (innovators) had no behavioural examples. Consequently, they were forced to elaborate on the need-satisfying capacities of that opportunity, thus employing their cognitive abilities to a relatively large extent. However, the more people who consume that particular opportunity, the more potential consumers are confronted with behavioural examples by others. Consequently, less cognitive ability is required for using that particular opportunity consumption .

Thirdly, in most domains there are several opportunities that roughly satisfy the same needs. Examples are found in the domain of personal transportation, with opportunities such as the private car and public transportation, or the tourism domain, with a lot of different destinations and activities, and the food consumption domain, with a lot of different opportunities (types of food). Especially when several opportunities are capable of roughly satisfying the same needs (so that they are mutual substitutes), the effects of the level of consumption on the opportunity characteristics (need-satisfying capacity and required abilities) will result in a particular balance between two (or more) types of opportunity consumption. For example, suppose there are two opportunities A and B that (roughly) satisfy the same need. The more people consume A, the scarcer A becomes and the more available B becomes, and vice versa. Consequently, a certain balance will emerge between the consumption levels of A and B. Such a balance results in an 'opportunity distribution', which tends towards a distribution that (sub)optimises the outcomes of all consumers. Moreover, the need-satisfying capacity of A and B may depend on the level of consumption. For example, suppose A is commuting by car, and B is commuting by train. The more people commute by car, the slower one travels because of congestion and the more difficult it becomes to find a parking space. In this situation the train will gain attractiveness because of an abundancy of free seats. Contrary, the more people commute by train, the less attractive this travelling mode becomes because of crowding. In the meantime, driving by car will gain attractiveness because of empty roads and plenty of parking space. Opportunities that are substitutable, as demonstrated in the previous example, typically show such a balance, and not a curve like development[4]. Policy measures as well as suppliers may influence this balance.

As a consequence, in simulating the social diffusion of (new) opportunities, it would be necessary to incorporate several opportunities simultaneously in a function, whilst allowing the opportunity characteristics to constantly change as a part of the process. Moreover, such a function should be capable of simulating the balances that emerge among substitutable opportunities. Because of these complexities we have serious doubts about the mathematical possibilities of developing such a function.

At the onset of the current project, a preliminary behaviour module using a single-actor approach was developed and tested for the domain of domestic water use (see Appendix 2 for a description of this module). This exercise aimed at exploring the feasibility of modelling behaviour in terms of P-S-I-R within the context of integrated assessment. In line with the explorative character of this exercise, the relevant behavioural processes were rudimentarily

[4] This concept of balance is also a crucial aspect of real-life social dilemmas. Especially in Chicken-type dilemmas it appears that the more people make a cooperative choice, the more attractive the defective choice becomes. See also Chapter 2 under Commons dilemmas.

modelled. First experiments with this preliminary model showed the value and feasibility of such behavioural modelling. However, this preliminary behaviour module shows several omissions which can be related to the above-mentioned problems of single-actor-oriented modelling. For example, it was not possible to operationalise and simulate cognitive processing and social interaction. Consumer motivation, learning and adaptation were operationalised in a very simple manner. A good operationalisation of these processes is necessary as they form the root of many developments in consumptive behaviour, such as habit formation and the 'trickling down' of new consumptive behaviours. Therefore such a single-actor-oriented behaviour module seems less suitable for the modelling and simulation of transitions, such as the impacts of an industrialisation of India on the national consumption pattern, and the development of the transport system in Western countries. A more promising approach, especially in the context of balances or 'opportunity distributions', is based on modelling several 'meta-consumers', and letting them interact in a simulation programme. Because each individual 'meta-consumer' would use a varying number of the available opportunities (individual consumption pattern), combining the consumption of all the 'meta-consumers' would yield a distribution of opportunity consumption. In the following section the pro's and con's of such a multi-actor approach will be discussed.

Simulating consumptive behaviour using a multi-actor approach

Modelling consumptive behaviour using a multi-actor approach raises the questions: 1) at what level of genericity should the meta-consumers be modelled, and 2) how many types of meta-consumers do we need to model to attain valid simulations of a given consumtive behaviour? In answering these questions, it is essential to keep a proper balance between simplicity and comprehensiveness in mind. The following aspects have to be weighted to determine the level of genericity and the number of meta-consumer types to be modelled.

Firstly it is necessary to determine the domain which will be modelled. Evidently, modelling developments in material consumption in general for, for example, the southern hemisphere requires that meta-consumers are modelled at a higher level of aggregation than, for example, the meta-consumers in modelling personal mobility in The Netherlands.

Secondly, it is important to decide which aspects of the domain are subject of modelling. Modelling exercises may range from rough simulations of long-term developments (decades) to the simulation of the effects of a single policy measure during a relatively short period of time (months). This decision has to be made on the basis of the purposes one follows with the simulations. Developing long-term projections regarding consumptive behaviour will require a more highly aggregated type of meta-consumers than short-term projections regarding the effects of a specific intervention.

Thirdly, it is important to identify the most important characteristics of (groups of) people who determine their consumptive behaviour. Only the most important characteristics will be used to construct a limited set of meta-consumers. In an extreme case, for example, a small domain with very similar people, this would result in the construction of only one meta-consumer. In simulating consumptive behaviour, several (e.g. 50) of these equal meta-consumers can interact with each other. However, in most domains people differ very much. As such, different types of meta-consumers may be constructed in order to simulate different groups of consumers. Moreover, because the meta-consumers in a simulation will change with respect to their abilities and levels of need-satisfaction, a group of originally similar meta-consumers will quickly show a diversity, thus evolving towards a group consisting of differing meta-consumers. To start with the most relevant diversity in a simulation, we propose to start a simulation with a heterogeneous set of meta-consumers. These meta-consumers differ with respect to the relevant pressure variables. Depending on the domain to be simulated, an appropriate diagnosis should reveal the distribution of certain important pressure variables. For example, if financial ability is a crucial pressure variable, the meta-consumers in the simulation should be equipped with different financial abilities resembling the financial abilities of the population to be simulated. Following this procedure, we will try to construct a small population of meta-consumers that represent the multitude of consumers in the real world. A major advantage of this approach is that the user of such a model has the opportunity of monitoring and/or influencing a certain group of meta-consumers. For example, in modelling personal mobility in The Netherlands, one could make a general distinction between: (1) young people (< 18 yr.) without a driver's license, (2) 'middle-aged' people (18<>65 yr.) with a more than

average income, (3) 'middle-aged' people (18<>65 yr.) with a less than average income and 4) older people (>65 yr.). This would yield four types of meta-consumers. To allow for the simulation of interactions, we need a larger population than just four meta-consumers. Suppose we need 50 meta-consumers to model social processes validly, and that the proportions of the categories for The Netherlands are: (1) : 25%, (2): 31%, (3): 31% and (4): 13%. In this case we would include 12 meta-consumers of type 1, 16 meta-consumers of type 2, 15 meta-consumers of type 3 and 7 meta-consumers of type 4. Instead of leaving it at that, we can make a further distinction on the basis of another relevant variable, e.g. accessibility of public transportation. This procedure continues until we have 50 different meta-consumers that represent the Dutch population. In a simulation it would be possible to monitor the age groups separately, as well as to experiment with group-oriented policy measures.

Fourthly, a selection has to be made with respect to the opportunities to be modelled. This also addresses the question of what the purposes of the modelling exercise are. Here, too, an example may be illuminating. For modelling long-term developments in personal mobility within The Netherlands, it would seem useful to distinguish between general opportunities such as car, bike and public transportation. However, if one is interested in simulating the effects of introducing an electric car to the Dutch market, it would seem obvious that it is important to distinguish between different types of cars as well.

A fifth point refers to the incorporation of macro-developments in the simulations. Developments with respect to, for example, economy and population have to be included in the simulations. In a fully integrated assessment modelling exercise these developments are simulated by other submodels and thus interact with behavioural simulation. For example, consumptive behaviour influences economic developments, and economic developments influence the consumers' ability to consume (income). Because we intend to test and develop our simulation model first as a stand-alone model, projected developments with respect to the economy and population will be included as fixed scenarios. With respect to back-casting experiments this seems quite simple because data on past developments are usually available. For example, in simulating the developments in personal mobility in The Netherlands from the 1950s until 1990, the developments in the economy and population can be included as fixed developments in certain pressure variables. For simulations of possible future developments, existing scenarios (future projections) can be used to incorporate macro-developments in the simulations. Applying the behavioural module in a fully integrated assessment setting would imply the 'import' of such developments as they are projected by, for instance, economic and population models.

The foregoing makes a multi-actor approach sound appealing. However, such an approach, based upon the modelling of several meta-actors for the domain to be simulated, requires a multi-actor modelling technique. This modelling technique should allow for the translation of the conceptual model in a computer-programmable simulation model. In the next section, such a technique will be introduced and discussed.

Simulating the consumer behaviour of meta-consumers

In order to model processes of learning, habit formation and adaptation, the behaviour module should also incorporate processes of feedback. A system-dynamics approach is adopted, in line with the TARGETS philosophy, thus describing the behavioural process in terms of Pressures, States, Impacts and Responses (see *Figure 1*). This implies that meta-consumers have to be modelled in a framework that includes a Pressure system, describing the needs, opportunities and abilities that determine consumer behaviour, a State dynamics system, describing the behavioural process itself, an Impact system, describing the quantities of consumer goods used and changes in levels of need-satisfaction (quality-of-life), opportunities and abilities, and a Response system, describing the policy strategies to change behaviour.

Furthermore, Chapter 2 emphasised that the behavioural system includes the dynamical processes of learning and adaptation. It was concluded that theories on *complex adaptive systems (CAS)* are useful in providing a framework for the conceptual understanding of these dynamical processes. Moreover, theories on CAS form the theoretical root of several simulation techniques. As such, the principles of complex adaptive systems will be incorporated in the behaviour module.

Much of the research on complex adaptive systems is based on the development of so-called *cellular automata*. A cellular automaton can be conceived as

an abstract machine with a set of rules. This machine can be in a state, which, for example, can be visualised by means of a colour (e.g. green is high in energy, red is low). The machine can exist in only one state at the time, and there is a limited number of possible states. In computational experiments a group of such machines are positioned in a matrix that constitutes a 'virtual world'. Every time-step results in a new state, depending on the previous state and the state of the neighbouring machines. The 'natural laws' in this universe are the rules which describe the conditions for a change of state. Von Neuman (1966) proved that such machines are capable of self-reproduction.

In computational studies on cellular automata four types of 'behaviour' emerged, depending on the degree to which information could move freely in communications or be retained in a message structure (Langton *et al.*, 1992). These four types of behaviour are:

- Stable forms, resulting from a frozen regime where structures exist but information cannot be transmitted;
- Periodic forms, which can show periodic motion but cannot change. An analogy is made with a somewhat more flexible regime where behaviour is seen as crystal growth;
- Complex forms, where information is both stable enough to support a message structure and loose enough to transmit messages;
- Chaotic forms, where information moves so freely that its structure cannot be maintained; the regime is too chaotic to support life.

Computational experiments revealed that in Langton's (1992) model the types of computational process that might permit artificial life were just on the ordered 'edge of chaos'. Many researchers in different fields (see, e.g., Waldrop, 1992) found such classes of behaviour, where, in particular, complex forms of behaviour show processes of self organisation, adaptation, evolution and exploration. These processes seem to touch upon some essential aspects of life. Moreover, in computational research a tendency was found that both chaotic and stable/periodic forms moved towards complex forms of behaviour.

The cellular automata approach provides a fruitful paradigm for the exploration and simulation of complex adaptive systems. Further research has concentrated on various rules of cellular automata. For example, virtual food was introduced (e.g. Sugarscape: Epstein & Axtell, 1995), and the amounts of food a machine gathered determined its fitness (state) and the related chance of replication (offspring). Furthermore, *genetic algorithms* (GAs) were introduced to describe the mathematics of striving towards solutions with a higher fitness. Originating from biology, GAs describe the evolutionary processes of how species adapt towards changing environments. As GAs can be computer-programmed, they are useful to simulate scenarios of possible developments in complex dynamic situations (e.g. Holland *et al.*, 1986; Holland, 1992; Janssen, 1996). GA's allow the development (or evolutionary growth) of new behaviour by using the mathematical equivalents of crossing-over and mutation.

To simulate the behaviour of a meta-consumer, the behavioural rules which can be derived from the conceptual model should determine the changes of state of a cellular automaton. Such a cellular automaton equipped with behavioural rules will be named *'consumat'*. The consumat will be used as a modelling tool for the multiple actor simulation of consumptive behaviour. The basic set-up of every consumat comprises a set of rules derived from the conceptual behavioural model (Chapter 2). However, the consumats differ with respect to their levels of need-satisfaction and abilities, and will be confronted with a set of different opportunities.

Referring to the previous example of personal mobility in The Netherlands, it is conceivable that the meta-consumers will be translated into a set of consumats that have different levels of need-satisfaction and abilities. The consumats will be confronted with a given set of virtual opportunities, which in this case represent modes of transportation (car, bike, train, etc.). These opportunities differ with respect to the needs they (may) fulfil, and the resources that are required to use them. Each time-step in the behaviour simulation comprises a full P-S-I-R cycle. That is, the driving forces underlying consumer behaviour will be assessed in the Pressure system; the resulting behavioural process will be represented in the State system; the outcomes of the behaviour will be presented in the Impact system and policy instruments will be represented in the Response system. The next time-step in the behaviour simulation starts with the assessment of the new (changed) Pressure system. This new Pressure system incorporates the impacts (i.e. actual consumption) and the effects of policy instruments as designated in the previous time-step. As such,

these impacts and policy instruments will feed back to the driving forces (pressures) underlying the simulated consumer behaviour. A subsequent report (Jager, Janssen & De Greef, in preparation) will present an operational behavioural model including the behavioural rules for the consumat and will present and discuss a series of simulations for the domain of person transportation in The Netherlands.

5. CONCLUSIONS AND FUTURE RESEARCH

This chapter will, first, recapitulate the advances which have been made in the development of a conceptual behaviour model. The second section will discuss the topics requiring further research within the behaviour modelling project.

5.1 Conclusions and recapitulation: where are we now?

A sophisticated version of a conceptual behaviour model is presented in this report. This version has been used to develop a preliminary version of a behaviour module for domestic use of fresh water (Appendix 2). Experiments with this preliminary behaviour module have provided more sophisticated projections on future water use by consumers, and offered a more comprehensive view on the feasibility and effectiveness of strategies for behavioural change than the implicit modelling of behaviour in the AQUA-module. Despite the first positive practical results of this behaviour module, its preliminary character does not allow for more sophisticated projections of consumer behaviour. For this reason the behaviour *model* developed in this report is being translated into a more comprehensive conceptual behaviour *module* (see Chapter 4), which will guide the computer programming of consumptive behaviour in integrated assessment models. Compared with existing behaviour models, the main advantages of the current conceptual behaviour model are:

- The system-dynamical approach, describing behavioural processes, including feedbacks, in terms of Pressures, State, Impacts and Responses;
- The incorporation of a complex-adaptive systems approach, allowing for the simulation of learning and adaptation using a cellular-automata structure;
- The inclusion of both 'reasoned' and 'automatic' (habitual) processing of information, as well as individual and social processing of information, employing a comprehensive behaviour-theoretical framework (See Section 3.3, Table 4);
- Its generic character, allowing for implementation in different domains of consumptive behaviour, for different environmental issues and on different levels of analysis;
- The integrative approach, aimed to allow linkage of the conceptual behaviour module to specific issue-oriented models. With respect to TARGETS, this integration deals with the 'import' of developments as projected by other TARGETS modules, and the 'export' of information on human consumption levels. Although the possibilities for such an integration have yet to be assessed, the conceptual framework has been explicitly designed to allow for such an integration;
- The consistent use of behavioural concepts, providing a theoretical framework that facilitates the translation into a computer-programmed behaviour module.

5.2 Subsequent research: where do we go from here?

The operationalisation and testing of the behaviour module will be the prime objectives in the subsequent stages of the behaviour project. Chapter 4 presented a perspective on the possibilities to operationalise the conceptual behaviour model into a computer-programmed behaviour *module* simulating several 'consumats' using various opportunities. The development of such a computer-programmed behaviour module requires the translation of theoretical knowledge into computer-programmable rules. Currently, a preliminary module incorporating only 2 types of needs, 2 types of opportunities and 100 consumats has been operationalised. This version does not include explicit cognitive processing. The rules applying to the consumats and opportunities are written in C++, and the developments on the number of opportunities, level of need satisfaction et cetera are presented using a graphical interface, named "M" (De Bruin *et al.*, 1996). Development of this module, in spite of its simplicity, has been helpful in exploring the difficulties one faces in operationalising the conceptual model. Thus far this modelling approach seems viable. Therefore we will proceed with the operationalisation of the behaviour module, the translation of the conceptual behavioural model (Chapter 3) into a computer-programmed module.

In testing the behaviour module, relevant empirical data have to be translated into the behaviour module. Such a translation of domain-specific empirical data

would allow for the development of tailor-made behaviour modules for different domains of consumptive behaviour. Several types of data are required. Below, a preliminary listing is presented of variables and data collection methods:

- Satisfaction of needs. Methods to estimate the satisfaction of needs are currently in development (Max-Neef, 1992), and research on the assessment of quality-of-life may produce methods for collecting empirical data.
- Actor resources. Empirical (statistical) data are available in large quantities via governmental institutions, the United Nations and the World Bank. For example, data on income, education, licences, health, et cetera are available. These data can also be classified according to many actor attributes, such as age, socio-economic status, region, et cetera.
- Opportunity resource demands. Some data may be available in existing literature and in data provided by producers, e.g., data on prices, knowledge required, licenses et cetera. Other data may be obtained by letting consumers estimate these data (explorative empirical research). These data are required to include valid opportunities in the simulations.
- The effects of policy instruments on actor resources and opportunity demands on resources. Domain experts (policy-makers and scientists) may estimate these effects. Various procedures, e.g. a Delphi-like procedure, for conducting such an estimation process may be used.

Such empirical data will be represented in a simplified manner in the behaviour module. Nevertheless, including such empirical data provides a more valid basis for simulating the dynamics of consumptive behaviour and the effectiveness of policy measures.

The first 'real-life' domain selected for operationalisation in a behaviour module is personal transportation in The Netherlands. The choice of simulating this domain is based on (1) the expertise we have in our (psychology) research group with respect to this subject, (2) the availability of (historically) relevant data, and (3) the environmental, economic and thus political relevance of this domain. As such, this domain appears to be suitable for use as a test case in the further development of the behavioural module.

If the simulation of personal transportation in The Netherlands results in a satisfactory behaviour module, the challenge shifts towards the operationalisation of other domains of human consumption. The domains for which consumptive behaviour will be modelled are in line with the domains as discerned in TARGETS. Such domain-specific behaviour modules have to be developed for the use in integrated assessment modelling, e.g. a nesting of domain-related behaviour modules in corresponding TARGETS submodels.

Experiments aimed at testing the internal consistency will be geared firstly to the stand-alone versions of the different behaviour modules for the various TARGETS submodels, and will guide the calibration of the behaviour modules. Secondly, the behaviour modules will be integrated within the other TARGETS models. Experiments here will be aimed at (1): developing projections of consumption levels, (2): simulating behavioural substitution processes, and (3): testing the efficacy of various policy measures and strategies. These experiments include back-casting tests to calibrate the model, comparing simulations of the period 1900 - 1995 with historical developments, as well as forecasting, and thus developing projections for the 1995 - 2100 period. Finally, experiments will be run with the complete TARGETS framework, including the behaviour modules.

Recapitulating, the following research activities are planned for the behaviour project:

- Programming a generic behaviour module;
- Developing and experimenting with domain-specific behaviour modules, starting with personal transportation in The Netherlands;
- Experimenting with the integration of domain-specific behaviour modules within stand-alone versions of the TARGETS submodels;
- Experimenting with the complete TARGETS framework, including several different behaviour modules.

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APPENDIX 1: EXEMPLARY MODELS FOR BEHAVIOUR HAVING ENVIRONMENTAL IMPACTS

In this appendix six representative behavioural models are graphically presented and briefly characterised with respect to (1) the domains/stages of a product life-cycle captured in the model, (2) the theories and behavioural mechanisms incorporated in the model, (3) the empirical validation of the model, (4) the level of genericity of the model, (5) the behavioural determinants identified in the model, (6) the type of actor(s) which are modelled and (7) the strategies for behavioural change incorporated in the model.

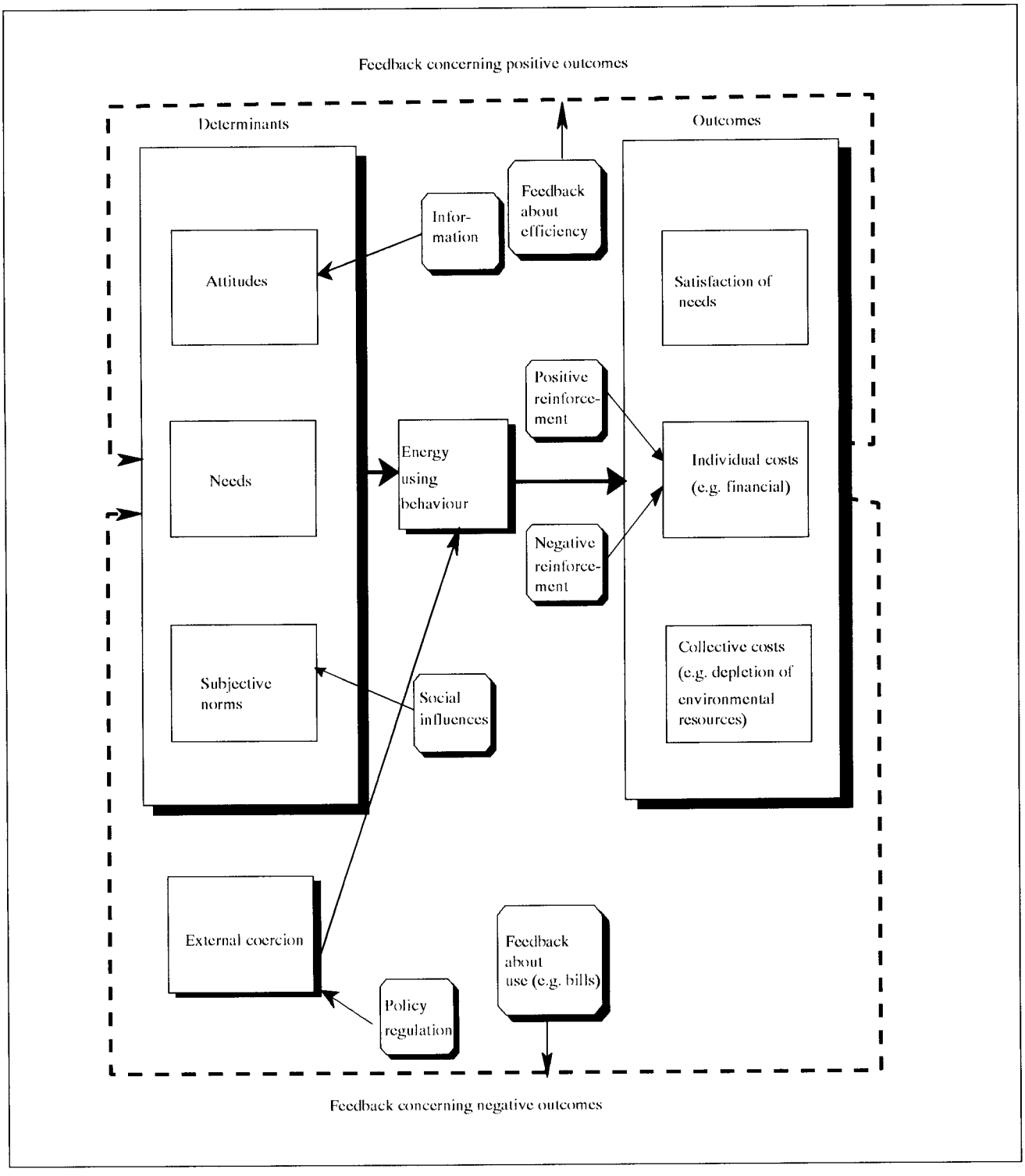

Figure A: Model of Midden, Weenig, Houwen, Meter, Westerterp & Zieverink (1982).

Description of the model of Midden, Weenig, Houwen, Meter, Westerterp & Zieverink (1982)

a: *Domain/stage of product life-cycle*
The model describes energy consumption in general.

b: *Included theories and behavioural mechanisms*
Theories on attitudes, motivation, social comparison and learning.

c: *Empirical validation*
The model serves to schematise several relevant factors. The model has not been empirically validated.

d: *Genericity*
Generic with respect to energy consumptive behaviour.

e: *Behavioural determinants identified in the model*
Actor determinants:
Attitudes, needs and subjective norms
Situational determinants:
Information, social interaction, external constraints, feedback and financial stimulation.

f: *Type of actor*(s)
Individuals.

g: *Strategies for behavioural change*
Financial economic, feedback on level of electricity use and efficiency, information, social interaction and governmental prescriptions.

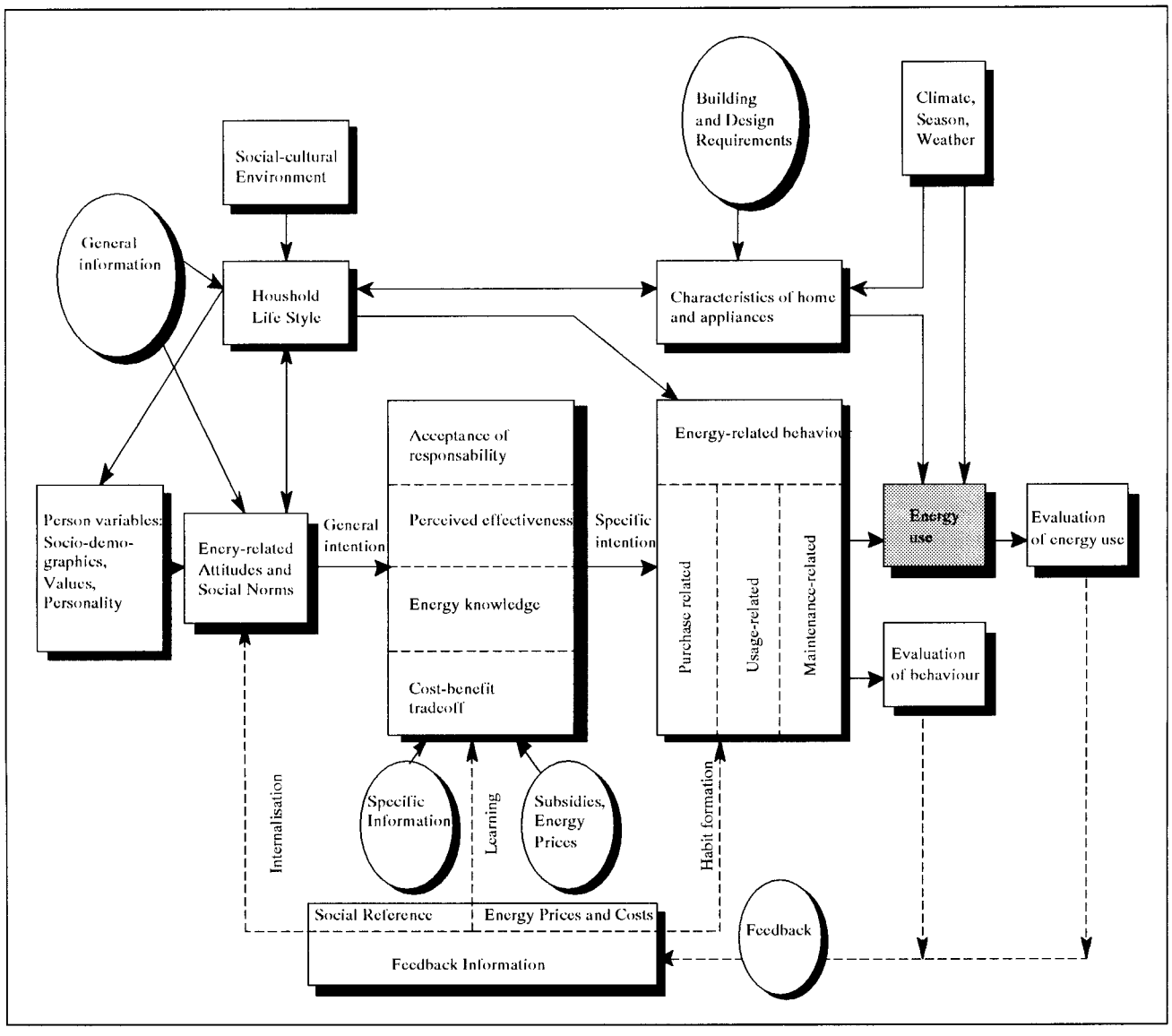

Figure B: Model of Van Raay & Verhallen (1983).

Description of the model of Van Raay & Verhallen (1983).

a: *Domain/stage of product life-cycle*
Domestic energy consumption, including the purchase, use and maintenance of appliances. The model focuses on behavioural aspects.

b: *Included theories and behavioural mechanisms*
Theories on attitudes, habits (life-style), behaviour with respect to purchase, use and maintenance, reasoned behaviour (cost-benefit analysis), social comparison (socio-cultural environment).

c: *Empirical validation*
The relationships in the model are empirically validated. The factors that determine domestic energy consumption were derived from a survey of relevant literature.

d: *Genericity*
The model is focussed at the domain of energy consumption.

e: *Behavioural determinants identified in the model*
Actor determinants:
Personal characteristics such as socio-demographic factors and personality, habits (life-style), attitudes and social norms with respect to the use of energy, general intentions, responsibility, perceived efficacy, knowledge on energy and specific intentions to conserve energy.
Situational determinants:
The socio cultural environment, available information (both common and specific), energy costs, subsidies, regulations regarding the design of a building, characteristics of the building and appliances, climate, season and weather conditions.

f: *Type of actor*(s)
Individual actors as part of a household in a socio-cultural environment.

g: *Strategies for behavioural change*
Evaluation of behaviour, information on using and maintaining devices, providing specific information on the conservation of energy, changing relevant characteristics aimed at changing the outcomes of a cost-benefit analysis, providing information aimed at a attitudinal change, direct behavioural change using recommendations, prompts, feedback and the improvement of the building.

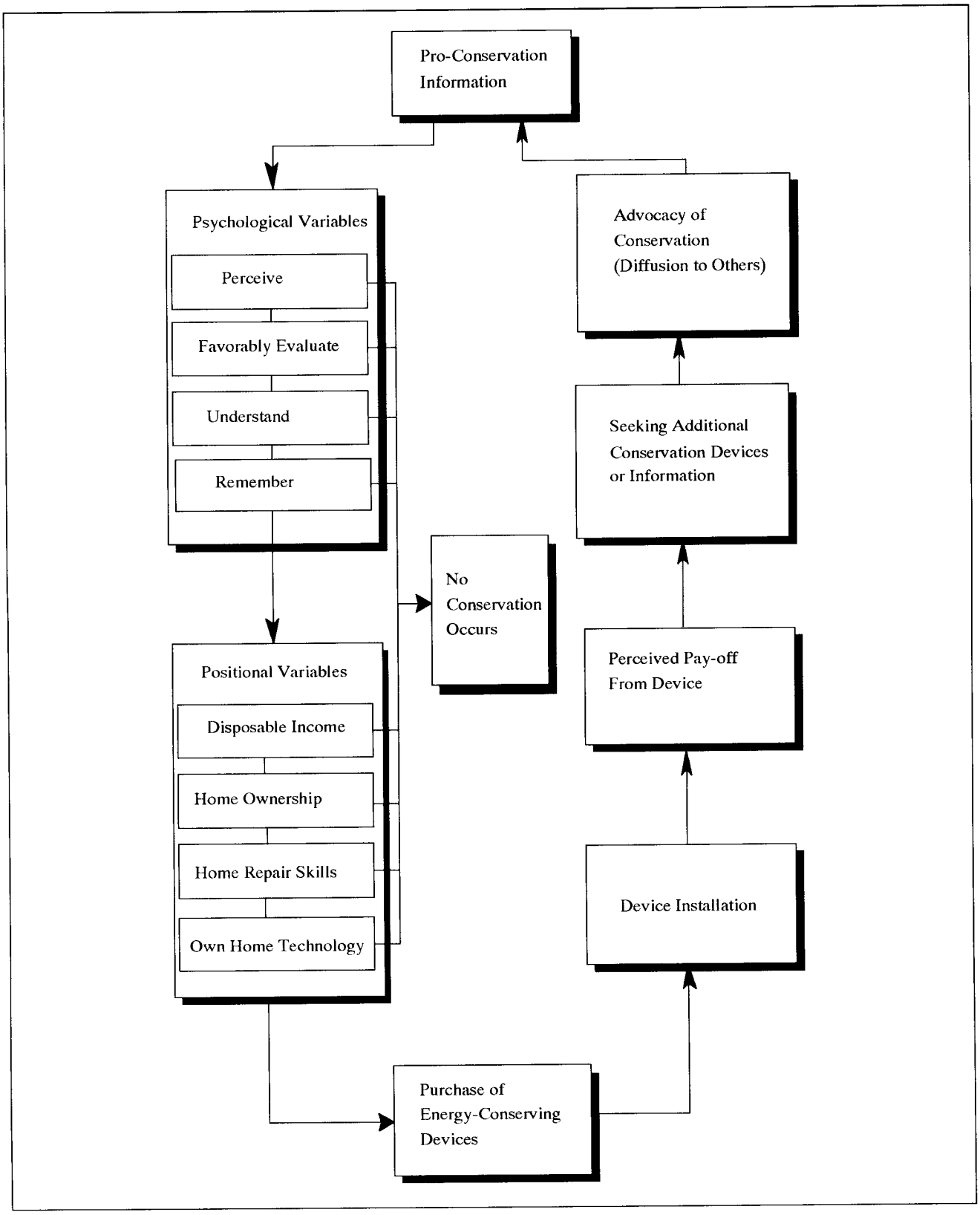

Figure C: Model of Costanzo, Archer, Aronson & Pettigrew (1986).

Description of the model of Costanzo, Archer, Aronson & Pettigrew (1986).

a: *Domain/stage of product life-cycle*
Energy conservation in general

b: *Included theories and behavioural mechanisms*
Theories on attitudes and decision theory.

c: *Empirical validation*
Theoretical model lacking empirical validation.

d: *Genericity*
Behaviour with respect to the conservation of energy.

e: *Behavioural determinants identified in the model*
Actor determinants:
Perception, appraisal, understanding and recollecting behavioural opportunities, demographical characteristics and technical skills.
Situational determinants:
Available technology and the remunerativeness of investments (pay-off).

f: *Type of actor*(s)
Individuals including their relations.

g: *Strategies for behavioural change*
Information (persuasive, mass-media), technical options, social diffusion (social networks), financial economical stimulation.

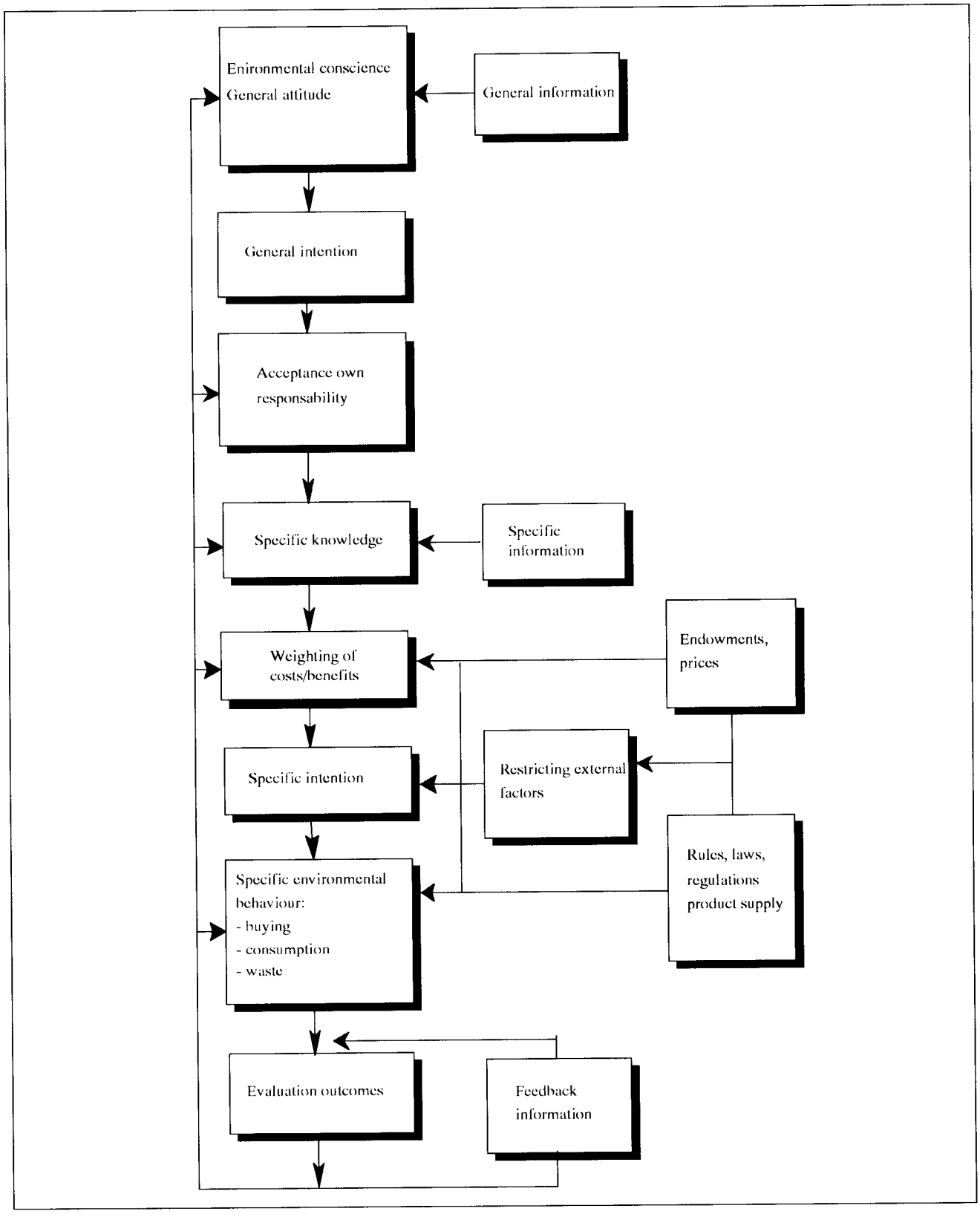

Figure D: Model of Rosendaal & Poiesz (1987)

Description of the model of Rosendaal & Poiesz (1987)

a: *Domain/stage of product life-cycle*
Consumer behaviour.

b: *Included theories and behavioural mechanisms*
Theories on attitudes, decision theory and habits.

c: *Empirical validation*
The model is based on a more generic behavioural model describing the behavioural determinants as identified in the literature. Empirical validation is lacking.

d: *Genericity*
The model can be used to diagnose environmentally relevant behaviour.

e: *Behavioural determinants identified in the model*
Actor determinants:
Attitudes, general intention, responsibility, available knowledge, costs-benefits analysis, specific intentions and evaluations of behaviour.
Situational determinants:
Provided and/or available general and specific information, financial economical stimulation, regulation and enforcement, behavioural options and feedback.

f: *Type of actor*(s)
Individual consumers.

g: *Strategies for behavioural change*
Information, financial economical stimulation, regulation and enforcement, developing new behavioural opportunities.

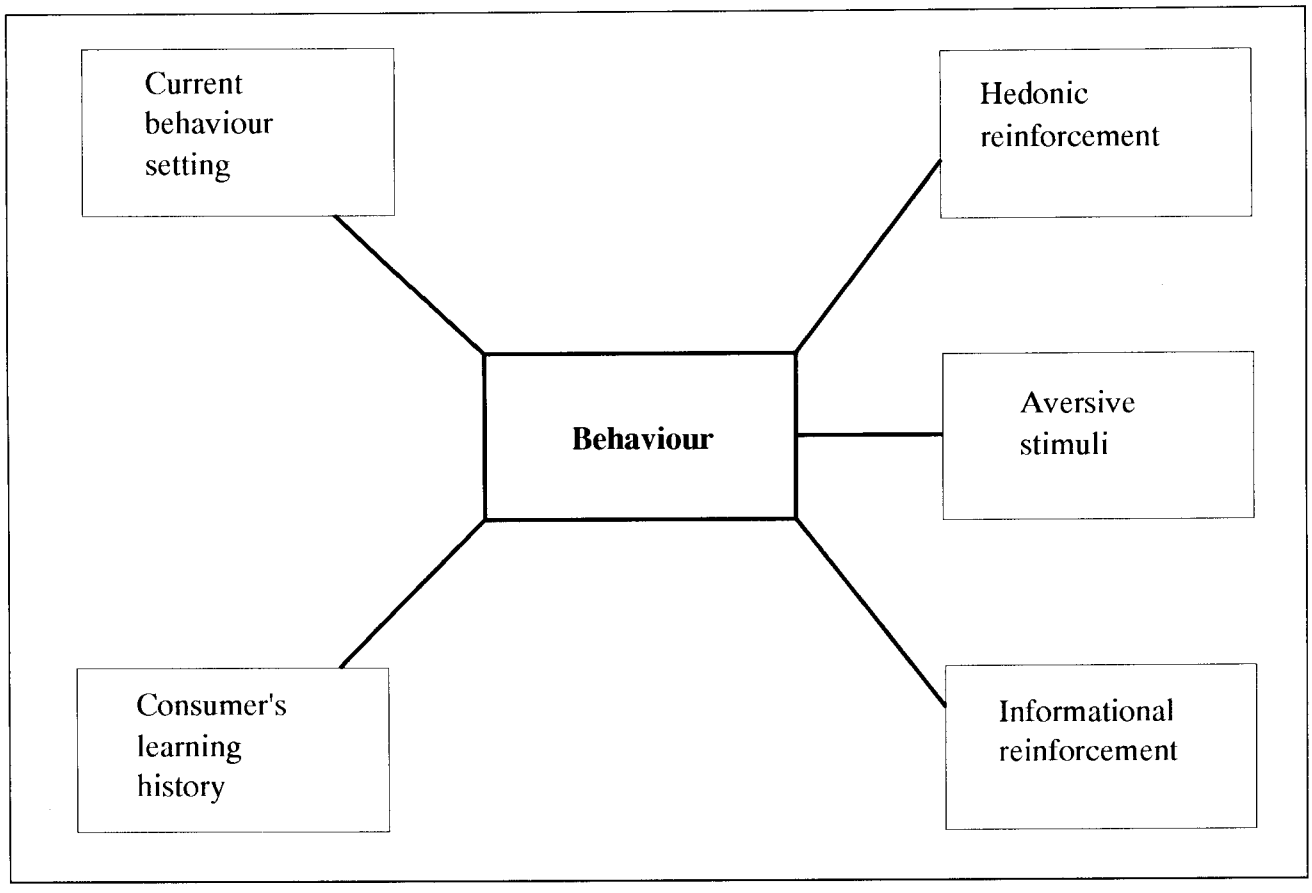

Figure E: The Behavioral Perspective Model of purchase and consumption (Foxall, 1994).

Description of the Behavioral Perspective Model of purchase and consumption (Foxall, 1994).

a: *Domain/stage of product life-cycle*
Consumer behaviour.

b: *Included theories and behavioural mechanisms*
Behaviouristic approach, assuming that reinforcements and punishments affect consumers' learning history.

c: *Empirical validation*
The model serves as a diagnostic framework, and has not been empirically validated.

d: *Genericity*
The model is a diagnostic framework that is aimed at describing all consumer behaviour.

e: *Behavioural determinants identified in the model*
Actor determinants:
Learning history, personal variables, level of satisfaction/deprivation, ability to pay.
Situational determinants:
Behaviour setting, viz. physical and social discriminative stimuli, verbal rules.

f: *Type of actor*(s)
Individual consumers.

g: *Strategies for behavioural change*
Not explicitly accounted for in the model, however, the focus is placed on changing the relevant reinforcement schedule, e.g. by means of prompts, feedback and incentives.

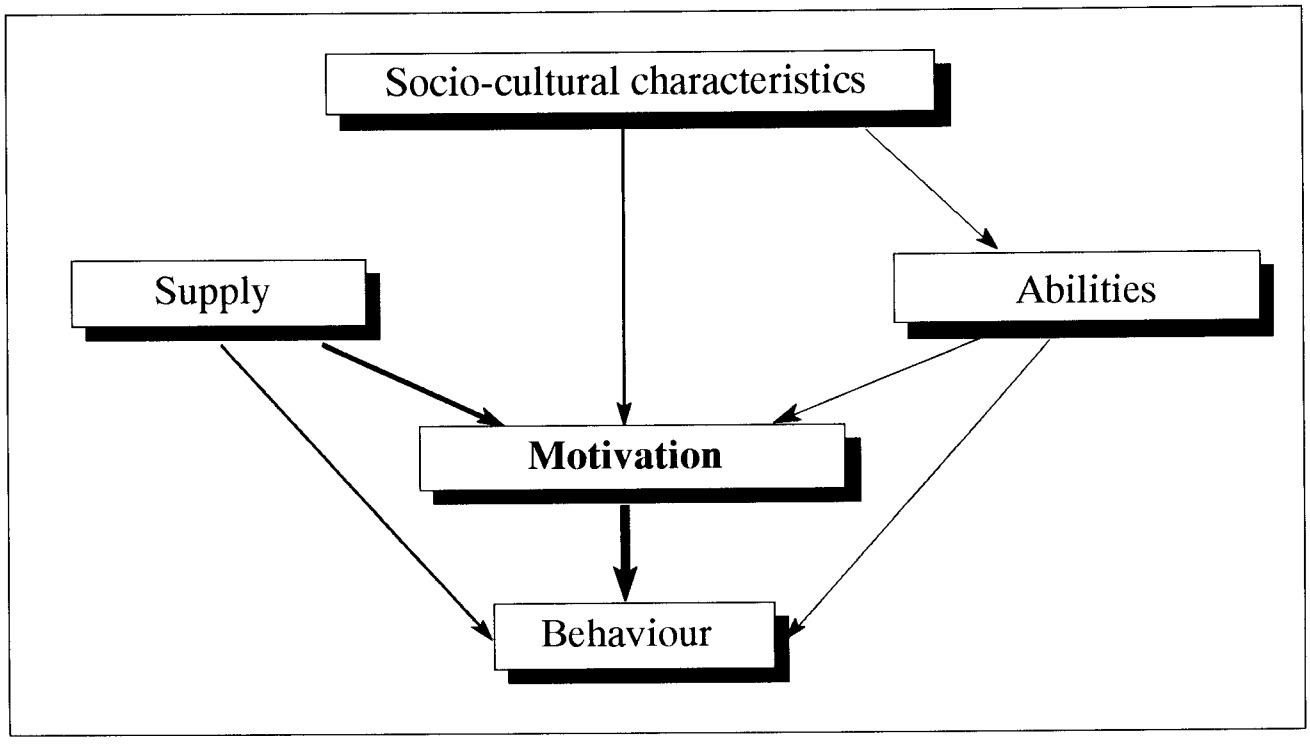

Figure F: Model of Social Cultural Planning Office (1996)

Description of the model of the Social Cultural Planning Office (1996)

a: *Domain/stage of product life-cycle*
Consumer behaviour.

b: *Included theories and behavioural mechanisms*
Theory on motivation, opportunity and ability (MOA-model).

c: *Empirical validation*
The theoretical model is used to select behaviour determining factors in diagnosing a specific domain. The model itself has not been empirically validated.

d: *Genericity*
The model can be used to diagnose environmental relevant behaviour.

e: *Behavioural determinants identified in the model*
Actor determinants:
Socio-cultural characteristics, abilities, motivation.
Situational determinants:
Supply.

f: *Type of actor*(s)
Individual consumers.

g: *Strategies for behavioural change*
Not explicitly included in the model.

APPENDIX 2: A CASE STUDY OF CONSUMER BEHAVIOUR: DOMESTIV WATER USE IN THE NETHERLANDS

M.B.A. van Asselt & P. Costerman Boodt

1 Introduction

Simulation models of behaviour are rarely employed for practical purposes (see also Chapter 1). Most social scientific models are static or conceptual in nature. To outline the problems associated with simplification and quantification, and to assess the additional value of simulation models as compared to more qualitative methods, we employed a simple prototypical version of the behaviour module to the small domain of domestic water use by consumers in the Netherlands. This case-study should be regarded as an exploratory exercise, which merely serves as an illustrative device. As any model, the behaviour module should consist of elements which can be traced back to observable entities, which are in principle measurable. One of the main aims of this exercise is to explore how the conceptual notions and entities as identified in Chapter 2 can be associated with measurable quantities to arrive at applications of the behaviour module which can, in principle, be calibrated and validated against empirical observations. In this regard, the case-study enables us to identify obstacles which can be expected when implementing the conceptual structure into a simulation framework such as TARGETS.

In line with our aim to implement a behaviour module to render implicit assumptions on consumer behaviour explicitly, we have chosen to take one of the domains comprised in TARGETS 1.0 as field of investigation. For example, in AQUA (Hoekstra, 1995) domestic water demand is modelled as a function of technological and financial factors, leaving the behavioral dimension unaddressed, and thus AQUA does not comprise adequate levers for policy measures for behavioural change. Domestic water demand is simply represented by the price elasticity mechanism. In principle, a module addressing the behavioural dimension of water use by consumers can be implemented within the AQUA framework (see Figures 2 and 3). Taking into account that we have access to the CPB and SCP databases comprising monitoring data on water consumption in the Netherlands, we can therefore propose a case study for the behaviour module concerning water use by Dutch consumers.

We do not pretend that the case-study presented in this chapter fully covers the behavioural dimension of water demand and use by consumers, but we do consider the attempt to translate the theoretical notions into quantities and mathematical relationships as a manner to evaluate the feasibility of modelling consumer behaviour within the context of integrated assessment of global change. In other words, the example and the associated exploratory model results should be regarded as illustrative and discussion material to enhance collaboration between social scientists and the modelling community.

2 Model description

The generic conceptual structure of a behaviour module is presented in the previous chapters. Following the P-S-I-R approach, the main subsystems can be summarised as follows:
1) The *pressure system* describing the driving forces behind domestic water use by consumers.
2) The *state system* simulating the behavioural processes preceding domestic water use, resulting in a distribution of options.
3) The *impact system* describing the outcomes of the behavioural process, defined here (in a limited manner) as the total amount of domestic water used by consumers.
4) The *response system* representing policy strategies, instruments and measures to influence the total amount of domestic water used by consumers.

The largest amount of water used by consumers cannot be attributed to individual persons, due to the fact that most of the water is used within households for functions such as cleaning or washing clothes (Groenen *et al.*, 1994). In line with this, data on water use is usually available in terms of 'm^3 per household' (DBO, 1992; CBS, 1992). 'Household' can therefore be considered as a plausible entity of analysis. We adopted the definition of households used by Groenen *et al.* (1994), in which persons below the age of 18 are considered to be part of their parent households, while persons above 18 are considered to form a household of their own. The following sections describe successively the pressure system, the state system, the impact system and the response system in more detail.

2.1. The PRESSURE system

Chapter 2 identifies three clusters of pressures, namely, motivations, opportunities and abilities. So-called macro-level variables (see section 2.2) partly influence these driving forces. If a behaviour module is implemented within the TARGETS framework, such background variables are generally imported from other submodels in TARGETS. In the stand-alone prototype version described in the present sections, developments in the economy, population and relevant socio-demographical factors are derived from SCP and CBS (e.g. DBO, 1992; CBS, 1992).

Motivation
Applied to water use, motivation as conceptualised in section 2.2 is interpreted as the motivation of households to be thriftly modest in using clean fresh water. In line with the argument made in Chapter 2, variations in motivation are related to differences in cultural perspective. To take account of the heterogeneity of motivations, at least to a certain extent, we used the four perspectives as expounded in the cultural theory (see Chapter 2 for a more detailed discussion) as heuristic to characterise the cultural composition of the population. The four perspectives derived from Cultural Theory are the hierarchist, the egalitarian, the individualist and the fatalist.

Concomitant with their general need-reducing strategy, egalitarians are seriously motivated to be thriftly with water. In line with the individualistic strategy to increase needs and resources, individualists are in principle not intrinsically motivated to reduce their water consumption. Concomitant with the hierarchistic driving force of stability, when potential limits to present and future water availability are observed, hierarchists are to some extent motivated to display water-saving behaviour. Fatalists cannot be ascribed any particular motivation.

The next step involves translation of those qualitative notions into mathematical terms. We chose to represent motivation as a quantity on a scale of 0 to 1, where 0 signifies no motivation at all to be modest with water, while 1 signifies high motivation. High motivation is associated with the egalitarian perspective, while the individualistic perspective is ascribed the value of 0. Translation of the hierarchistic motivation is more problematic, but is for the sake of simplicity considered to be 0.5. We assume the fatalist motivation to be random, which in technical terms means that the associated value varies randomly between 0 and 1.

Furthermore, we need to estimate the distribution of cultural perspectives among the total population. In the absence of empirical data allowing comparison between the cultural characteristics of single persons and family households, we assume that the distribution of perspectives do not vary with the type of household. Longitudinal data on the cultural characteristics of particular populations are hardly available. Hofstede's work (1990) can be considered as one of the rare attempts to classify nations according to the typology as proposed in cultural theory. Concomitant with his characterisation of the Dutch society we assume the following distribution: 30% of the households has a hierarchistic perspective, 30% an egalitarian perspective, 20% an individualistic perspective and 20% a fatalistic perspective.

Under certain circumstances, such as long-lasting budget constraints or policy measures, the perspective of a household is likely to change. We have implemented a simple straightforward 'learning' mechanism, which assumes motivation adjustment where the household is continuously confronted with budget constraints lasting five years.

As stated in section 2.2, motivation can in principle be altered by policy measures. In line with general theory as outlined before, social and cognitive stimulation is considered to be the primary strategy. We have implemented the effect of social and cognitive stimulation in terms of evoking and influencing transitions from households to more highly motivated perspectives. Dependent on the policy effort, we assume that hierarchists move to the egalitarian perspective, while fatalists and individualists gradually move to the hierarchistic perspective. We assume that in the event of maximum policy effort at a particular point in time, 50% of the hierarchists move to the egalitarian perspective, and 20% of the fatalists and 50% of the individualists move, respectively, to the hierarchistic perspective.

Opportunities

Opportunity is concerned with the availability or services one can use to fulfil needs. In the context of water use by consumers, needs can be described in terms of water use functions. In the Netherlands, the following water-use functions are generally distinguished: disposal, hygiene, laundering, food preparation, drinking, dish washing, et cetera (Van Vliet, 1995; Fonk & Schep, 1989). Opportunities then describe the characteristics of the options which can be used to fulfil those functions. As sketched in Chapter 2, the available opportunities can be described in many dimensions. In line with our aim to relate consumer behaviour to human-induced pressure on the environment, we have decided to focus on the degree of impact on the environment, i.e. the amount of litres of water associated with each particular option. The high level of abstraction does not allow us to describe the opportunities in terms of single options such as the water-saving showerhead or the time period associated with a shower. For reasons of simplicity, we have chosen to aggregate singular options into two categories: water-intensive and water-saving options. By 'intensive' options we refer to a non-restrictive consumer behaviour to satisfy one's needs, while 'saving' options consist of those options which require a minimum amount of water to meet one's needs sufficiently. Considering our aim to offer levers for policy-induced changes in behaviour, it is a serious omission to not distinguishe between technical options and behavioural options.

The water-intensive and water-saving option is described for each function in terms of litres of water per year, where we used the estimates given by Van Vliet (1995) (see Table 1) to arrive at estimates for the period 1900-1990.

Table 1: Litres of water per day per household per function for intensive options and saving option, values based on 1992 data. (Source: Van Vliet, 1995).

Water use functions:	Water-intensive option	Water-saving option
disposal	118	25.8
hygienic	43.4	30.7
laundering	35.0	13.8
food and drink	2.6	1.9
cleaning dishes	17.6	11.4
other	3.3	3.3

The assumed autonomous trends represented in Table 2a and 2b signify primarily technological developments in water-use equipment. For the first half of the century we see an increase due to the fact that new technological opportunities require more water (compare washing the dishes and the use of an automatic dishwasher), while technological improvements in the second half of the century are assumed to result in equipment which use less water to fulfil similar functions.

Due to the fact that prices associated with the opportunities are left out in this exploratory case study, which we recognize as a significant omission, we assume that the amount of water associated with the different options is the main decision-making criterium in the behaviour process. We fully admit that this one-dimensional approach is too simplistic in its representation of consumer behaviour processes. A following study will require extensive elaboration of how to translate multi-dimensional characteristics of opportunities into quantitative and measurable entities.

In our application to water use by consumers, opportunities furthermore comprise the price of water. The estimates used are derived from Hoekstra (1995) (see Table 3).

Opportunities can in principle be altered by policy measures. The future price, for example, can be influenced by water pricing-policy. Water pricing is therefore implemented as response option in our case-study model, where we assume that the water price established by politicians will overrule the market-induced water price as represented in the exogenous trends. Section 3.5 distinguishes four policy strategies to change the determinants of behaviour. With regard to the opportunities distinguished in this section, the provision of physical alternatives, and regulation and enforcement, are considered to be the most relevant. In the case of water consumption, physical arrangements comprise for example the supply of new water-

Table 2a: Assumed litres of water per day per household per function for intensive options

Water use functions:	1900	1950	1990	2100
disposal	5	80	118	118
hygienic	15	25	43.4	43.4
laundring	10	15	35	35
food and drink	5	3	2.6	2.6
cleaning dishes	5	8	17.6	17.6
other	1	2	3.3	3.3

Table 2b: Assumed litres of water per day per household per function for saving options

Water use functions:	1900	1950	1990	2100
disposal	5	50	25.8	25.8
hygienic	10	15	30.7	30.7
laundring	8	10	13.8	13.8
food and drink	4	3	1.9	1.9
cleaning dishes	4	6	11.4	11.4
other	1	2	3.3	3.3

Table 3: Trends in water price (Based on Hoekstra, 1995)

Year	Water price per 1000 litres in $
1900	0.10
1989	1.27
1992	1.45
2100	1.45

saving alternatives, where regulation, for example, comprises building instructions such as the distance between the connection to the public waterworks and taps. We assume that physical arrangements together with regulation will, with a delay of about 10 years, decrease the required litres of water associated with the different opportunities. In the case of water-saving options a reduction of 50% of the difference between water-saving and water-intensive options is assumed to be possible in the event of maximum efforts into the provision of alternatives and regulation. For water-intensive options, a reduction of 20% on the autonomous trend is considered to be attainable.

Abilities

Ability is concerned with the skills and capacities one can utilise to actually use an opportunity. For the case study we have chosen to concentrate on financial resources, physical and cognitive capacities (aggregated into skills), which cover only a few of the dimensions sketched in section 3.2. We intend to characterise each household's abilities in terms of water budget and skills.

Water budget is expressed in terms of the annual amount of water a household can afford. Water budget then depends on income and water price. Estimates for nett income per household type are calculated using GNP per capita estimates. Due to lack of longitudinal data on nett incomes, we assume the household's income roughly equal to the GNP per capita multiplied by the number of persons in that particular household.

CBS 1992 data informs us on the fraction of the nett income spend on water expenditures, which is 0.7% for single households and 0.6% for family households. Concomitant with the observation in Keller & Van Driel (1985), Kooreman (1993) and Groenen *et al.* (1993) that the price elasticity for water is rather low in the Netherlands, we take that factor to be constant in time. We realise, however, that the part of the income devoted to water also depends on behavioural preferences with regard to other domains. In this case study we focus on a single domain, which does not allow us to address such substitution processes. However, substitution processes will be a central issue in the operationalisation of a generic behaviour module (see also Chapter 4). Multiplication of the water-expenditure fraction with the household's income results in the water budget in guilders. Division of the water budget by the water price leads us to estimates for the household's budget in terms of the maximum litres a household can afford to use annually.

The concept of skills is an umbrella term for both physical skills, i.e. physical possibilities to perform a behaviour and cognitive skills, e.g. knowledge, adequate planning (Breemhaar & Midden, 1992). Certain behaviour alternatives require the possession of particular skills. We assume that a household needs certain skills to be able to perform water-saving behaviour. Taking into account that physical skills refer to the physical condition of people, we relate such skills to the average age of the people in the household. We assume that only households in the age ranging from 15 to 64 possess the required physical possibilities to use water-saving options. Cognitive skills, in general, correlate with the level of education. We have therefore defined cognitive skills in terms of the level of education of the households, where we distinguish between low and high level of education. We assume that households with a high level of education possesses the required knowledge to change from water intensive to water-saving behaviour. Educational data are derived from the CBS (1990) and SCP (1992), whose data distinguish between male and female, and different age groups. The following assumptions have been made to aggregate the data in the format needed for implementation in the behaviour module: i) the fraction of male and female is equal, ii) the age groups 20-49 and 50-64 represent the age groups 15-44 and 45-64, respectively, iii) the level of education of age group 75+ of the behaviour module is similar to the level of education of age group 65-74, iv) the number of persons in age groups 20-34 and 35-49 represent the number of persons in age groups 15-44 and 45-64, respectively.

Assuming that households need both physical and cognitive skills in order to be able to apply water-saving options, the number of households which possess sufficient skills is defined as those households of which the average age falls within the range of 15-64 and which have a high level of education. Furthermore, no differentiation is made between single and more person households on the distribution of age groups and level of education. Using the translated education data we arrive at a workable education distribution within the relevant age groups (Table 4):

Table 4: Fraction of households with 'skills', i.e. a high level of education and on age group 15-44, 45-64 (Based on SCP, 1992).

Year	Age group 15-44, fraction with high education	Age group 45-64, fraction with high education
1900	0.10	0.10
1980	0.47	0.32
1990	0.48	0.39
2000	0.61	0.48
2100	0.65	0.55

It is important to note that in the implementation we have adopted the characteristics of households in terms of abilities, which are calculated for each time-step. In other words, abilities are not ascribed to a particular cohort. In a more sophisticated version, we have to recognise the omission of so-called 'cohort-effects'.

In line with section 3.2. we assume that skills which households possess can in principle be extended by policy measures, and by social-cognitive measures in particular. In the case-study, we have concentrated on the effect of social-cognitive measures, leaving other policy measures aside. Social-cognitive measures will elevate some of the households with insufficient skills to the group of households possessing the required skills. In order to quantify the effect, we assume that with a maximum policy effort 50% of the households with insufficient skills will switch to the group of households with the required skills.

Macro-level variables

What macro-level variables are important for the domain of water consumption? For an analysis in terms of households, the number of households is needed in order to perform simulations of the total water use by consumers. The number of households depends on the size of the population and the composition of the households. The population numbers used in the model are derived from CBS (1992). Analysing empirical data shows that an increase of the single-person households causes an increase in the total amount of water used (Groenen *et al.*, 1993). Furthermore, a non-linear relationship occurs between number of persons in a household and the amount of water used. One person extra per household leads to an increase of 87.7 litres water per day in 1992 (Groenen, 1993) compared to one person using on average of 125 litres of water per day (RIVM, 1991). We therefore conclude that it is relevant to distinguish between single-person and family households. In order to derive an estimate of the number of households per household type, the fraction of single-person households (see Table 5) and the number of people in family households (see Table 6) are included in the model.

The number of households per type can be derived in combination with the size of the population.

Water price, GNP per capita, the composition of the population in terms of age groups and the level of education are other macro-level variables which are relevant for determining motivation, opportunities and

Table 5: The fraction of single-person households (Source: SCP (1990))

Year	Fraction single- person households
1960	0.11
1975	0.19
1980	0.22
1985	0.28
1990	0.31

Table 6: Average number of persons in family households (Source: SCP, (1990); CBS, (1989)).

Year	Average persons per family households
1975	3.42
1980	3.28
1985	3.13

abilities, as will be described below. The time samples with respect to GNP are based on CBS (1992), while the water price trends are derived from Hoekstra (1995). The age distribution of the population is based on CBS (1992). Longitudinal estimates of the level of education are derived from SCP (1990).

2.2 The STATE system

The state system addresses the behaviour of households formulated in terms of the behavioural processes preceding the distribution of options. In principle a large number of possible distributions exists, depending on the processes used by households to choose between the various opportunities, i.e. water-intensive versus water-saving options. This so-called behavioural process depends on the abilities, i.e. water budget and skills, and the motivation. Social sciences recognise different types of behaviour ranging from reasoned actions to habitual or 'automatic' behaviours, as discussed in the previous chapters. In this exploratory exercise we have restricted ourselves to reasoned behaviour, where we have adopt to following a set of simple decision rules:

* Households with both the skills and a high motivation to be thriftly with water will use water-saving options.
* If households lack the skills or have a low motivation to be thriftly with water, they are inclined to choose water-intensive options. However, where the water budget is insufficient to meet the associated amount of water, households are obliged to reduce the required amount of water by adoptingwater-intensive options to the level necessary to create a balance between water demand and the household's budget.

We fully admit that the actual behavioral processes involving reasoned behaviour is much more complicated than is envisioned in this set of decision rules. We merely aimed at illustrating how decision rules might be translated into model terms. Modelling of these decision rules enables us to derive at a time-dependent distribution of water-intensive versus water-saving options among the population.

2.3 The IMPACT system

The impact system calculates how much water is actually used by consumers in a certain year. Depending on the choice households have made for water-intensive and/or water-saving functions, the volume of clean fresh water can be determined by multiplying the distribution of opportunities by the amount of water associated with a certain opportunity.

In a default-run, where the projections of SCP and CPB, with regard to the macro-level variables (e.g. population, GNP, number of persons per household and the level of education), are taken as starting point, we arrive at an annual domestic water use of 756 billion litres in 1990. Historical data shows a total amount of 757 billion litres domestic water used in the Netherlands in the year 1990 (Achttienribbe, 1993). This result seems to imply that the processes as described in the behaviour module provide a plausible description of past and present dynamics. However, sensitivity and uncertainty analysis, and extensive module testing, are necessary to justify such an argument. At the moment it is just an illustration to indicate in what order of magnitude the results lie.

2.4 The RESPONSE system

The response system represents responses of policy-makers to impacts in terms of policy strategies to reduce the water use by consumers. We claim that the current set of policy options used in the AQUA submodel can be extended by using socioscientific knowledge on policy strategies and instruments. In other words, with regard to the policy-supporting aim of integrated assessment models, we argue that besides providing adequate levers for policy, a behaviour module might serve to increase the scope of policy measures.

In AQUA, the response model simulates expenditures demanded and actually made (e.g. infrastructure, technology and education), financial measures (e.g., water pricing) and legislative and managerial measures

(Hoekstra, 1995). A distinction is made between policy measures focused at, for example, water quality improvements, and at policy measures, focused at reducing the water demands by households. Water-supply policy may be directed towards the construction of new infrastructure or the regulation of water quality. Water-demand policy may be directed towards education or technological development to bring about a more efficient water use. Water pricing may also be a proper instrument to reduce the demand. Some of these measures are aimed at changing behaviour of consumers at the household level, some others influence the consumer behaviour indirectly, such as water pricing. We propose including the first type of measures in the behaviour module, where more adequate levers are provided. With regard to the response options in the AQUA submodel, this holds for improvement of education and technological measures.

In Chapter 3 four types of policy strategies are discussed: provision of physical alternatives and (re)arrangements, regulation-and-enforcement, financial-economic stimulation and social and cognitive stimulation. As follows from the discussion of the influence of policy measures on motivation, abilities and opportunities we have included the following policy measures: i) physical policy, which consists of R&D programs aimed at the provision of more water-efficient opportunities; ii) regulation, which consists of requirements on water efficiency; iii) water pricing; and iv) social cognitive policy, primarily education. We assume that R&D programs will extend the scope of water-saving options. In other words, physical policy will affect the opportunities. We assume that regulation in the context of water policy involves requirements with regard to efficiency. These include building requirements, which reduce the transport in houses (e.g. taps close to the reservoirs) and thereby improves the efficiency. In this sense, regulation influences the amount of water associated with water-saving and water-intensive options. Furthermore, a process of 'internalisation' might take place. This means that regulation measures have the side-effect of making people aware of the issue of water-use efficiency, which evokes a 'spontaneous' response of consumers in motivational terms. In order to take account of 'internalisation' we assume that regulation also sidely influences motivation. One of the primary determinants of the water budget is water price. A policy-induced increase in water price will thus decrease the water budget, and thereby limit the financial abilities a household has. Social cognitive measures, of which educational efforts are the most prominent, aims at increasing the level of education. The level of education is one of the determinants of skills, which signify the cognitive and physical abilities people have. We therefore assume that social-cognitive policy affects abilities. Meanwhile, it is recognised that more information might alter people's attitude towards a certain issue. In the model we assume that social cognitive policy slightly influences the motivation as well.

3 An illustrative experiment

In line with our limited ambitions on the case-study on water use by consumers, we do not provide experiments which have more than illustrative value. However, experiments carried out with the proposed simple module helps to understand what the added value of endogenous modelling of consumer behaviour might have. What are important changes and processes which cannot be addressed by the present generation of integrated assessment models, but are very important considering the political agendas? One of these issues is the advancing individualisation and the consequences in environmental terms. We have performed an experiment in which the household size declines, i.e. the average number of members of family households is

Table 7: Implemented policy measures and the behavioral determinants they affect

Policy measures	Influence on:
physical policy	- opportunities
regulation	- motivation - opportunities
water pricing	- abilities (e.g. budget)
social cognitive policy	- ability (e.g. skills) - motivation (e.g. distribution of perspectives)

assumed to decrease from 3.1 in 1990 (SCP, 1990) to 2.5 in 2100. Using the same population data as for stabilisation of the household size, the result will be more households, as is expected in a situation of advancing individualisation. The experiment shows an increase in water use from about 2.0 million m^3 and 3.5 million m^3 in 2050 and 2100, respectively, to about 4.5 million m^3 and 6.0 million m^3 in 2050 and 2100, respectively, in the individualisation case. The consequences assessed with our simple model show that in such circumstances the total amount of water used by consumers might increase by approximately 5% in the next century, which will amplify the human-induced pressure on water resources. Such an assessment is important with regard to scanning the future, but remains unaddressed by the current generation of integrated assessment models.