A CONCEPTUAL MODEL FOR THE DEVELOPMENT OF HOUSEHOLD SUSTAINABLE CONSUMPTION INDICATORS

Sandra Caeiro[1*], Tomás B. Ramos[2], Donald Huisingh[3]

[1]IMAR – Institute of Marine and Environmental Research and Departmento de Ciências e Technologia, Universidade Aberta, Rua Fernão Lopes nº 9, 2º Direito, 1000 – 132 Lisboa, Portugal, scaeiro@univ-ab.pt, Tel. +351 2139150039

[2]CENSE – Center for Environmental and Sustainability Research, Departamento de Ciências e Engenharia do Ambiente, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Campus da Caparica. 2829-516 Caparica, Portugal, tabr@fct.unl.pt

[3]Institute for a Secure and Sustainable Environment, University of Tennessee, 311 Conference Center Building, Knoxville, TN 37996-4134, U.S.A., dhuising@utk.edu

Abstract

Despite the diversity of tools to measure household consumption, indicators are one of the approaches with great potential, due to their communication and comprehensible easiness for non-scientific public, like families. The main objective of this research was the development of a framework to define the main steps and criteria to built household sustainable consumption assessment tools based on indicator sets. To put in practice the proposed model an overview of available household sustainable consumption metrics initiatives was conducted, including a comparison of their methodological approaches. This overview showed that the majority of these metrics are focus on some specific domains (e.g. energy or waste), not using an integrated approach of the sustainable consumption domains, and that very few used indicators to measure and assess household sustainable consumption. The developed framework is supported by several principal components and a checklist of key good-practice factors that a household sustainable consumption indicator system should have. Due to the demonstrated need to communicate easily, to engage stakeholders and due to the complexity involved in the measurement and assessment of

* Corresponding author

household sustainable consumption, the proposed framework can be very usefulness in developing and evaluating the effectiveness of household sustainable consumption indicator sets. Nevertheless it should be used as a flexible framework that can be tailored to each particular case and continuous monitored and reviewed about its overall accuracy and feasibility.

Key words: *households, sustainable consumption, indicators, criteria, framework*

1. Introduction

Economic and consumption growths are closely linked and have followed similar patterns. In other words, as we become wealthier and rich we also in most cases consume more. The projected economic growth of 2.4 % per year in the EU-25 between 2000 and 2030 will be accompanied by similar growth in consumption (EEA, 2005). Material intensive consumption patterns and lifestyles those present a major challenge to sustainability (Drukman *et al.*, 2008). In recent years, it has become increasingly clear that sustainable economies must be built around Sustainable Consumption (SC) (Clark, 2007). The most widely used definition of SC in the literature is the Oslo definition according to which SC is 'the use of goods and services that respond to basic needs and bring a better quality of life while minimising the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardise the needs of future generations' (OECD, 1997).

European Union (EU) has been putting increasing emphasis on sustainable use and management of natural resources, especially since the adoption in 2001 of the EU Sustainable Development Strategy and the Sixth Environment Action Programme (EEA, 2005). The Johannesburg Summit in 2002 recommended the development and promotion of the "Marrakech process" or the 10-Year Framework of Programmes on Sustainable Consumption and Production (SCP) in which the United Nations Environment Program (UNEP) and the UN Department of Economic and Social Affairs (UNDESA) are the leading agencies. This global multi-stakeholder process has several Task Forces, providing a forum for developing countries and promoting implementation of SCP at National and International level. The 2002 United Nation Summit also outlined a number of actions namely develop awareness-raising programmes, particularly for youth, through education, consumer information, and advertising and develop and adopt consumer information tools (Clark, 2007).

Household consumption forms an important part of the production-consumption chain, as it is consumers who make the final choice of which goods and services to consume, and lifestyles determine the way families influence sustainability practices. Individuals should be seen as part of the solution, and not simply as part of the problem, in promoting sustainability because their values and participation should be the basis for individual and public action (Comim *et al.,* 2007).

A simple receipt to realize SC is impossible or ethically disputable. Nevertheless, the empirical findings support many of the preconceived ideas about unsustainable consumption, notably that it is generally positively related to income, age, family size, education and high-status job (Ferrer-i-Carbonell and Van Den Bergh, 2004) and household expenditures (Kerkhof *et al.,* 2009 b).

Understanding household consumption patterns is also about understanding human behavior. Important factors that drive our consumption include growing incomes, globalization of the economy, technological breakthroughs (such as the Internet and mobile phones), decreasing household sizes and an ageing population. At the same time, the growing number of goods and services we consume often offsets the efficiency gains we achieved through, for example, improved production technologies and processes. As a result, environmental pressures are increasing. Housing, food and drink and mobility have the greatest environmental impact over their lifecycle in terms of emissions of greenhouse gases, acidifying and ozone-depleting substances as well as resource use (EEA, 2005).

Routines in daily life are crucial for household consumption behaviours and practices and may actually be decisive for the size of energy and water consumption and waste production. Those routines usually include comfort (heating and lighting the home), hygiene (washing clothes and drying), cooking (storing food and preparing meals) and communication and entertainment. As these routines and practices are developed together with social, cultural and physical infrastructure, changes in routine follow from broader structural changes. This kind of understanding might thus be relevant from a household SC and production perspective as it indicates the importance of social and cultural aspects in the consumption and use phases of technology (Gram-Hanssen, 2008).

Lifestyle has been used in several research studies to understand and explain different consumption patterns, but these studies have encountered problems in linking actors' environmental awareness and measured consumption, and then relating this to lifestyles theories (Jensen, 2008).

The research on household SC thus strives to integrate various disciplines on order to depict the driving forces of consumer behaviour and to derive policy instruments aiming at changing consumer behaviour (Kletzan *et al.,* 2002). This research should also be linked with environmental innovations in housing which are strongly related with financial advantages (Hal, 2007).

The main objective of this research is the development of a framework to define the main steps and criteria to built Household Sustainable Consumption (HSC) assessment tools based on indicator sets. This framework can also be used to evaluate the effectiveness of existing household SC indicator sets. In the context of this research work it is important to clarify the definitions of indicators. According to Ott (1978) and Jackson *et al.* (2000) indicator is a sign that conveys a complex message, potentially resulting from numerous factors in a simplified and useful manner. An indicator is derived from a single variable to reflect some attribute.

2. An overview of household sustainable consumption metrics

Despite the diversity of tools to measure household consumption, indicators are one of the approaches with great potential, due to their communication and comprehensible easiness for non-scientific public, like families. Indicator sets, in particular, Sustainable Development Indicators (SDIs) are used to collect, process, and use information with the goal of making better decisions, directing smarter policy choices, measuring progress, and monitoring feedback mechanisms, as emphasized in the United Nations Conference on Environmental and Development, held in Rio de Janeiro in 1992 (Agenda 21, Chapter 40). Though the adoption of indicators helps in the analysis of many types of information, evaluation, as a process, allows the use of measures to drive policies, through the implementation of concrete and effective improvement plans, provided that they respond to the strengths and weaknesses emerging from the analysis of the indicators (Scipioni *et al.,* 2008).

There is a proliferation of indicators for sustainability ranging from environmental profiles and trends to a wide variety of quality of life measures. But proliferation makes difficult the choice of indicators for policy-making and for civil society actions. Although not in agreement within research community, some authors defend that general SDI are not applicable to SC and production. Most international agencies and institutions have responded to this problem of choosing indicators by building large databases, assuming that the availability of data would encourage users to incorporate different indicators in the formulation of their actions and policy-making (Comim *et al.,* 2007). According to these authors the two most important roles of SC indicators should be: (i) educational, stimulating communication of SC results that can be used as inputs in participatory processes, building accountability to concrete targets and (ii) managerial, informing policy interventions and guiding planning decisions.

Indicators permit the combination of different approaches like input-output analysis, environmental statistics, questionnaire surveys and household budget data, allowing to achieve improved understanding of the influence of various household characteristics on environmental degradation (Munksgaard *et al.,* 2005). According to the 10-Year Framework of Programmes on SCP, indicators are important tools for measuring progress of SC at local, regional or national level (UNDESA/UNEP, 2010).

A large number of environmental assessment methods are now available to help assess the sustainability of products, processes and ultimately lifestyle, but few studies have been undertaken to compare the finding of these different tools (Huijbregts *et al.,* 2008).

Table A1 presents an overview of studies that measure or assess household SC, as examples of the ongoing work that is being carried out around the world. The table shown the studies aims/scope, methodology, domain, target-audience, and some comments or drawbacks.

The majority of the studies are about consumption patterns regarding one specific domains of HSC (like energy consuming plus carbon dioxide emissions, water, waste, food and resources use) or two domains (e.g. energy plus water plus waste). As stated by Munksgaard *et al*. (2005), many studies about HSC consider only one or a few environmental pressures such as energy consumption or CO_2 emissions.

Different methodologies are used to measure and assess HSC. They vary from questionnaire surveys, inputs-outputs analysis, indicators and other mathematical and statistical models, like multivariate statistics (Table A1). There are several works that use questionnaire surveys complemented or not with interviews to improve the data collection (e.g. Fahy and Davies, 2007 or Baker and Rylatt, 2007). This collecting method is most related with understanding consumer sustainable (or unsustainable) behaviour. The input-output analysis is also a method used within HSC, mostly found intertwined with the study of the domain waste (e.g. Takase *et al.,* 2005) or energy (Munksgaar *et al.,* 2005).

Few studies measure and assess HSC using indicator sets. Most of these studies are about the operational level of household consumption (inputs as energy and materials and outputs as waste or used materials), in a specific domain like energy, food, water or waste (e.g. Wood and Newborough, 2003 - energy-consumption indicators), or about the strategic level of household consumption, like quality of life, behaviour, routines or actions (e.g. Katz-Gerro and Talmud, 2005 - stratification indicator to predict ability in estimating consumption behaviour based on household expenditures).

Energy is an important issue within household consumption helping to find green consumer with low greenhouse gases GHG emissions. However, although households can show certain tendencies, there is no clear indicator that always identified green consumers. For example Girod and Haan (2009), in study about GHG reduction potential of changes in consumption pattern in Swiss household consumption survey, found high GHG emitters who bought organic food, lives in car-free household and were vegetarian. This shows the importance that an indicator system of HSC should consider and integrate several domains and levels of analysis.

Some HSC researchers have been working about ecologic and carbonic footprint which study the household consumption behaviour with a set of aggregated metrics, taking into account the main domains (e.g. Wiedman *et al*., 2005, Sutciffe *et al*., 2008, Druckamn and Kackson, 2009). However, the major drawback of Ecological Footprint is that it covers a limited scope of environmental "stressors"/domains: energy consumption, land use, food, and CO_2 emissions and do not allow a thorough and rigorous assessment of a certain domain. In addition ecologic footprint does not give an overview of each domain separately

so the families would know what changes should be implemented, what mistakes are being made and how to correct them (Munksgaard *et al.,* 2005).

Other studies do not evaluate directly HSC, but services strongly related with HSC. For example Halme *et al.* (2006), evaluate European household services based on a preliminary set of indicators, related to household consumption that contribute to at least two of the three dimensions of sustainable development: environment, social and economy aspects. Services can at least partially replace products, as need satisfiers for consumers and as solutions for organizations. Eco-efficient services and product-service system can simultaneously fulfil people's needs and considerably reduce the use of material and energy.

3. Development of the conceptual model and key components-criteria

3.1. General Framework

A conceptual model to develop and evaluate household sustainable consumption indicators was developed with the aim of identifying how to put the Household Sustainable Consumption (HSC) evaluations challenges into practice (Figure 1). This framework was designed to be applied to spatially aggregated household's initiatives (at the national, regional or local levels) or to individual households initiatives (condominiums or families), supporting indicator development and allowing continuous evaluation of the assessment procedures and outcomes.

The model assumes that household consumption assessment processes, and their respective measurement tools, should be centred on the entire household system, by taking into account the different material and non-material flows, practices and behaviours. Sustainability evaluation systems should avoid the issues by category compartmentalization, which leads to the division of household economic, environmental, institutional/governance and social aspects. It is the convergence within the different domains that ultimately define whether the 'system' is sustainable. Sustainability consumption evaluation, requires integrated approaches, based on the weighting of the different sustainability domains, that in due course define whether a system is sustainable or not. As stated earlier, there is no guarantee that sustainable conditions in one domain (e.g. energy consumption) will be the same for other domains (e.g. waste production, species diversity losses, toxics use reduction).

This approach is supported by several principal components, including stakeholder's engagement, reflecting their views and opinions along the entire process. This cross fertilisation process should include key-stakeholders (experts and non-experts), in particular governmental institutions, non-governmental organizations, local communities and residents/family's representatives', private operator's and service providers, academia and research institutions. These collaborative and participative activities will have a central role on the development, implementation, operation and follow-up of the HSC assessment system. These participative processes could adopt various techniques, in particular focus group workshops and meetings, interviews, questionnaires, visualization techniques (drawing and mapping – Public Participation using Geographic Information System (PPGIS)). Furthermore, the results of the indicators should be used to inform all stakeholders.

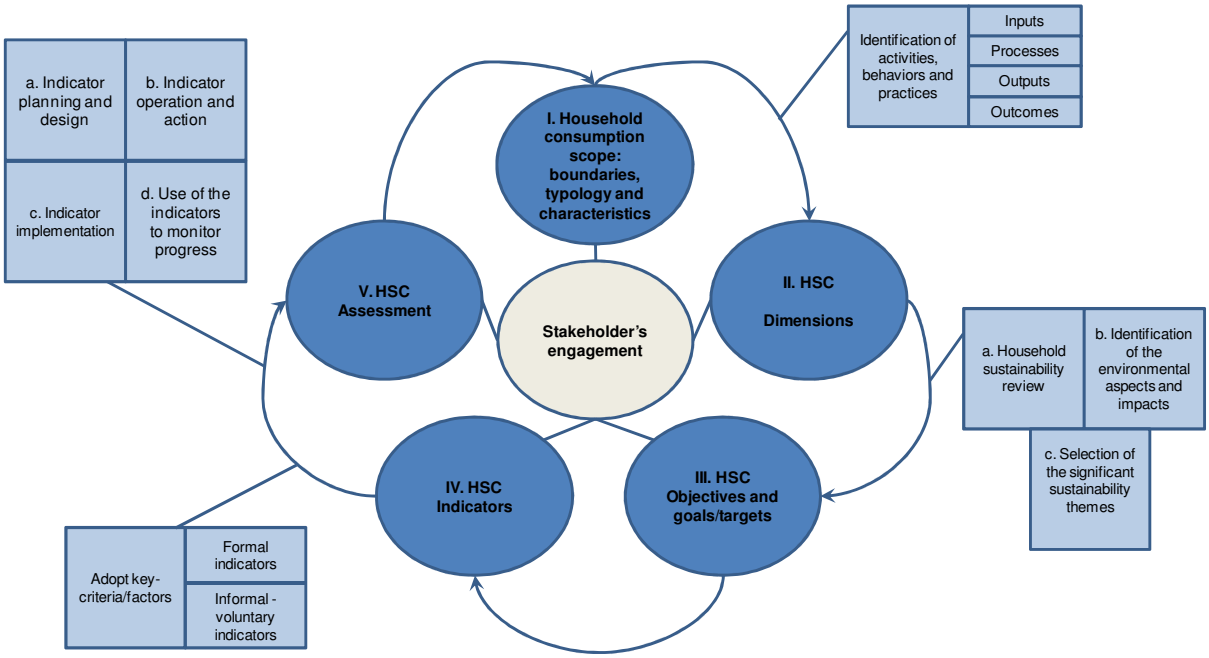

Figure 1: A conceptual model for the development of household SC indicators

The proposed method should be used as a flexible and dynamic framework that can be tailored to each particular case. Furthermore, as it is implemented, the performance of it much be monitored in an on-going manner in a transparent, accurate and valid manner. The results of the on-going monitoring of effectivity must be shared with all stakeholders. Furthermore improvements in the system much be integrated cybernetically from the beginning of the entire multi-year process. The following main steps are useful in such systems:

I. Household consumption scope: boundaries, typology and characteristics

Identification of the household consumption scope, defining the boundaries of the consumption areas (including food consumption, housing, personal travel and mobility, tourism) that will be included at operational level (typical inputs, outputs measures and related practices or actions) and strategic level (household consumption policies, planning/programming and behaviours). Household activity characteristics should analyse inputs, processes, outputs and, when possible, the outcomes; this include a clear description of household estate, including type and/or size of compartments/sectors and buildings, land area owned, residents, material and equipment used;

II. HSC Dimensions

An initial review of the household consumption strengths, weaknesses, opportunities and threats should be conducted, identifying the most positive and negative, internal and external, signals, providing a representative picture.

This check covers an analysis of the integration of sustainability considerations into household's policies, and operations. Based upon this review, the following items should be identified:

- Significant environmental and sustainability "aspects"/pressures: This refers to specific environmental and sustainability pressures such as water, materials and energy consumption, pollutant emissions, waste disposal or land use patterns produced by the household activities, products and services (or parts);
- Significant environmental and sustainability impacts: This refers to human effects on the state of the environment and sustainability systems originated by the pressures and relevant for human health and/or ecosystem well-being. It should be stressed that the term significant carries no statistical meaning when used in this context; this term refers to criteria such as the importance of effects on a human receptor or natural resource, or to the degree of compliance with an environmental standard or goal.

At the end, the identification of the more significant HSC domains or themes should be used to address the activity scope characterized in the previous step with the social, economic, environmental and governance/institutional areas that are affected by those household driving forces (understood as the social needs that require the existence of a given household activity).

III. HSC Objectives and targets

The definition of the main objectives and targets for household SC, is to reflect upon the needs, desires, sensibilities and aspirations This information will provide the framework within which to proceed with the evaluation, allowing comparison with the results of the assessment produced by the indicators (next methodological step), as well as in mapping the distance to the desired aims and targets.

IV. HSC Indicators and V. HSC Assessment

The HSC indicators should be developed according to the results obtained in the previous steps. General indicator selection criteria (e.g. Ott, 1978; Hardi and Zand, 1997) should be taken into account to obtain a consistent and robust indicator set.

The indicator system could be structured in two main branches: formal and informal indicators. Formal indicators are represented by a “technical” set, selected and developed according to above mentioned general criteria and following the different procedures and a series of actions and decisions with various data and information flows, that characterise the development cycle of sustainability indicators: planning and design; operation and action; implementation; and monitoring progress of the HSC. Informal indicators could follow less rigid procedures but be part of the effort to assess the HSC; these kinds of informal indicators will be put into practice by the residents and will correspond to easy monitoring issues with particular socially relevance to the volunteers. These voluntary indicators can provide high-quality reliable data to supplement the formal evaluation. Some authors discuss the connection between environmental awareness and metering data on household consumption, defending that some symbolic actions apparently play a larger role than

other, more environmentally serious consumption practices (Jensen, 2008). The integration of "formal indicators" and "informal/voluntary indicators" will also help to ensure the commitment, education and awareness of the residents.

The relationship with existent "external" sustainability indicator systems or other indicator related initiatives should be taken into consideration in the selection of the relevant HSC indicators. In Figure 2 these relationships are synthesized, assuming that other monitoring tools could positively contribute to the development of HSC indicators, despite the different objectives, scopes and approaches. This procedure of maximizing synergies between different initiatives, finding indicators already in use could avoid the proliferation of independent efforts to attain connected or similar objectives, since indicator selection criteria are fulfilled.

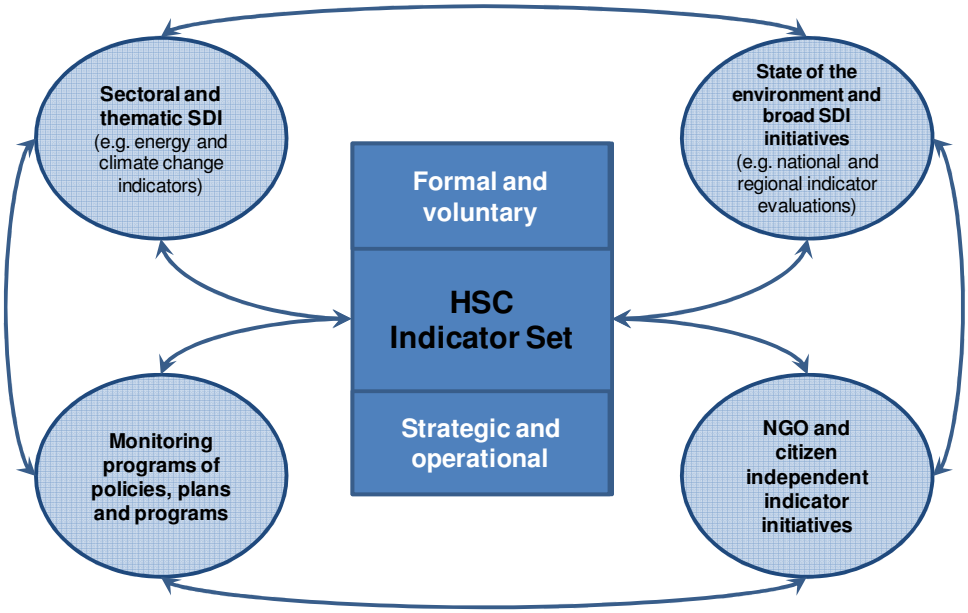

Figure 2: Relationship of the HSC indicator set with existent "external" sustainability indicators systems or other indicator related initiatives

Additionally, it should be underlined that a HSC indicator system will depend significantly upon the desired primary scale of analysis (Figure 3). A HSC evaluation at the national level, designed to identify/support/guide/monitor the performance of a country on this domain will be certainly different from initiatives carried out at municipal or individual household levels. In fact, the proposed framework and key-criteria/factors should be focused and tailored to each spatial level, avoiding blurred designs and interpretations. Nevertheless, it is fundamental that the HSC indicators that are selected and used foster dynamic interactions among all

spatial levels, through a cascading/cybernetic process. As suggested by Coelho *et al.* (2010) for the regional SDI scale interaction, this could be achieved through specific indicators (Common Indicators – CI), which are simultaneously relevant for sustainability assessment at different scales. Each CI HSC subset should be established at the national level for all regions, complementing specific regional indicators, and should not prevent each region from having its own regional headline HSC indicator set that may correspond entirely or partially to the national headline indicators. On the other hand, using the same design, the regional set will define CI that should be used at the local level. The same relationship is applied until the individual/person level.

Specific HSC key-criteria/factors for the development and evaluation of indicators should be adopted. This component is a critical step to assure that this tool integrates the singularities and common features of HSC area when compared with others.

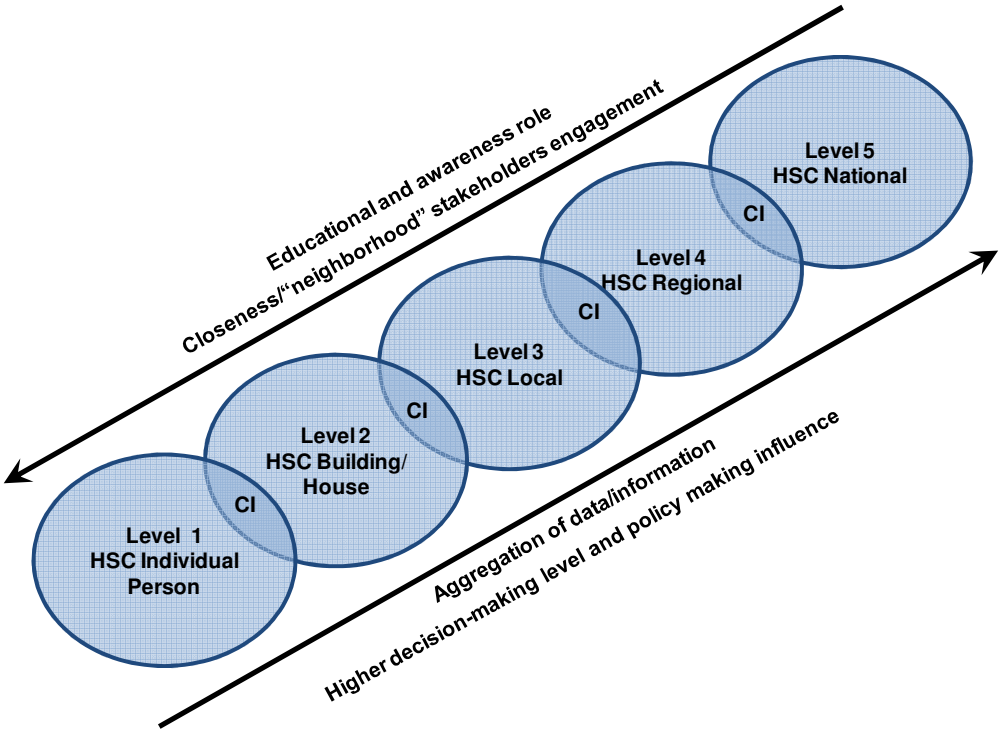

Figure 3: Cascading interactions among different levels of HSC

3.2. Key-criteria/factors

As emphasised earlier, operationalising sustainability measures of consumption is not an easy task. It is strongly influenced by difficulties in clarifying the conceptual meaning of (SC),

which in turn are caused by the ambiguities in the notions of sustainable development. In a pragmatic account of SC, many problems remain unaddressed; this makes it difficult to properly formulate and to implement SC indicators. A particular problem for SC lies in its diversity and its domain of application that cannot be universally captured by traditional metrics (Comim *et al.*, 2007). Due to that, a definition of key-criteria/factors and recommendations to support the development of a HSC indicator set are proposed in Table 1.

Therefore, a fundamental component is to use the key-criteria/factors to build the HSC assessment initiatives. These criteria-factors can also be used to evaluate the effectiveness of existing household SC indicator sets. The approach is supported by a checklist of criteria that a household SC indicator system should have, such as its scientific background, including conceptual coherence and relevance to SC assessment, indicator organization and structuring and methodological approaches for data collection and analysis. Also, wide criteria such as being comprehensible and meaningful to the residents or families and have an integrative approach among the different domains of SC should be taken in to account.

Table 1: Key-criteria-factors for household SC indicators

key-criteria/factors	**Summary of rationale**
Strong sustainability principles	HSC indicator sets should be base on strong sustainability principle closer to the principles of environmental conservation and involving decreasing or constant levels of consumption over time, thus priority should be given to critical levels of Natural Capital (Comim *et al.,* 2007).
Driving forces	HSC is strongly related with driving forces and that should be taken into account in the indicator set development. Those driving forces are for example technological innovation, level of environmental awareness and concern and environmental protection polices (Zacarias-Farah and Geyer-Allély, 2003; Hobson, 2003).

key-criteria/factors	Summary of rationale
Integrative domains	SC metrics should integrate the different domains of SC. According to EEA, household SC should include the following components: food consumption, housing, personal travel and mobility and tourism (EEA, 2005). HSC indicator should integrate the significant SD themes and the household consumption should include significant environmental sustainability aspect/pressures and impacts. SC should take into account, economic, ecological and social components of consumer behaviour, including socio-psychological factors that shape consumer behaviour (e.g. limits to rational and optimising behaviour, status, perceived quality of life) as well as technological and institutional conditions (e.g. product alternatives, infrastructures, policy measures)(Kletzan *et al.,* 2002, Zacarias-Farah and Geyer-Allély, 2003). Less common SDI areas should be considered, e.g.: quality-of-life, should be integrated into emphases upon broader informational spaces, including not only (a) resources, (b) subjective views but also (c) beings and doings that individuals are able to achieve and to value (Comim *et al.,* 2007). Family incomes (Ferrer-i-Carbonell and Van Den Bergh, 2004) and expenditures (Kershof *et al.,* 2009) should be taking into account in terms of the family economy (Chatterjee and Michelini, 1998).
Relevancy with family strategic options	HSC indicator sets should be related with strategic options, goals and targets of the families. Also the indicator set should be related with the main household strengths, weakness, opportunities and threats.
Dynamic behaviours, actions and routines	Household SC metrics should take into account routines of everyday consumption that emerges, develops and changes, and by focusing on the role that routines have in establishing a secure and liveable, everyday life (Gram-Hanssen, 2008). Household SC metrics should evaluate the actions and not only the attitudes behind the consumption (Jensen, 2008). Selection of the variables should also take into account representations of consumers' choices and autonomous behavior (Comim *et al.*, 2007). According to an OECD Work Program on Sustainable Consumption, consumer decision-making and specific influences of household consumption suggests a broad web of influence upon consumer choice, including environmentally friendly purchases and behavior (Zacarias-Farah and Geyer-Allély, 2003).

key-criteria/factors	Summary of rationale
Comparability and robustness	HSC indicators should be robust and comparable among different applications and the justification of the choice of particular sets of indicators for different circumstances should have a conceptual way for organizing these choices. Indicators should be comparable, with their specific content being allowed to differ among different societies, but the category that they represent should be universal across cultures (Comim *et al*., 2007).
Governance and public participation process	HSC indicator sets should be developed in accordance with a bottom-up process with emphasis on public participation, with a weighting procedure defined by public priorities (Comim *et al.,* 2007. The European Commission defines five principles of good governance: "openness, participation, accountability, effectiveness and coherence," which are of particular significance in sustainability assessments. The promotion of dynamic interactions among all stakeholders should exist from the beginning of the process. It should be supported by participative and collaborative procedures, where different actors are empowered to play important roles, improving capacity building and assuring transparency, credibility and robustness, beyond the strict, predetermined, technical and scientific tasks. The design, construction, operation and revision of the indicators can also be submitted to a panel of experts, in accordance with expert consensus practices, for instance by means of the Delphi technique.
Target audience and type of language	Clear identification of the types of target audience to be reached and the corresponding preferred language (non-technical) in the indicator system. The target end-users (residents or families) and the respective requirements and realities should be considered in the indicator set design and operation. It is also essential to give a clear definition of the central indicator audience, as it can limit the overall assessment and reporting structure.
Comprehensibility and communication	The household SC indicators should be comprehensible to the families and also be meaningful and relevant. They should be suitable to communicate with local communities and other local stakeholders (e.g. local decision-makers, user groups), when working at the local scale, or with other stakeholders, depending of the target scale.
Relevancy with public policies and plans	HSC, indicator sets should be related with local/regional/national and public policies, plans and programs, including related sustainability monitoring initiatives in use for the main scale (national, regional, local).

key-criteria/factors	Summary of rationale
Voluntary indicators	The adoption of HSC voluntary indicators should be encouraged, because it encourages better commitment, awareness and education of the stakeholders, in particular residents and families, engaged in the monitoring process. These kinds of informal signals can complement the formal indicators provided by the more traditional technical assessment procedures.
Performance and benchmarking	HSC indicator sets should be able to demonstrate differences between households, allowing to evaluate their performance and offering good practices references and incentives for continuous improvement.
Interlink with environmental management tools and certification processes	HSC indicator sets should be linked with existent environmental management tools including certification processes (e.g. sustainable construction, energy, water, forest). These tools will provide useful guidance and data for the indicators sets and vice versa.

Despite the proposed key-criteria-factors could be somehow also applicable to other sectoral sustainability indicator applications, different than HSC, the ones presented are customized to the particular characteristics of HSC field.

In addition other broader factors developed for the overall evaluation of the sustainability indicator systems performance (see in Ramos and Caeiro, 2010) could also be taken into account in the HSC indicator applications.

4. Conclusions and recommendations

In this article an overview of household SC metrics has been conducted, analysing their aims/scope, domain and target public, as well as a comparison of their methodological approaches. This analysis allowed concluding that most of the available metrics, although using different measurement methods, are focused in only one or two SC domains and few studies use structured HSC indicator sets. Usually, the metrics do not integrate the different sectoral domains of HSC, such as food consumption, housing, personal travel and mobility and tourism, and also do not integrate the main environmental, social, governance and economic components of HSC, including the systemic analysis of the drivers and their effects. The majority of the identified metrics are not designed to allow effective communication with stakeholders, in particular to non-technical audiences, and to allow comparisons among those metrics. They do not give an integrated HSC performance overview, lacking structured monitoring signals about the impacts of family's changes or corrections implemented for achieving a better sustainable consumption.

The review results demonstrates the importance of the development of a framework to define the main steps, components and criteria- to built household sustainable consumption assessment tools based on indicator sets, such as the one proposed in this work. The developed conceptual model can also be used to evaluate the effectiveness of existing household sustainable consumption indicator sets. The presented approach integrates several steps from the definition of the HSC scope, dimensions, objectives and targets to the indicator development and assessment. The framework is supported by a checklist of criteria that a household sustainable consumption indicator system should have, such as: i) being comprehensible and meaningful to the families, ii) developed in accordance with a bottom-up process with emphasis on public participation, iii) having an integrative approach among the different domains, iv) reporting the dynamic behaviours, actions, and routines of HSC v) allowing to evaluate HSC performance and offering good practices references and incentives for continuous improvement . Family strategic options and external driving forces and actions by government and private factor are also important factors to be considered in the HSC indicator set.

The conceptual model presented in this research should be used as a flexible tool that can be adapted to each particular case. For follow-up research the framework will be tested in different household SC public metrics, not only to find their strengths and weaknesses, but to analyse the effectiveness and usefulness of the framework developed and to introduce the required improvements.

Acknowledgments

We would like to acknowledge the valuable collaboration of Ana Lavado in the preliminary stage of this research.

References

Baker, K. J., R. Rylatt, M. (2007). Improving the prediction of UK domestic energy-demand using annual consumption-data. Applied Energy, 85, 475 - 482.

Barr, S., Gilg, A. & Ford, N. (2005). Defining the multi-dimensional aspects of household waste management: A study of reported behaviour in Devon. Resources, Conservation and Recycling, 45, 172 – 192.

Cai, J. &Jiang, Z. (2007). Changing of energy consumption patterns from rural households to urban households in China: an example from Shaanxi Province, China. Renewable & Sustainable Energy Reviews, 12, 1667 – 1680.

Chatterjee, S. & Michelini, C. (1998). Household consumption equivalence scales: some estimates from New Zeland household expenditure and income survey data. Australian & New Zealand Journal if Statistics, 40(2), 141 - 150.

Clark, G. (2007). Evolution of the global sustainable consumption and production policy and the United Nations Environment Programme's (UNEP) supporting activities. Journal of Cleaner Production, 15, 492 - 498.

Coelho, P., Mascarenhas, A., Vaz, P., Dores, A. & Ramos, T.B. (2010). A framework for regional sustainability assessment: developing indicators for a Portuguese region. Sustainable Development, 18(4), 211-219.

Comim, F. Tsutsumi, R. & Varea, A. (2007). Choosing sustainable consumption: a capability perspective on indicators. Journal of International Development, 19, 493–509..

Curran, A.; William, I. & Heaven, S. (2007). Management of household bulky waste in England. Resource Conservation & Recycling, 51, 78- 92.

Dahlén, L., Åberg, H., Lagerkvist, A. & Berg, P. E. O. (2009). Inconsistent pathways of household waste. Waste Management, 29(6), 1798-1806.

Delgado, M. & Miles, D. (1997). Household Characteristics and Consumption Behaviour: a nonparametric approach. Empirical Economics, 22, 409 – 429.

Delgado, O. B., Ojeda-Benítez, S. & Márquez-Benavides, L. (2007). Comparative analysis of hazardous household waste in two Mexican regions. Waste Management, 27, 792-801.

Druckman, A. & Jackson, T. (2008). Household energy consumption in the UK: a highly geographically and socio-economically disaggregated model. Energy Policy, 36, 3177 – 3192.

Druckman, A., Jackson, T. & Sinclair, P. (2008). A geographically and socio-economically disaggregated local household consumption model for the UK. Journal of Cleaner Production, 16, 870 - 880.

Druckman, A. & Jackson, T. (2009). The carbon footprint of UK households 1990-2004: a socio-economically disaggregated, quasi-multi-regional input-output model. Ecological Economics, 68, 2066 – 2077.

EEA. (2005). Household consumption and the environment. Report nº 11. Copenhagen.

Fahy, F. & Davies, A. (2007). Home improvements: Household waste minimisation and action research. Resources, Conservation and Recycling, 52,13-27.

Ferrer-i-Carbonell, A. & Van Den Bergh, J. (2004) . A Micro-Econometric Analysis of Determinants of Unsustainable Consumption in The Netherlands. Environmental and Resource Economics, 27, 367–389.

Firth, S., Lomas, K., Wright, A. & Wall, R. (2008). Identifying trends in the use of domestic appliances from household electricity consumption measurements. Energy and Buildings, 40, 926 – 936.

Gilg. A. & Barr, S. (2006). Behavioural attitudes to water saving. Evidence from a study of environmental actions. Ecological economics, 57(3), 400 – 414.

Girod, B.& Haan, P. (2009). GHG reduction potential of changes in consumption patterns and higher quality levels from Swiss household consumption survey. Energy Policy, 37(12), 5650-5661.

Gram-Hanssen, K. (2008). Consuming technologies - developing routines. Journal of Cleaner Production, 16, 1181 - 1189.

Gram-Hanssen, K., Bartiaux, F., Jensen, M. & Cantaert, M. (2007). Do homeowners use energy labels? A comparison between Denmark and Belgium. Energy policy, 35, 2879 – 2888.

GrØnhØj, A. (2006) Communication about consumption: a family process perspective on 'green' consumer practices. Journal of Consumer Behaviour, 5, 491 – 503.

Hal, J. D. M. (2007). A labeling system as stepping stone for incentives related to the profitability of sustainable housing. Journal of housing in the built environment, 22, 393–408.

Halme, M., Anttonen, M., Hrauda, G. & Kortman, J. (2006). Sustainability evaluation of European household services. Journal of Cleaner Production, 14, 1529 – 1540.

Hardi, P. & Zand, T. 1997. Assessing sustainable development: Principles in Practice. Canada, Winnipeg: International Institute of Sustainable Development.

Hobson, K. (2003). Thinking Habis into Action: the role of knowledge and process in questioning household consumption practices. Local Environment 8(1): 95 – 112.

Huijbregts, M. A. J., Hellweg, S. and Frischknecht, R. (2008). Ecological footprint accounting in the life cycle assessment of products. Ecological Economics, 64, 798 - 807.

Jackson, L. E., Kurtz, J. C. & Fisher, W. S. (2000). Evaluation Guidelines for Ecological Indicators

U.S. Environmental Protection Agency, Office of Research and Development, Research Triangle Park, NC.

Jensen, O. (2008). Measuring consumption in households: interpretations and strategies. Ecological economics, 68: 353 - 361.

Jeroen C.J.M. & van den Bergh, (2008). Environmental regulation of households: an empirical review of economic and psychological factors. Ecological Economics, 66, 559 – 574.

Katz-Gerro, T. & Talmud, I. (2005). Structural analysis of a consumption-based stratification indicator: relational proximity of household expenditures. Social Indicators Research, 73, 109 – 132.

Kerkhof, A. C., Benders, R. M.J. & Moll, H. C. (2009 a). Determinants of variation in household CO_2 emissions between and within countries. Energy Policy, 37, 1509-1517.

Kerkhof, A. C., Nonhebel, S. & Moll, H. C. (2009 b). Relating the environmental impact of consumption to household expenditures: AN input-output analysis. Ecological Economics, 68, 1160 - 1170.

Kletzan, D., Koppl, A., Kratena, K., Schleicher, S. & Wuger, M. (2002). Modeling Sustainable Consumption. From theoretical concepts to policy guidelines. Empirica, 29, 131 - 144.

Larsen, E. R. (2009). Using inverted Engel curves to estimate material standards of living in a household. Empirical Economics, 36, 109 – 132.

Lins, M. P. E., Silva, A. C. M. & Rosa, L. P. (2002) Regional Variations in energy consumption of Appliances: Conditional Demand Analysis Applied to Brazilian Households. Annals of Operation Research, 117, 235 – 246.

Löfström, E. & Palm, J. (2008). Visualising Household Energy Use in the Interest of Developing Sustainable Energy Systems. Housing Studies 23(6), 935 – 940.

Márquez, M. Y., Ojeda, S. & Hidalgo, H. (2008). Identification of behavior patterns in household solid waste generation in Mexicali's city: Study case. Resources, Conservation and Recycling, 52(11), 1299 – 1306.

Moll,H. C., Noorman, K., Kok, R., Engström, R., Throne-Holst, H. & Clak, C. (2005). Pursuing more sustainable consumption by analysing household metabolism in European Coutries and cities. Journal of Industrial Ecology, 9(1-2), 259 – 275.

Munksgaard, J., Wier, M., Lenzen, M. & Dey, C. (2005). Using input-output analysis to measure the environmental pressure of consumption at different spatial levels. Journal of Industrial Ecology, 9(1-2), 169 - 185.

Noorman, K. J. & Kamminga, K. J. (1998). Reducing residential energy use for a sustainable future: fossil fuel taxation as a tool to reduce energy demand and related CO_2 emissions of Dutch households. Sustainable Development, 6(3), 143 – 153.

Organization for Co-operation and Development (OECD). (2001). Sustainable consumption: sector case study series. Household food consumption: trends, environmental impacts and policy responses. Working Party on National Environmental Policy. Environment Directorate. Environment Policy Committee. Organisation fro Co-operation and Development. ENV/EPOC/WPNEP(2001)13/FINAL.

OECD. (1997). Sustainable Consumption and Production. Paris: Organization for Co-operation and Development.

Ott, W. R. (1978), Environmental Indices - Theory and Practice. Michigan: Ann Harbor Science.

Ojeda-Benítez, S., Armijo-de Veja, S. C. A. & Marquez-Montenegro, Y. (2008). Household solid waste characterization by family socioeconomic profile as unit of analysis. Resources, Conservation and Recycling, 52, 992 – 999.

Qu, X., Li, Z., Xie, X., Sui, Y., Yang, L. & Chen, Y. (2009). Survey of composition and generation rate of household wastes in Beijing, China. Waste Management, 29, 2618 – 2624.

Ramos, T.B. & Caeiro, S. (2010). Meta-performance evaluation of sustainability indicators. Ecological Indicators, 10, 157 – 166.

Sardianou, E. (2007). Estimating energy conservation patterns of Greek Households. Energy Policy, 35, 3778 – 3791.

Saunders, C. (1979). Measures of total household consumption. In Review of Income & Wealth. (pp 351 – 366) Blackwell Publishing Limited.

Schenkel,M., Sturam, D. & Occari, F. (2005). Between transition and enlargement: the composition of consumption in European households. Transition studies review, 12(1), 58 – 73.

Scholderer, J. & Grunert, K. G. (2005). Consumers, food and convenience: the long way from resource constraints to actual consumption patterns. Journal of Economic Psychology, 26, 105 – 128.

Scipioni, A., Mazzi, A., Zuliani, F. & Mason, M. (2008). The ISO 14031 standard to guide the urban sustainability measurement process: an Italian experience. Journal of Cleaner Production, 16, 1247-1257.

Sujauddin, M., Huda, S. M. S & Hoque, R. A. T. M. (2008). Household solid waste characteristics and management in Chittagong, Bangladesh. Waste Management, 28(9), 1688 – 1695.

Sutcliffe, M., Hooper, P. & Howell, R. (2008). Can eco-footprinting analysis e used sucessfully to encourage more sustainable behaviour at the household level? Sustainable Development, 16, 1 – 16.

Takase, K., Kondo, Y. & Washizu, A. (2005). An analysis of sustainable consumption by the waste input-output model. Journal of Industrial Ecology, 9(2), 201 - 219.

UNDESA/UNEP (2010). Proposed input to csd 18 and 19 on a 10-year framework of programmes on SC and production (10YFP ON SCP) Revised Draft (7 April 2010). Document prepared by the Marrakech Process Secretariat: UNDESA and UNEP.

Wiedmann, T., Minx, J., Barrett, J. & Wackernagel, M. (2005). Allocating ecological footprints to final consumption categories with input-output analysis. Ecological Economics, 56, 28 – 48.

Wood, G. & Newborough, M. (2003). Dynamic energy-consumption indicators for domestic appliances: environment, behaviour and design. Energy and Buildings, 35, 821 – 841.

Zacarias-Farah, A. & Geyer-Allély, E. (2003). Household consumption patterns in OECD countries: trends and figures. Journal of Cleaner Production, 11, 819–827.

Zhou, Z., Wu, W., Chen, Q. & Chen, S. (2008). Study on sustainable development of rural household energy in northern China. Renewable & Sustainable Energy Reviews, 12, 2227 – 2239.

Table A1 Household sustainable consumption metrics according to their aims/scope, methodology, domain, target-audience, scale and some comments or drawbacks.

Author	Name, Aims and Scope	Methodology	Theme/Domain	Target audience	Comments/Drawbacks
Baker and Rylatt (2007)	**Prediction of Energy Demand.** The aim is to use an approach using a questionnaire survey, supported by annual data and floor-area estimates to predict how changes in patterns of usage in different types of dwelling can affect energy consumption which is important if efforts to reduce demand and carbon emissions are to be effective.	**Survey:** questionnaire based on the NHER level 1 survey for houses and bungalows and it was postally distributed. **Data-analysis procedure:** annual gas and electricity data and floor-area estimates derived from a GIS plus a two-step clustering technique.	energy	Uk's Government's Energy Review	Clusters of higher and lower energy consumers were discovered and these were related to indicators of energy consumption. Although significant effects of the built-form type were not observable in the data available, the effects of related measurable and countable aspects of form were seen.
Barr *et al*. (2005)	**Household waste management.** This paper examined the structure of waste reduction, reuse and recycling behaviour within the context of wider research on environmental action in and around the home.	The strategy was based on previous work on waste management in Exeter, England. Using a sample of 1265 households from Devon, England, the research examined a range of environmental behaviours, focusing on energy saving, water conservation, green consumerism and waste management. Using **factor analysis**, the data were analysed to examine how the different behavioral variables related to each other.	waste	Economic and Social Research Council (ESRC)	An analysis of the frequency of each of these factorials-defined behaviors revealed that recycling was still the activity most practiced by individuals, with reduction behaviors least popular. This was explored further by the use of cluster analysis, which define four distinctive behavioral types with different demographic characteristics. Accordingly, the research demonstrated that examining waste management behaviors within the context of wider environmental actions could be valuable.
Cai and Jiang (2007)	**Comparison in Energy Consumption between Rural and Urban Households**. The aim is to confirm the prediction of the 'ladder of fuel preferences' theory.	Surveyed the family sizes and economic statuses, as well as the types and quantities of energy consumed from July 2003 to October 2004. They collected the data using three methods: **pre-designed questionnaires, participant observations, participatory rural appraisals.**	energy (different sources)	Chineses policy-makers	Energies used in urban households are more convenient, cleaner, and more efficient than those used in rural areas, where biomass and coal are common fuels. The amount of energy used for entertainment and electrical appliances is greater in urban areas, whereas the quantity used for cooking is larger in rural districts.
Chatterjee and Michelini (1998)	**Household Budget Consumption Data**. The aim is to use data on expenditures and incomes of New Zealand households of different demographic profiles to construct equivalence scales.	**Extended Linear Expenditure System + Data from New Zealand Household Expenditure and Income Survey + Consumption Equivalence Scales**. The survey target population consisted of private households living in permanent dwellings and residing in New Zealand. The sampling design used a two-stage selection method where the first stage consisted of stratified geographical areas and the second was a list of dwellings	food; household operations; apparel; transport	New Zealand Consumers	This was the first attempt at constructing equivalence scales with New Zealand household budget data in the framework of hypothesized utility maximizing behavior of households.

Author	Name, Aims and Scope	Methodology	Theme/Domain	Target audience	Comments/Drawbacks
Comim *et al.* (2007)	**Conceptual Nature of Sustainable Consumption (SC)**. The authors propose that the informational space provided by the capability approach offers a conceptual framework to elaborate SC.	**Capability Approach (CA)**; "building blocks for SC indicators". The CA is employed here (i) as part of a strategy for enhancing quality-of-life and (ii) to investigate the links among the different dimensions of SC.	resource use (not specified)	Policy-makers, consumers	The use of a capability perspective can assist in clarifying procedures for understanding and operating within the issues of SC.
Curran *et al.* (2007)	**Household Waste Disposal**. The aim of the research was to learn how the residents in England recycle and re-use bulky items and to understand how the management of these items is perceived from the point of view of service users.	British researchers performed a **survey of a 1450 households in 3 areas of England**, in order to assess the collection and reuse rate of bulky items in England.	waste (furniture and electrical equipment)	Consumers, policy makers	The researchers concluded that for effective and efficient waste management, it is important to understand the public perception of convenience. The residents are globally satisfied with the national waste management schemes but they think this service should be free of charge
Dahlén *et al.* (2009)	**Household Waste pathways.** The aim was to provide policy-makers and waste management planners with information about how recycling programs affect the quantities of specific materials recycled and disposed of.	Compiling **waste collection data annual recycling reports** from local authorities. A number of different waste collection methods were included in the study. Waste management professionals were interviewed regarding the design of the collection system and collection results.	waste	policy-makers and local waste management	Sixteen sources of error in official waste statistics were identified and the results of the study emphasise the importance of reliable waste generation and composition data to underpin waste management policies.
Delgado and Miles (1997)	**Household characteristics and consumption behavior**. Application of non parametric methods in order to discuss some empirical aspects of household consumption behavious.	First, study the differences in the consumption behaviour between household types. Secondly, derive the functional form for the **food Engel curve**, using specification tests consisted in the direction of nonparametric alternatives. Finally, use this specification to discuss misleading conclusions.	household characteristics (goods, food, alcohol, cloth, domestic fuel, transport, recreation, non-durables)	consumes	Except for food, consumption behavior is not significantly affected by changes in the household characteristics.
Delgado, *et al.* (2007)	**Analysis of household hazardous waste (HHW).** The aim of this work was to determine the dynamics of solid waste generation and to be able to compare the results of both regions, regarding consumption patterns and solid waste generation rates.	In two regions of **Mexico household solid waste was analyzed quantitatively**. In order to perform this analysis, the population was categorized into three socioeconomic strata (lower, middle, upper). The work was carried out in four phases: 1) Selection of sampling areas according to income range of the households; 2) Survey study to determine socioeconomic parameters; 3) Solid waste generation analysis; 4) Hazardous waste characterization.	hazardous waste	environment and public health policy-makers	The study demonstrated that the production of HHW is independent of income level. Furthermore, the composition of the solid waste stream in both regions suggested the influence of another set of variables such as local climate, migration patterns and marketing coverage. Further research is needed in order to establish the effect of low quantities of HHW upon the environment and public health.

Author	Name, Aims and Scope	Methodology	Theme/Domain	Target audience	Comments/Drawbacks
Druckman and Jackson (2008)	**Household Energy Consumption + Household CO_2 Emissions**. Exploration of the patterns of UK household energy use and associated carbon emissions at national level and also at high levels of socio-economic and geographical disaggregation	**Local Area Resource Analysis (LARA) + Output Area Classification (OAC)**. Examination of specific neighborhoods with contrasting levels of deprivation, and typical 'types' of UK. households based on socio-economic characteristics.	energy use; carbon emissions	policy-makers	It is shown that household energy use and associated carbon emissions are both strongly, but not solely, related to income levels. Other factors, such as type of dwelling, tenure, household consumption and rural/urban location are also extremely important.
Druckman and Jackson (2009)	**Carbon Footprint**. The authors present a socio-economically, disaggregated framework for attributing CO_2 emissions to people's high level, functional needs	**Quasi-Multi-Regional Input-Output (QMRIO) Model**: takes into account all CO_2 emissions that arise from energy used in production of goods and services to satisfy UK household demand, whether the emissions occur in the UK or abroad.	CO2 emissions from energy used in production of goods and services to satisfy UK households demand	UK policy-makers	CO_2 emissions attributable to households were 15% above 1990 levels in 2004, and that although absolute decoupling occurred between household expenditure and CO_2 during the UK's switch from coal to gas in the early 1990's, since then only slight relative decoupling is evident. The proportion of CO_2 that arises outside UK borders in support of UK consumption is rising, and reducing these emissions is particularly problematic in a global trading system.
Druckman *et al.* (2008)	**Geographically and socio-economically household consumption model.** This paper presented an approach to household consumption modeling in which the material demands of small socio-economically homogeneous neighborhoods are estimated on the basis of consumer expenditure data in conjunction with census data	**Household waste arising are estimated through incorporation of a household metabolism model.** Local Area Resource Analysis (LARA) model + census data.	waste (households appliances, carpets and clothing)	SC policy-makers and local waste strategy planning	**Limitations:** the study relies on the census data which has a 10-year interval, revealing a static throughout the study period; the use of linear regression to estimate values for 2001 when the conversion values were anomalous; in the model it used an average expenditure to physical unit conversion values for all items within one commodity category.
Fahy and Davies (2007)	**Waste Management Behaviour**. The study builds on research findings from a 3-year project that investigated householders' attitudes and actions with regard to waste in Ireland.	The study was conducted with approximately 2000 participants and involved a **survey, interviews with selected participants and focus groups with young people** in order to understand their perceptions of waste. The final phase consisted in a **household waste exercise** with a selected group of participants **lasting one month**.	waste	policy makers and local communities	One of the main obstacles to improving waste management in households was related to the accessibility of recycling and waste management facilities. Also, the issue of space is a factor influencing household management attitudes and behaviors. There was more resilience to changing purchasing habits leading to the reducing of waste.
Ferrer-i-Carbonell and Van Den Bergh, (2004)	**Consumer Behavior and Decision Making**. The study presents a first econometric analysis of consumption in the context of environmental sustainability	**Econometric and Empirical Analysis of Consumption**. The data used to estimate the models are from the Budget Survey by Statistics Netherlands.	household expenditure (car, travel)	environmental policy makers	The Budget Survey has been running since 1978 but does not follow a panel structure as the household change year by year.

Author	Name, Aims and Scope	Methodology	Theme/Domain	Target audience	Comments/Drawbacks
Firth *et al*. (2008)	**Household electricity consumption trends.** Monitoring study of the electricity of a sample of UK domestic buildings.	**Five minutely average whole house power consumption was recorded** for 72 dwellings at five sites over a 2-year monitoring period. Five-minutely average values of PV system electricity generation, import of electricity from the grid and export of electricity to the grid were recorded by current and voltage sensors and pulsed output meters. Data were collected using loggers installed in a number of the homes and was downloaded on a regular basis via the public telephone network. The data loggers had a constant power draw of 10W and this power consumption was subtracted from the recorded household power consumption where necessary. The monitoring systems were funded by the UK Department of Trade and Industry under the PV Domestic Field Trial Programme and the energy consultants for the sites were Energy for Sustainable Development Ltd.	energy (electricity)	UK Government's Climate Change Bill and Policy-makers	The overall increase in electricity consumption is attributed to a 10.2% increase in the consumption of 'standby' appliances and a 4.7% increase in the consumption of 'active' appliances. The consumption of different energy user groups was also investigated and low and high users are identified as contributing to the overall increase in consumption. The need for further investigation, such as quantitative and qualitative studies, to improve understanding in domestic electricity consumption is discussed.
Gilg and Barr (2006)	**Water Saving Behaviour**. The authors have identified four different types of individuals according to their behavioural characteristics. The main goal of this research was to examine the links between water saving, energy conservation, green consumerism and waste management in and around the home.	British researchers examined the social, attitudinal and behavioural composition of water saving activities using a sample of 1600 households from Devon (UK). The authors used a **14-page questionnaire** that asked a series of questions about "environmental habits" and that included a frequency scale.	water	policy makers	The authors concluded that it is necessary to recognize behavioral complexity in order to ensure that policies and initiatives for water conservation are effective.
Gram-Hanssen (2008)	**Consuming Routines**. Knowledge of how routines develop and change is extremely relevant from a SC perspective.	**Interviews, studies**. The main question is to what extent routines are influenced by the social or the cultural structures of society, including both norms unconsciously carried from childhood, as well as influences from present technology or individual reflection.	energy	Individuals, consumers	Routines are investigated from these three different perspectives: an historical perspective of how new technologies have entered homes, a consumer perspective of how both houses and new technologies are purchased and a user perspective of how routines develop while these technologies are being used
Gram-Hanssen, *et al*. (2007)	**Energy Labels on Buildings**. Understand if energy labels on households provide the homeowners with good incentives to reduce their energy consumption.	**Qualitative, in-depth interviews and surveys** with 10 households in Denmark and 10 households in Belgium.	energy	Consumers, policy makers	The survey shows that personal contact and oral communication with the expert enhances trust in the labeling system and means the label is better understood. Performing similar studies in other countries would consolidate the results of their investigation.

Author	Name, Aims and Scope	Methodology	Theme/Domain	Target audience	Comments/Drawbacks
GrØnhØj (2006)	**Consumer Practices and Behaviour**. The study used quantitative research methods to examine family member interactions in relation to four topics: organic food, water and energy, waste and transport.	**Qualitative Interviews**. One hundred families with children were randomly chosen from the local telephone directory and screened by means of telephone interviews. The aim of this was to recruit informants representative of Danish families in terms of socio-economic background and environmentally oriented consumption habits. In the qualitative interviews, short descriptions of hypothetical choice situations were applied. When using this method, informants were encouraged to respond to a description of a situation in a specific, everyday, easily recognisable context.	organic food, water and energy, waste, transport	consumers	Many green consumer practices involve several family members, who may be able to exert significant influences on household subscription to these practices. Assessing past instances of talks or discussions in a family is not an easy task.
Hal (2007)	**Sustainable Building; Sustainable Housing; Labeling System**. The aim is to prove that sustainable building is NOT more expensive than standard building practice.	**Labeling system** with 8 points of incentives: an overall quality test for housing to make quality a controllable element of the price negotiations; green mortgage, climate mortgage; discount on (property) tax; integration in the Dutch Funda System; private law agreements between the developer and a municipality; objective standards in a design competition; development of affordable and green innovative housing concepts; a green rebuild fund.	energy; health	Dutch housing corporation(s); Netherlands	The research showed that the positive financial aspects are hardly ever used to promote sustainable building. Recommendation to give priority to the introduction of a labeling system that translates sustainability in housing into a manageable and controllable system, this one should clearly identify the level of sustainability of a specific house.
Halme *et al.* (2006)	**Sustainability evaluation of European household services.** Evaluation of household services that contribute to at least two of the three dimensions of sustainable development: environment, social aspects and economy.	The sustainable evaluation method was based on a set of **indicators**	material use, energy use, water use, waste, space use, emissions	household members	It appears that the social effects of the assessed services are larger than their environmental and economic benefits.
Hobson (2003)	**Household Consumption Practices**. This article's focus is on the importance of the consideration of how individuals read and react to SC information.	Giddens' theory that leads to the creation of a framework which emphasizes the importance of 'known' and 'local' information, as well as discursive processes. **Questionnaire** methodology and **interviews**.	energy, water, waste, transport and shopping	household members	There are some doubts over the effectiveness and reliability of questionnaire methodologies
Jensen (2008)	**Household Consumption: Measures and Patterns**. Discussion of the connection between environmental awareness and metering data on household consumption, how families'	**Interviews**. The main intention was to combine maps of social segregation in the city with maps of segregation in consumption in order to illustrate the linkages between lifestyle and consumption. The research has generally been based on an "everyday-consumption" approach, in combination with an exhaustive	energy (electricity, heating); water	individuals, consumers	It is argued that the social structures underlying consumption and green behavior should be recognized in the formulation of environmental policies, and that instead of using sustainable practices such as 'environmental awareness' as a sales argument, more reflexive strategies that take consumers' preferences into account should be

Author	Name, Aims and Scope	Methodology	Theme/Domain	Target audience	Comments/Drawbacks
	understanding of environmental awareness and environmental practices relates to their overall household consumption.	use of household consumption data, as well as lifestyle indicators and building data.			considered
Jeroen and van den Bergh, (2008)	**Effectiveness of Environmental Regulation of Household Behaviour**. To overcome the lack of a firm empirical basis, economic studies in 3 areas of environmentally relevant activities of households were reviewed: residential use of solid waste and recycling, and residential use of water.	**Econometric and Empirical Studies.** Next to price and income elasticities, attention was devoted to individual socio-economic features and psychological factors, such as attitudes, knowledge, perceptions and values.	energy, generation of solid waste and recycling, residential use of water	policy-makers	There are a few empirical studies that systematically combine socio-economic and psychological determinants. A range of insights for environmental policy is derived, and research recommendations are offered.
Katz-Gerro and Talmud (2005)	**Consumption Patterns of Household Expenditures**. The paper proposed a new analysis of consumption inequality using relational methods, derived from network images of social structure.	Combination of the **structural analysis** with **theoretical concerns** in consumer research to propose a relational theory of consumption space, to construct a stratification indicator, and to demonstrate its analytical efficacy with aggregate consumption data. Statistical Surveys	Expenditure patterns	consumers	First, analysis should look at relational patterns between consumption groups in a more empirically refined way, using notions of social topology of consumption space, structural equivalence, and a system of co-determination. Second, due to data limitation, we did not differentiate between individual-level and household-level consumption patterns. Third, the vertical consumption vector should be tested vis-à-vis various life outcomes to establish its validity as a compound indicator of social inequality. Forth, further analyses should explore the ways to which role equivalence recovers the existence of social strata, as manifested on aggregate consumption data, and also examines the ways to which statistical classifications of both social units and consumption categories affect vertical and horizontal dimensions of social hierarchy.
Kerkhof *et al.* (2009 a)	**Comparison between and within countries in household emissions**. The aim was to identify some determinants of national household CO_2 emissions of households in the Netherlands, UK, Sweden, Norway around the year 2000.	**A hybrid approach of process Analysis and Input-Output Analysis** with data on Household Expenditures, was used.	CO_2 emissions of household (12 different categories)	policy makers	A comparison of the national results at the product level points out that country characteristics, like energy supply, population density and the availability of district heating, influence variation in household CO_2 emissions between and within countries.
Kerkhof *et al.* (2009b)	**Relationship between Household Expenditures and the Environmental**	**Input-Output Analysis**, based on product groups purchased by Dutch consumers, expenditure data and environmental impact	household expenditure (food, house, clothing and footwear, hygiene and	policy makers	The environmental impact increases with increasing household expenditures, although the degree to which the environmental impact

Author	Name, Aims and Scope	Methodology	Theme/Domain	Target audience	Comments/Drawbacks
	Impact Categories. Evaluation of the relationships between household expenditures and the environmental impact categories: climate change, acidification, eutrophication and smog formation, by combining household expenditures with environmentally extended input-output analysis.	per consumer.	medical care, development, leisure and traffic, other)		increases differs per impact category. Climate change and eutrophication increase less than proportionally with increasing expenditures. Acidification increases nearly proportionally with increasing expenditures, whereas smog formation increases more than proportionally. It appears that the mix of necessities and luxuries to which an environmental impact is related is essential in explaining the relationships.
Larsen (2009)	**Household consumption expenditure.** The article demonstrates how to estimate latent total consumption expenditure or material standard of living in households by inverting estimated Engel Curves	Derives a variance-minimizing, unbiased estimator by first estimating and inverting Engel curves; then combining the estimators from the inverted Engel curves.	categories of expenditure, i.e. food, clothing, furniture and household equipment	policy-makers	This article demonstrates how it is possible to improve upon current practice in estimating total household consumption expenditure.
Lins *et al.* (2002)	**Energy consumption of appliances.** The paper applies the new technique known as Conditional Demand Analysis (CDA) to estimate consumption of appliances.	**basic model:** linear relationship between electricity consumption in each surveyed household and the ownership of several appliances.	energy	Brazilian National Electricity Conservation Program and Brazilian Electric Utility Companies	They address the need of considering not only appliance ownership but also specific regional consumption differences, when dealing with forecasting and planning. Information given by conditional demand analysis is valuable in forecasting future regional energy and power demands, as well as planning future electrical generating capacity.
Löfström and Palm (2008)	**Household Energy Use**. The aim is to discuss three different methods for visualizing energy use, namely information tools, keeping time-diaries and using 'Power-Aware Cord'	Three different ways of seeking to raise awareness: energy advice directed to households, keeping time-diaries to visualize energy-related behavior and, as an example of a technical solution, the **'Power-Award Cord'**.	energy	Consumers, policy-makers	Each method has its pros and cons, but combining different methods could prove to be a useful way to draw attention to household energy use and the possibilities for energy reduction. By combining the data gained from the different methods, it will be more likely that strategies will be found that are better suited to people's behavior.
Márquez *et al.* (2008)	**Behaviour patterns in Household solid waste generation. The authors** proposed that a strategy of household waste data analysis be used that is based on the WEKA workbench, The data were collected from homes at residential areas in the city of Mexicali, México.	**Sampling procedure + Likert scale development + application of data mining techniques.** The householders were selected using non-random sampling, working on only with those who agreed to participate at every stage of the study.	waste (glass, organics, paper, inert, mixer containers and sanitary)	policy-makers and local waste management	The elements identified on each rule indicate that socio-economic strata are important factors, related to behavioral attributes and consumption habits; the main relationship is based on attributes of waste generation.

Author	Name, Aims and Scope	Methodology	Theme/Domain	Target audience	Comments/Drawbacks
Moll *et al.* (2005)	**Household Energy Metabolism**. This concept was applied to analyzing consumption patterns and to identifying possibilities for the development of sustainable household consumption patterns	Household metabolism was determined in terms of total energy requirements (production, distribution, consumption and waste processing), including both direct and indirect energy requirements, using a **hybrid method (process analysis +input-output analysis)**. This method enables us to evaluate various determinants of the environmental load of consumption consistently at several levels.	energy (food, transport, recreation)	policy makers	Analyses of different types of households are important for providing a basis for options to induce decreases of the environmental load of household consumption. The identification of determining factors that affect change is helpful for governmental, economic and institutional actors in designing approaches and policies aiming at a decrease in the environmental load of household consumption.
Munksgaard *et al.* (2005)	**Environmental Pressure of Consumption**. It shows how the input-output approach can be used to enumerate the problems of SC.	**Input-output analysis + Data Envelopment Analysis (DEA)**. Based on a literature survey the authors present measures of the emissions of carbon dioxide at different spatial levels. Further, the authors take more environmental effects into account and introduce the concept of environmental efficiency by combining input-output modeling and data envelopment analysis	CO_2 consumption and emissions; energy use structure	Policy-makers	It was demonstrated that input-output modeling has a wide range of life-cycle oriented applications when combined with other data sources such as detailed trade statistics, foreign input-output and environmental statistics, and household expenditure data.
Noorman and Kamminga (1998)	**Indirect Energy Use of Households**. The article explores potential relationships between a substantial energy tax - subsidy scheme directed at manufactures and the indirect energy use of Dutch households.	Energy intensities derived from **input-output analyses** and financial data from input-output tables. Data collection from Dutch National Accounts.	(indirect) energy (use), CO_2 emissions	institutions	Two important issues were not addressed: the assumption that the physical output of sectors will not change does not seem to be very realistic and the effect of such economic issues as transaction costs on the reimbursement of the tax revenues and the issue of early depreciation of the technology currently used have not been considered. These two aspects may have a negative impact on the energy conservation potential calculated in this article.
OECD (2001)	**Household Food Consumption.** The case study team's followed common terms of reference to explore trends in household food demand, the economic, demographic and social factors driving these trends, and their environmental impacts, they also briefly explored the policy implications of household food consumption patterns.	The study used the **needs-opportunity-ability model of consumer behavior**, Cumulative energy requirements analysis, Input-output analysis, Hybrid analysis, Life Cycle Assessment, Ecological footprint, Ecological rucksack, Material-flux analysis, Transport related methods	food, direct/indirect environmental impacts from households food consumption patterns (energy, waste generation, transport, greenhouse gas emissions, air and water pollution)	policy makers, decision makers	The report presents the key results from the national case studies and the separate study on methodologies and indicators for estimating household environmental impact.
Ojeda-Benítez *et al.* (2008)	**Solid waste characterization.** The objective of this research was to learn about the composition and quantity of	This research was divided in two phases: the first entailed a sample identification and selection process aimed at obtaining a representative group of suburbs or Basic Geostatistic Areas (AGEB) involving the three	waste	policy-makers and local waste management	Using the results,iti was possible to determine the composition and quantity of solid waste generated by family typology and by socioeconomic stratum. The results showed that the per capita and the average family waste generation varies according

Author	Name, Aims and Scope	Methodology	Theme/Domain	Target audience	Comments/Drawbacks
	solid waste generated by family typology.	socioeconomic strata detailed above. The second stage of this project corresponded to RSW waste characterization and quantification. This phase required Residential Solid Waste (RSW) collection and analysis of field data, as well as the design and layout of a work area where collected solid waste samples were characterized and quantified.			to the family typology and to the socioeconomic stratum where the family belongs. In contrast waste composition did not show any differences, except for some of the categories such as garden waste, newspaper, textiles and disposable diapers, these wastes explain the lifestyles of the generators.
Qu *et al.* (2009)	**Survey of composition and generation rate of household wastes.** This paper presents the results of a survey on household waste generation and composition in Beijing, China. Sample communities were selected by the integration of five indices including family population, income, age and education.	**Determination of samples + implementing the survey + weighing and recording**. To ensure the representativeness of samples, the selected households were geographically scattered and of different socio-economic levels.	waste	household	The survey envisaged covering 113 households. An evaluation of the relationship between daily per capita generation of household waste and socioeconomic factors indicated that household size and income both showed a negative relationship with household waste generation.
Sardianou (2007)	**Energy Conservation Framework for Greece**. Development of an empirical model to investigate the main determinants of household energy conservation patterns in Greece employment cross-section data.	In the **Empirical Analysis**, household energy-conserving choice models were employed, using a discrete and a latent trait variable respectively as a dependent variable. $conserve_i = \alpha_0 + \alpha_1\ age_i + \alpha_2\ sex_i + \alpha_3\ univ_i + \alpha_4\ married_i + \alpha_5\ member_i + \alpha_6\ lninmon_i + \alpha_7\ lnel_i + \alpha_8\ ownh_i + \alpha_9\ typeh_i + \alpha_{10}\ norooms_i + \alpha_{11}\ tm2_i + \alpha_{12}\ infoenv_i + \alpha_{13}\ cresp_i + u_i$	energy	policy-makers	The results show that socio-economic variables are suitable to explain differences towards energy conservation preferences, they also suggest that electricity expenditures and age of the respondent are negatively associated with the number of energy-conserving actions that a consumer is willing to adopt.
Saunders (1979)	**Concept of Total Household Consumption**. The author showed how far figures of total household consumption and its division between collective and private consumption, can, in fact ,be derived, for the advanced countries, from the data provided to the UN *Yearbook of National Accounts*, supplemented by the ICP.	**International Comparison Project (ICP)**. By expenditure on public services, governments provide many goods and services, which are alternatives to, or additional to, household expenditures on consumption. The combination of the two has obvious importance for the measurement and comparison of living standards and for the formulation and analysis of policy.	education; health; housing & community amenities; other social services	policy-makers, consumers	The method is rarely used explicitly in Western national accounts, one reason is the slow progress in the analysis by purpose of government expenditure, and the other is the incomplete data provided by national accounting statistics.
Schenkel *et al.* (2005)	**Household Consumption (HC) Structure**. The aim is to specifically consider the effect of the enlargement of markets, resulting from the	**Discriminatory Analysis**. This was performed on recent data published by OECD and Eurostat, it proposes to address three main questions: if during transition the HC patterns, measured by budget shares, have changed; if	food; furnishing; housing; transports; education and leisure; health, clothing	European households	Between 1995 and 1999 there was certainly a change in the consumption patterns in Eastern European Countries. However, it is not possible to say with certainty whether this process has already come to an end, nor, if it were to continue, what the

Author	Name, Aims and Scope	Methodology	Theme/Domain	Target audience	Comments/Drawbacks
	process of transition in Central and Eastern European countries, on the structure of household consumption.	from this point of view, Central and Eastern European Countries are similar among themselves and do they diverge from Western ones; if today there are any signs of convergence between the two groups of countries.			outcome will be, particularly in respect of the budget shares in real time.
Scholderer and Grunert (2005)	**Behaviour and Consumption.** A model is developed that synthesizes both approaches - the household production and the convenience orientation, assuming that the influence of resource constraints, and then by convenience orientations.	**Model Development:** a random sample of 1000 households was drawn, interviews were conducted personally at home with the participant that (i) did not work in advertising, market research or public relations, (ii) was responsible for food shopping and cooking in the household and (iii) whose age filled the quota.	food	consumers	All effects of perceived resources constraints on store choice and product choice were completely mediated by consumers' convenience orientations. The relationship between objective and perceived resources is rather more complex than often assumed.
Sujauddin *et al.* (2008)	**Household solid waste characterization and management.** This study adequately showed that household solid waste can be converted from burden to resource through segregation at the source, since people are aware of their role in this direction provided a mechanism to assist them in this pursuit exists and the burden is distributed according to the amount of waste generated.	The study involved a structured **questionnaire** and encompassed 75 households from five different socioeconomic groups: low, lower middle, middle, upper middle and high. Wastes, collected from all the groups of households, were segregated and weighed	waste	Urban authorities, local waste management and policy-makers in developing countries	The general community, which is the most important stakeholder in waste management activities, must als take an active part in solving the problems by modifying their behavior patterns for proper Solid Waste Management. Physical composition of the waste shows that there is a mixture of different types of components, with a significant portion of them bein compostable. The study has revealed that the households that have larger earnings generate more waste.
Sutcliffe *et al.* (2008)	**Ecological Footprint**. The EP analysis has the potential to measurably personalize the link between global SC and individual lifestyles.	Questionnaire + Ecological Footprint Analysis	food and energy consumption, transport use, house and garden size, waste production, consumer spending	individuals or the collective household	EFA aggregates a range of individual consumption and waste components and converts them into the bio-productive land area required to support this activity. The results show that EFA can be used at household level to encourage changes in behavior towards less resource intensive lifestyles.
Takase *et al.* (2005)	**Household Sustainable Consumption Patterns**. Estimation of direct and indirect emission loads induced by household consumption according to the WIO model	**Waste Input-Output (WIO) model, based on** goods and services producing sectors, waste-treatment sectors, waste types and waste generation coefficients.	CO_2 emissions; landfill consumption; waste	Japanese households'	The model is applied to some typical SC scenarios: shifting transportation modes, the longer use of household electric appliances, and less cooking at home. The income rebound effects should be considered to evaluate environmental loads induced by different consumption patterns

Author	Name, Aims and Scope	Methodology	Theme/Domain	Target audience	Comments/Drawbacks
Wiedmann *et al*. (2005)	**Ecological Footprint**. Presentation of a method that allows the disaggregation of UK EF by economic sector, detailed final demand category, sub-national area or socio-economic groups	**Combination of National Footprint Accounts with monetary Input-Output Analysis**. This method allows the disaggregation of existing national footprint estimates by economic sector, final demand category, sub-national area, or socioeconomic groups while ensuring full comparability of results. It also may help to extend the potential application of EF concept to inform policies and strategies on SC. . The method involves seven steps: 1 - associate NFA EF of production and imports with industrial sectors; 2 - prepare combined supply matrix; 3 - prepare combined use matrix in basic prices; 4 - calculate direct and indirect requirement matrix; 5 - calculate direct and indirect intensity vectors; 6 - calculate EF of final demand categories; 7 - disaggregate final demand categories	food, electricity and gas distribution, catering services and transport	individuals, organizations, governments and policy-makers	The novelty lies in the use of input-output analysis to re-allocate existing Footprint accounts. This extends the potential for applications of the EF concept and helps to inform scenarios, policies and strategies on SC. The method can be applied to every country for witch National Footprint Account exists and where appropriate economic and environmental accounts are available. Nevertheless the input-output approach is exclusively based on monetary flux between the 76 industrial sectors studied, and does not take into account that actual physical flows of materials and energy.
Wood and Newborough (2003)	**Energy indicators for domestic appliances.** The paper presents the findings of a UK field study involving 44 households which considered domestic cooking: it compares the effectiveness of providing paper-based energy use/saving information with electronic feedback of energy-consumption via Energy-Consumption Indicators (ECI) designed specifically for this investigation.	Twelve **Control Group** households were monitored for a period of at least 12 months. Some of the groups received feedback others received bills as normal.	energy	Consumer, decision maker	The associated behavioral changes and the importance of providing regular feedback during use were identified. It is recommended that further attention be given to optimizing the design and assessing the use of energy-consumption indicators in the home, in order to maximize the associated energy-saving potential.
Zacarias-Farah and Geyer-Allély (2003)	**Household Consumption Patterns**. It shows that environmental impacts from trends in household tourism travel, energy consumption and waste generation will increase, and also identifies some of the most important driving forces behind household consumptions patterns.	**Statistics**. Key facts and figures from OECD Environment's Directorate's 1999-2000 Programme on Sustainable Consumption, which provided new data and analysis on household consumption trends and government policy to promote more SC patterns.	energy consumption, waste generation, tourism travel	governments (policy instruments)	This discussion of consumer decision-making and specific drivers of household consumption suggests a broad web of influences on consumer choices, including for environmentally friendly purchases and behaviors.

Author	Name, Aims and Scope	Methodology	Theme/Domain	Target audience	Comments/Drawbacks
Zhou *et al.* (2008)	**Sustainable development of rural households energy.** Review the evolution of the rural household energy consumption structure in northern China from 1996 to 2005.	Rural household Energy Consumption **Statistical Yearbook of China** (1996-2995) and Statistical Yearbook of China (1996-2005).	energy	policy-makers	Some countermeasures were suggested to overcome the obstacles involved in the sustainable development of rural household energy in northern China, from energy resources to sociopolitical policies.