Kiyo Kurisu

Pro-environmental Behaviors

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Kiyo Kurisu
Department of Urban Engineering
The University of Tokyo
Tokyo
Japan

ISBN 978-4-431-55832-3 ISBN 978-4-431-55834-7 (eBook)
DOI 10.1007/978-4-431-55834-7

Library of Congress Control Number: 2015957996

Springer Tokyo Heidelberg New York Dordrecht London

Printed on acid-free paper

Springer Japan KK is part of Springer Science+Business Media (www.springer.com)

Preface

Environmental problems are common issues that we humans have to address. We should always behave in an environment-conscious manner and endeavor to reduce environmental loading through our behaviors. Some say the best way to achieve this is to develop machines or facilities that can automatically reduce environmental loading, disregarding environmental consciousness and without any effort on our part. Of course, while it is important to develop environment-friendly machines and facilities, we should always keep in mind that any and all of our activities have some environmental impacts on the Earth. It is our responsibility to act with environmental awareness in sharing the Earth with other living things.

Academic studies dealing with pro-environmental behaviors (PEBs) are increasing. Multidisciplinary approaches involving social psychology, education, and environmental engineering are also on the rise. However, despite this, each approach is quite individual and a truly holistic view is still lacking. It is difficult to find a good textbook on PEBs that covers not only environmental engineering but also the social psychology behind PEBs.

This book starts from a consideration of how we define and categorize PEBs (Chap. 1) and offers a holistic viewpoint. It also includes a long list of 200 possible PEBs that can help researchers and students who want to target more PEB options. Chapters 2 and 3 deal with the factors influencing PEBs. Chapter 2 focuses on barriers and accelerators and Chap. 3 summarizes the psychological models for PEBs that have been proposed by various researchers. Chapter 4 shows how to survey PEBs and related factors. Here, the basic concepts behind the design of questionnaires and various questioning techniques are discussed. This book covers not only psychological aspects but also engineering approaches, such as Life Cycle Assessment (LCA). Chapter 5 looks at methodologies to estimate life-cycle environmental loadings of PEBs in the LCA framework. Finally, for a possible implementation of the theoretical analysis to the real world, several ideas to foster PEBs are given in Chap. 6.

This book provides students, researchers and practitioners with a comprehensive overview of PEBs. Offering an in-depth introduction to the fundamental concept as

well as practical academic tools, it serves as an excellent guide for students new to PEB research. The featured scales for questionnaires will be useful for practitioners such as policymakers, as it can aid them in understanding citizens' environmental concerns and actual behaviors. Also included are a behavior list and LCA, which can be used to draft manuals or guidelines for the public to enhance pro-environmental behaviors. Lastly, the case studies presented provide an informative basis for designing public programs and workshops.

Tokyo, Japan Kiyo Kurisu

Acknowledgments

When I was a high school student in 1990, we were asked to write free essays about "the twenty-first century." At the time, global warming was beginning to be recognized as an important and all-encompassing issue and I became very interested in it. For the essay, I wrote that human efforts and behaviors are essential to solve environmental problems. At that point, I started to realize my inclination toward solving environmental problems and I became involved with the academic field of environmental engineering. I really appreciate this opportunity to write about pro-environmental behaviors. I would like to express my sincere appreciation to Dr. Mei Hann Lee at Springer Japan, who gave me the chance to publish this book. I also want to express my deep appreciation to my former supervisor, Prof. Keisuke Hanaki, for our longstanding collaboration on research works at The University of Tokyo. I am also grateful to my life partner, Prof. Futoshi Kurisu, who is a specialist in environmental microbiology but has always encouraged me to move forward in the field of my interest.

Contents

Chapter 1
What Are Pro-Environmental Behaviors (PEBs)?

Abstract This chapter provides an overview of pro-environmental behaviors (PEBs). There is no catchall definition or way to categorize PEBs; therefore, I propose various definitions and ways to categorize PEBs. Two main definitions for PEBs are shown here: purpose oriented and fact oriented. The relationships between these definitions are clearly shown in a diagram. Based on these definitions, narrowly defined PEBs and other definitions can be understood. In addition, based on various aspects, such as place, actor, influential fields, sub-impacts, household PEBs, and repeatability, the possible lower-level categorizations of PEBs are explained. Finally, I summarize behaviors proposed by various environmental agencies and present a list of 200 PEBs. In the list, the main classification is based on the major targets for reduction, such as greenhouse gases, air pollutants, water pollutants, resource consumption, and disturbance of nature, with 12 categories under the main targets, which are standard in many places. Under each category, subcategories are also shown, which can be modified by users.

Keywords Pro-environmental behavior • Definition • Purpose oriented • Fact oriented • Categorization • Place • Actor • Cost and benefit • Repeatability • Household pro-environmental behaviors

1.1 Definition of PEBs

> *Some people may say that "PEBs are behaviors that can contribute to reduction of current environmental burdens." If so, how do activities such as communing with nature fit in? Are these PEBs or not?*

As you can notice, the PEBs have not been clearly defined. In this section, the wider and narrower definitions of PEBs are discussed and the basic concept proposed by this book is explained.

To start with, how do we define "environment"? The basic meaning of the word is "surroundings." However, it does not necessarily give us a clear idea. For example, in a book entitled *Environmental Psychology*, the content matter can be

K. Kurisu, *Pro-environmental Behaviors*, DOI 10.1007/978-4-431-55834-7_1

Table 1.1 Alternative terms for PEB

Term	Count[a] in Google Scholar ([b])	Examples
Proenvironmental behavior	1660 (376)	
Pro-environmental behavior	4970 (4240)	
Environmental behavior[c]	32,400 (17,400)	van Liere and Dunlap (1978)
Ecological behavior	4520 (4090)	Kaiser and Fuhrer (2003)
Environmentally responsible behavior	2920 (1570)	Thøgersen (2004)
Responsible environmental behavior	2390 (915)	Hines et al. (1987)
Environment-friendly behavior	1460 (1580)	
Environmentally significant behavior	1660 (552)	Stern (2000)
Environmentally related behavior	68 (65)	Bamberg (2003)

[a]Count in August 2014
[b]Count for "behavior"
[c]Involving the terminology of behaviors of chemicals or other substances in the environment

of two different types. One would be the psychology of dealing with environmental problems, while the other is a consideration of how people perceive their surroundings, such as heat, light, other people, and so on. The meaning of "environment" that we are targeting here is the former one, which is **"environment" as public goods**, such as the global environment, natural environment, water environment, and so on.

PEBs are sometimes called "ecological behaviors," "environment-friendly behaviors," or other variants, as shown in Table 1.1. The phrase "environmental behavior" appears most frequently. However, this can also refer to the behaviors of chemicals or other substances in the environment as well as to people's behavior. To avoid any confusion, therefore, I use the term "Pro-Environmental Behaviors" (PEBs) in this book.

The definition of PEB has not been clearly delineated. Figure 1.1 shows the main possible definitions of PEB. There are essentially two options to define PEBs: **purpose-oriented** (dotted line) and **fact-oriented** (solid line) definitions. When we consider the purpose of PEBs, the narrow purpose is "conservation of environment" [B], whereas the wide purpose is "cultivation of environmental consciousness" [A]. The behaviors based on purpose [B] can also pursue purpose [A]; therefore, there is an inclusion relation [B] $\subset$[A].

In the case of [A], there is a small difference between the purpose-oriented and fact-oriented parts. The example of communing with nature can be categorized into [A-a], where the behavior is conducted with the purpose of cultivating environmental consciousness and actually contributes to cultivation of environmental consciousness. Some of these behaviors can have spillover effects and also contribute to environmental conservation (overlapped part with [B′]).

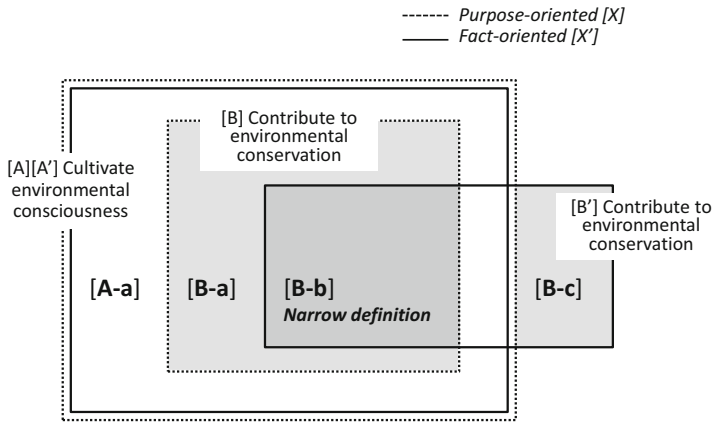


Fig. 1.1 Definition of PEB

On the other hand, in the case of [B], the fact-oriented part (B′) is different from the purpose-oriented part. Some behaviors can contribute to actual environmental conservation ("fact") without any environment-related purposes. For example, if a person chooses the stairs instead of the lift because they are being health conscious, this would be categorized into [B-c], where the behavior is conducted without any purpose relating to environmental consciousness, although it does actually contribute to the reduction of environmental burdens. Besides, some people can be motivated to reduce environmental burdens and conduct their behaviors accordingly, but the environmental burdens cannot be actually reduced, so their behaviors just contribute to the cultivation of environmental consciousness. Those behaviors fall into [B-a] in Fig. 1.1.

The behaviors categorized into [B-b] are **narrowly defined PEBs**. These behaviors are **conducted through the motivation to conserve the environment and actually contribute to environmental conservation**. The borderline between [B-a] and [B-b] is a gray area, especially when the actual environmental burden is not or cannot be evaluated or when trade-offs exist among different kinds of environmental burden (e.g., global warming vs. waste generation) for the target behavior.

Figure 1.2 summarizes the range of PEB definitions. In this book, the **behaviors** categorized into [B′]+[B-a], which **actually contribute or are perceived to contribute to environmental conservation**, are the ones mainly **considered as PEBs**.

Environmental conservation can be differentiated into two categories: **reduction of negative impacts** and **increase of positive impacts,** as shown in Fig. 1.3. These two aspects just seem to be opposite; however, as shown in the figure, the direction from the baseline condition can be different. The reduction of negative impacts through the reduction of environmental loadings from the base condition has been extensively regarded as the main approach of PEBs. However, if we only consider the reduction of environmental burdens, we ignore the positive behaviors, such as "construction of biotopes" and "tree planting." Although these behaviors cannot be

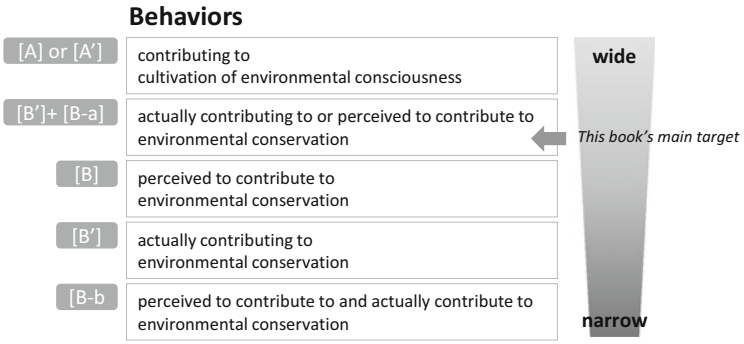


Fig. 1.2 Definition range of PEB

clearly related to the reduction of environmental burden, they can be recognized as behaviors contributing to environmental conservation or enhancement of positive impacts. In this book, we focus mainly on the reduction of negative impacts; however, essentially both categories shown in Fig. 1.3 are considered to be PEBs.

Column 1.1: Is the Narrow Definition of PEBs Enough to Consider?

Where in Fig. 1.1 would we place the behavior of using reusable chopsticks instead of disposable chopsticks? People may conduct this behavior to reduce environmental loading. Therefore, this behavior can be categorized into [B-a] or [B-b]. So, which one?

This can be determined based on the actual environmental loadings. Waste generation may be reduced by using reusable chopsticks. From this viewpoint, the behavior can be categorized into [B-b]. But how about other environmental aspects that might be involved in the manufacture, transport, use, and disposal of the chopsticks, like greenhouse gases, air pollutants, water consumption, and so on? If the use of reusable chopsticks shows a larger environmental loading in some fields, where should we place it? In that sense, if we want to place all behaviors accurately, we should estimate all aspects of the environmental burden and draw Fig. 1.1 for each one.

However, we usually recommend some behaviors as PEBs based just on simple environmental aspects, such as greenhouse gases and waste generation, or sometimes just based on our vague prejudice. Is this wrong or even reprehensible? From the perspective of a narrow definition of PEBs ([B-b]), accurate evidence is necessary. Moreover, in the case where providing accurate knowledge is important, it should be based on quantitative estimation. However, we also have another purpose ([A]) to foster PEBs, and if people can be motivated and increase their environmental consciousness by following some behaviors, this would, to some extent, be meaningful. In that sense, the behaviors that can be categorized into [B-a] can be also considered as PEBs.

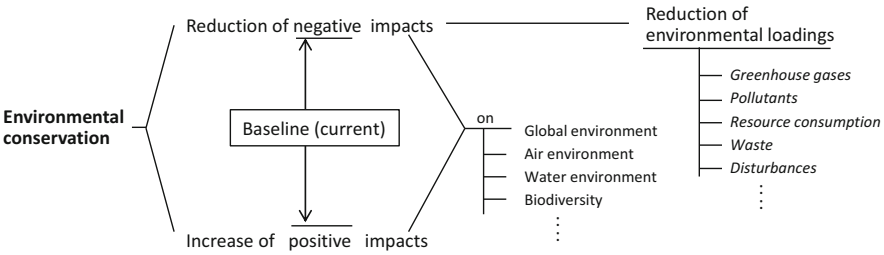


Fig. 1.3 Definition of environmental conservations

1.2 Categorization of PEBs

In this section, possible lower-level categorizations are explained in addition to the definition shown in Fig. 1.1.

1.2.1 Place

PEBs can be categorized by the place where a behavior can be conducted. Figure 1.4 shows the possible categorization by "place." Here, three places, namely, "**home**," "**office/school**," and "**outside**," are used. Although these places mean the physical places where the behavior is conducted, they can also represent the conceptual spaces as "**personal**," "**community**," and "**public**" from the viewpoint of relationship with others. In the case of "home," the relationship with other family members is strong; therefore, the pressure from a close family member would be strong, even though the behavior cannot be seen from outside and the external pressure would be weak. The role of "physical place" limits the possible behaviors. For example, "taking public transport" is a behavior conducted outside. On the other hand, "conceptual space" can determine the influential factors on the behavior; the behaviors conducted outside would be less influenced by important others (by subjective norms) but more influenced by other people's behaviors (by descriptive norms). These psychological factors are explained in detail in Chaps. 2 and 3.

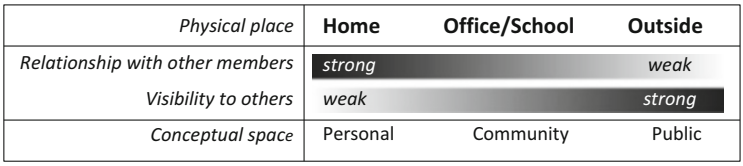


Fig. 1.4 PEB categorization based on "place"

1.2.2 Actor

In addition to individuals, we can also consider groups, such as companies, organizations, and nonprofit organizations (NPOs), as possible actors for PEBs. For example, some companies can conduct tree-planting projects for environmental conservation. However, in this book, individuals are considered as the main target actors for PEBs.

Even among individuals, PEBs can be categorized depending on who undertake them. Some PEBs are conducted mainly by limited groups of people, depending on their jobs or occupations, such as homemakers, caterers, office workers, farmers, manufacturers, etc. For example, women usually show higher practice rates of many PEBs. This can be explained by the greater opportunities to conduct domestic duties, such as cooking and washing.

1.2.3 Influential Fields

Each PEB possesses a different kind of environmental loading reduction. One behavior might focus on waste reduction, while another aims at greenhouse gas reduction. Therefore, PEBs can be categorized based on their targets. As shown in Table 1.2, there are several ways to categorize PEBs. One would be a rough categorization based on the loadings apparently (directly) saved. For example, one PEB can save energy, while another can save water. On the other hand, if we precisely focus on the target impacts, such as global warming, ozone depletion, waste generation, and so on, we should know what kind of impacts can be driven by each PEB. For that purpose, the methodology of life cycle assessment (LCA) can be effectively applied to the estimation of each environmental loading. More details are given in Chap. 5.

Table 1.2 Possible categorization by influential fields

Categorization by	Example of categorization items
Visual savings	Energy, water, waste, etc.
Target environment	Global warming, air, water, soil, nature, etc.
Target impacts	Global warming, acidification, eutrophication, waste generation, water scarcity, resource scarcity, extinction, etc.
Target safeguards	Human health, social property, biodiversity, etc.

Table 1.3 Examples of sub-impacts of PEBs

	Benefit	Cost
Money	*Energy saving* can also save money	For *installing solar panels*, a huge initial cost is required
Health	*Using stairs instead of an elevator* can be good for health	*Limiting meats* is not good for health
Time and effort	*Using a dishwasher* can save time and effort	*Using a broom instead of a vacuum cleaner* needs more time and effort
Taste and comfort	*Using organic products* can improve taste and comfort	*Using organic products* cannot maintain taste and comfort

1.2.4 Sub-impacts: Costs and Benefits

For each PEB, there can be additional costs and benefits in addition to the environmental loading reduction. Cost can involve not only monetary cost but also time and labor. Table 1.3 shows PEB examples of various sub-impacts. For example, with regard to time and comfort, if a broom is used instead of a vacuum cleaner, it can reduce the environmental loading, but more time and effort are required. On the other hand, dishwasher use can save time and effort as well as reduce environmental impacts. The former case is defined as a "trade-off" condition, whereas the latter shows a "win-win" relationship between environment and cost. Thus, fostering PEBs targeting **win-win behaviors is a promising approach**. Table 1.4 shows these relationships.

1.2.5 Categorization of Behavior Type in Households

Food, **clothing**, **and housing** are one way to categorize PEBs conducted within a household. As shown in Table 1.5, it can be also divided into three phases: **purchase**, **usage**, and **disposal**. At the purchase stage, selection of environment-friendly products for each category can be considered. At the usage phase, reduction of energy, water, and waste should be taken into account. Cooking and washing

Table 1.4 Relationships between environment and subcategories

		Environmental loading reduction
Sub-impacts	**Benefit** increase	Win-win
	Cost increase	Trade-off

Table 1.5 PEB examples for food, clothing, and housing at each phase

Category	Phase		
	Purchase	Usage	Disposal
Food	Selection of environment-friendly foods Avoidance of unnecessary packaging Use of reusable shopping bags	Eco-cooking Reusable food storage containers Reusable kitchen cloth Dishwasher use Wiping before washing dishes	Avoidance of food leftovers Avoidance of cooking oil discharge to sewers Composting Milk pack recycling Plastic tray recycling
Clothing	Selection of environment-friendly products Selection of longer-lifetime products	Repair Full load use of laundry	Clothes donation Recycling shop use Bazaar/flea market
Housing	Selection of eco-house Selection of energy-saving appliances Selection of water-saving appliances Selection of eco-car	Energy savings (light, air conditioner, etc.) Water saving (washing, watering, etc.) Repair	Donation of furniture Donation of appliances Recycling shop use

are considered as usage stage for foods. Wearing and washing are similarly considered for clothing. In the case of housing, usage of all equipment in a house is considered. At the disposal stage, reduction of wastes by recycling or donation should be considered.

1.2.6 Repeatability

Another aspect is "repeatability." This means whether the behavior is a **one-time** behavior or **repeatable** one (Table 1.6). Environment-friendly equipment-installation behaviors are mainly categorized as "one-time" PEBs. For example, buying a water-saving washing machine can be one-time behavior. (Of course, after several years, in the case of repurchase, this behavior can be repeated. However, in the

Table 1.6 Categorization of PEBs based on repeatability

Repeatability	Characteristics	Examples
One time	Behaviors conducted once and not frequently repeated *Installation of environment-friendly equipment is an example*	*Solar panel installation* *Purchase of an energy-saving television* *Adjusting the temperature of a refrigerator*
Repeatable	Behaviors conducted several times and frequently repeated *Daily behaviors are examples*	*Reusable shopping bag use* *Decrease of shower time* *Turning the light off when not needed*

sense of "not daily," this behavior can be categorized as "one time.") On the other hand, many daily behaviors are defined as "repeatable" PEBs.

1.3 List of PEBs

Various organizations and researchers provide lists of PEBs. Here is a review of those PEBs proposed by governments and researchers and a list of 200 recognized PEBs.

1.3.1 PEBs Proposed by Governments

Some governments try to encourage people's PEBs to reduce environmental loading. Japan's government launched a campaign running from 2010 to 2012 targeting a 25 % reduction of greenhouse gases called "Challenge 25 Campaign" following the statement by then Prime Minister Hatoyama Yukio in 2009 that Japan aimed to reduce its greenhouse gases by 25% from 1990 levels by 2020. Table 1.7 shows the six proposed categories and examples of PEBs used in the campaign.

Tables 1.8 and 1.9 also show the PEB lists drawn up by the UK Department for Environment Food and Rural Affairs (Defra) and US Environmental Protection Agency (US-EPA), respectively. Defra has developed the framework of PEBs and categorized them based on 12 goals and behavioral areas, such as consumption, food and drink, personal travel, homes and household products, and travel and tourism. The US-EPA list shows that environmental loading reduction and avoidance of citizens' exposure to toxic compounds are also recommended targets.

Tables 1.7, 1.8, and 1.9 list the PEBs with the abbreviation and number of each behavior for this book.

Table 1.7 PEBs proposed by "Challenge 25 Campaign" in Japan (2010–2012)

Categories	Behaviors recommended	Abbrev. in this book	
Ecological life style	Cool Biz[a]	32	Eh-CasuDres
	Warm Biz[a]	32	Eh-CasuDres
	Use of reusable bags instead of disposable ones	117	Eh-RU-ShopBag
	Use of reusable bottles instead of disposable ones	115	Eh-RU-Bottle
	Use of public transportation	67	Eh-PT
	Use of a bicycle	68	Eh-Bicycle
	Proper temperature settings of air conditioner	29	Ap-AC-Temp
	Frequently turning the light off	36	Eh-Lt-Off
	Saving water	91	Wt-Sav
	Frequently turning the faucet off	92	Av-WtRun
	Visualization of CO_2[b]	14	In-Vis
	Eco-drive (idling stop, furl-efficient driving etc.)	59	Eh-Car-EcoDrive
	Eco-cooking (running out of food, microwave use etc.)	153	Eh-Rd-FoodWs
		46	Eco-Cook
Selection of energy-saving products	Replacement of filament bulbs to LEDs	42	P-Lt-LED
	Replacement for energy-saving-type electrical appliances	43	P-EnSav-AppL
	Replacement for eco-cars	62	P-Eco-Car
	Introduction of fuel cells or high-efficiency water heaters	8	In-Eco-Eq
Selection of renewable energy	Installation of solar panels	4	In-Pv
	Installation of solar water heater	6	In-SHeat
	Introduction of wind power	5	In-Wind
	Support for companies using green electricity		
Green buildings and home	Eco-renovation	2	Eco-H
	Eco-building	2	Eco-H
	Introduction of high-efficiency insulator	13	In-Ins
	Introduction of insulated window glass	13	In-Ins
	Introduction of cogeneration system	11	In-Cogene
	Installation of solar panels	4	In-Pv
Support for CO_2 reduction projects	Selection of products based on carbon footprint	54	P-CFP-Pd
	Selection of carbon-offset products	56	P-COffset-Pd
	Consumption of locally produced foods	189	P-Food-Local
Participation in local ecological activities	Participation on environmental events		
	Car sharing	76	Eh-Car-Share
	Bicycle rental	68	Eh-Bicycle
	Parking and riding	75	Eh-ParkRide

[a]Campaigns encouraging casual dress codes to avoid the overuse of air conditioners
[b]Visualization of CO_2 emission by using environmental accounts or real-time navigation system

Table 1.8 Long list of behaviors proposed by Defra, UK (cited from "A Framework for Pro-Environmental Behaviours – Annexes: Annex A")

Behavior group	Behavior goal	Abbrev. in this book	
Energy efficiency/usage in home	Install insulation products	13	In-Ins
	Purchase (and build) energy-efficient homes (new)	2	Eco-H
	Purchase of energy-efficient homes (existing)	2	Eco-H
	Better energy management and usage	21	En-Sav
	Install more efficient heating system	8	In-Eco-Eq
	Install domestic micro-generation through renewables	3	In-En-Renw
	Change energy tariff		
Waste and recycling	Purchase products with a longer life span	133	P-LongLife-Pd
	Reuse, repair, resale	113	Eh-RU
		124	Eh-RP
	Increase recycling (and segregation)	134	Eh-RC
	Buy products with less unnecessary packaging	146	Av-Pack
	Waste less	112	Rd-Ws
	Increase home composting	156	Eh-Comp
Water efficiency/usage in home	Buy water-efficient products	96	P-WtSav-Pd
	More responsible water usage	91	Wt-Sav
Personal transport	Buy/use more energy-efficient (low-carbon) vehicles	62	P-Eco-Car
	Drive more economically	59	Eh-Car-EcoDrive
	Use car less – seek alternatives for short trips (<3 miles)	72	Av-Car
	Travel less/combine travel/car share	76	Eh-Car-Share
	Reduce nonessential flying (short haul)	74	Av-Air
Purchase of eco-friendly products	Buy energy-efficient products	41	P-EnSav-Pd
	Avoid commodities with significant impacts on international biodiversity		
	Eat food locally in season	189	P-Food-Local
		190	P-Food-Season
	Adopt diet with lower GHG/env. impacts		
	Increase purchase of organic or certified/assured food and drink (include fair trade)	192	P-Food-Organic
		194	P-Food-Certif
		191	P-Food-FairTrade
	Buy more certified/assured fish and fish products (instead of noncertified)	194	P-Food-Certif
	Purchase timber products from legal and sustainable sources		
	Buy plants and create habitats that encourage wildlife in the garden	178	Eh-Biotope
	Avoid commodities from unsustainable sources with significant impacts on national and international biodiversity, e.g., from loss of habitats	187	P-Env-Pd

Table 1.9 Behaviors recommended by US-EPA

Categories	Behaviors recommended	Abbrev. in this book	
Saving energy	Turn off appliances and lights when you leave the room	35	Eh-Off
	Use the microwave to cook small meals (it uses less power than an oven)	48	Eh-MWave
	Purchase "green power" for your home's electricity (contact your power supplier to see where and if it is available)	53	P-GrElect
	Have leaky air conditioning and refrigeration systems repaired		
	Cut back on air conditioning and heating use if you can	31	Av-Ac-Use
	Insulate your home, water heater, and pipes	13	In-Ins
Reducing air pollution and greenhouse gas emissions		77	Rd-Air-Pol
		1	Rd-GHGs
Conserving water	Don't let the water run while shaving or brushing teeth	93	Av-WtRun-Tooth
	Take short showers instead of tub baths		
	Keep drinking water in the refrigerator instead of letting the faucet run until the water is cool		
	Scrape, rather than rinse, dishes before loading into the dishwasher; wash only full loads	95	Eh-Wipe-Dish
	Wash only full loads of laundry or use the appropriate water level or load size selection on the washing machine	105	Eh-FuL-Ldry
		107	Ap-DishW-Load
	Buy highly efficient plumbing fixtures and appliances	96	P-WtSav-Pd
	Repair all leaks (a leaky toilet can waste 200 gallons a day)	103	Av-Wt-Leak
	Water the lawn or garden during the coolest part of the day (early morning is best)	109	Eh-Wtring-Cool
	Water plants differently according to what they need. Check with your local extension service or nurseries for advice	108	Ap-Wtring
	Set sprinklers to water the lawn or garden only – not the street or sidewalk	110	Ap-Sprinkler-Use
	Use soaker hoses or trickle irrigation systems for trees and shrubs	108	Ap-Wtring
	Keep your yard healthy – dethatch, use mulch, etc.		
	Sweep outside instead of using a hose		
	Landscape using "rain garden" techniques to save water and reduce storm water runoff		

(continued)

Table 1.9 (continued)

Categories	Behaviors recommended	Abbrev. in this book	
Reducing, reusing, and recycling materials	[Reduce]		
	Buy permanent items instead of disposables	113	Eh-RU-Pd,
		114	Av-Disp-Pd
	Buy and use only what you need	149	Av-Unnec-Pd
	Buy products with less packaging	146	Av-Pack
	Buy products that use less toxic chemicals		
	[Reuse]		
	Repair items as much as possible	132	Eh-Rp
	Use durable coffee mugs	116	Eh-RU-Cup
	Use cloth napkins or towels	122	Eh-RU-KitchCloth
	Clean out juice bottles and use them for water	115	Eh-RU-Bottle
	Use empty jars to hold leftover food		
	Reuse boxes	121	Eh-RU-Container
	Purchase refillable pens and pencils	145	P-Refill-Pen
	Participate in a paint collection and reuse program		
	Donate extras to people you know or to charity instead of throwing them away	124	Eh-RU-ByOthers
	[Recycle]		
	Recycle paper (printer paper, newspapers, mail, etc.), plastic, glass bottles, cardboard, and aluminum cans. If your community doesn't collect at the curb, take them to a collection center	134	Eh-RC
	Recycle electronics	136	Ap-RC-AppL
	Recycle used motor oil	140	Eh-RC-Oil
	Compost food scraps, grass and other yard clippings, and dead plants	156	Eh-Comp
	Close the loop – buy recycled products and products that use recycled packaging. That's what makes recycling economically possible	141	P-RC-Pd
Ensuring safe drinking water, improving indoor air quality			
Using toxics and pesticides safely, reducing your exposure to harmful substances			
Using safer cleaning products, pollution prevention			
Buying and maintaining an environment-friendly house		2	Eco-H
Lawn and garden care, tips for spring			

1.3.2 PEB List

The 200 items summarized in Table 1.10 are based on the behaviors identified by governments and from previous studies. In this table, the main classification is based on the major targets, for example, the reduction of **greenhouse gases**

Table 1.10 PEB list with 200 items (behavior number in each study is shown)

Main[a]target	Abbrev. in this book			Behavior	No. for this book	References[a]				
		Subcategory				1	2	3	4	5
	Category	Subcategory I	Subcategory II			Lee et al. (2013)	Kurisu and Bortoleto (2011)	Kaiser et al. (2003)	Barr et al. (2005)	Aoki et al. (2010)
Rd-GHGs				**Reduction of greenHouse gases**	1					
	Eco-H			Eco-house/building	2					
		In-En-Renw		Installation of renewable energy source	3			8.		
			In-PV	Installation of photovoltaic cells	4			7.		42.
			In-Wind	Installation of wind power	5					45.
			In-SHeat	Installation of solar heat system	6					43.
			In-WoodStv	Installation of wood stove	7					
		In-Eco-Eq		Installation of equipment for efficient energy use	8					
			In-FuelCell	Installation of fuel cell	9					44.
			In-HP-WtHeater	Installation of heat pump water heater	10					
			In-Cogene	Installation of cogeneration system	11					
		In-EnSav-Eq		Installation of energy-saving equipments	12					
			In-Ins	Installation of insulator	13					48.
			In-Vis	Installation of visualization system	14					
			In-HEMS	Installation of home energy management system	15					
			In-BEMS	Installation of building energy management system	16					
		In-Green		Installation of plants (to make shades)	17					
			In-Green-Roof	Installation of rooftop green	18					
			In-Green-Wall	Installation of wall green (such as ivies)	19					
			En-Green-Curtain	Enhancement of green curtain[a] ([a]: see Column 1.2)	20					
	En-Sav			Energy saving	21					
		Ap-Frd-Use		Appropriate use of a fridge	22					
			Av-Frd-Fill	Avoidance of filling up a fridge	23	B1				32.
			Av-Frd-Door	Avoidance of frequent opening and closing of a fridge door	24	B2				
			Ap-Frd-Temp	Appropriate temperature setting of a fridge	25	B3				33.
			Av-Frd-Hot	Avoidance of putting hot foods in a fridge	26	B4				

		Ap-AC-Use		Appropriate use of an air conditioner	27					
			Eh-AC-Filter	Enhancement of filter cleaning of an air conditioner	28	B6				16.
			Ap-AC-Temp	Appropriate temperature setting for air (heat) conditioners	29	B11		9.	EN2	17.
			Eh-AC-Off-Emp	Enhancement of turning the air (heat) conditioner off in empty rooms	30	B54		11.12.	WA1	
			Av-AC-Use	Avoidance of air (heat) conditioner use	31					
			Eh-CasuDres	Appropriate dressing to avoid air conditioner (heat) use	32				EN4	
			Eh-Curtain	Use of curtains for heat cutting	33	B57				20.
			In-Green	Introduction of plants to shade the wall	34					21.
		Eh-Off		Enhancement of frequent turning/plugging off	35					
			Eh-Lt-Off	Enhancement of frequently turning the light off	36	B7			EN5	26.
			Eh-TV-Off	Enhancement of frequently turning the TV off	37	B9				
			Eh-PC-Off	Enhancement of frequently turning the PC off	38					
			Eh-EnSav-Mode	Enhancement of energy-saving mode	39	B10				
			En-PL-Off	Enhancement of frequently plugging off	40	B8				15.
		P-EnSav-Pd		Purchase of energy-saving product	41					
			P-Lt-LED	Purchase of LED (or energy-efficient bulb)	42	B53		1.	EN7	50.
			P-EnSav-AppL	Purchase of energy-saving appliances	43	B41		2.	EN8	51.-53.
		Ap-Ldry		Appropriate laundry	44					
			Av-Ldry-Dry	Avoidance of laundry dryer	45			6.		
		Eco-Cook		Eco-cooking	46					31.
			Ap-Flame	Care about appropriate flame size	47	B56				29.
			Eh-MWave	Enhancement of microwave use	48					
		Av-Electronics		Avoidance of electronic devices	49					
			Av-Lift	Avoidance of electronic lift (stairs use)	50	B5				36.
	Eh-LCarbon			Enhancement of low-carbon society	51					
		P-LCarbon-Pd		Purchase of low-carbon products	52	B48, 49				
			P-GrElect	Purchase/select green electricity	53					40.
			P-CFP-Pd	Purchase of products with carbon footprint	54	B48				
		Eh-COffset		Enhancement of carbon offset	55					40.
			P-COffset-Pd	Purchase of carbon-offset products	56					

(continued)

Table 1.10 (continued)

Main[a] target	Abbrev. in this book			Behavior	No. for this book	References[a]				
		Subcategory				1	2	3	4	5
	Category	Subcategory I	Subcategory II			Lee et al. (2013)	Kurisu and Bortoleto (2011)	Kaiser et al. (2003)	Barr et al. (2005)	Aoki et al. (2010)
Rd-GHGs & Rd-Air-Pol				**Reduction of GHGs and air pollutants**	1+77					
	Ap-Transp			Appropriate transportation	57					
		Ap-Car-Use		Appropriate car use	58					
			Eh-Car-EcoDrive	Enhancement of eco-driving (no idling/fuel-efficient driving)	59	B36, 37		16.-18, 23.		56., 57.
			Eh-Car-Check	Enhancement of regular car check	60	B35				
			Eh-Car-TireP	Enhancement of keeping tire pressure	61	B38				55.
		P-Eco-Car		Purchase of eco-car	62					54.
			P-Car-Hybrid	Purchase of hybrid car	63	B50				
			P-Car-Elect	Purchase of electric car	64					
			P-Car-FuelC	Purchase of fuel-cell car	65					
			P-Car-FuelEff	Purchase of fuel-efficient car	66			24.		
		Eh-PT		Enhancement of public (lower env. loading) transportation	67	B40		15.27.28.		39.
			Eh-Bicycle	Enhancement of bicycle use	68	B39		15.		
			Eh-Walk	Enhancement of walking	69	B39				39.
			Eh-Bus	Enhancement of bus use	70					
			Eh-Rail	Enhancement of railway use	71					
			Av-Car	Avoidance of car use	72	B34		19.20.		
			Av-Taxi	Avoidance of taxi use	73					
			Av-Air	Avoidance of airplane use	74			26.		
			Eh-ParkRide	Enhancement of parking and riding	75					
			Eh-Car-Share	Enhancement of car sharing	76			21.		38.
Rd-Air-Pol				**Reduction of air pollutants**	77					
	Ap-Comb			Appropriate combustion	78					
		Av-OpenB		Avoidance of open burning	79	B58				

Rd-Wt-Pol				**Reduction of water pollutants**	80					
	Av-Pol-Wt			Avoidance of pollutant discharge to water	81					
		Av-Pol-Sewer		Avoidance of pollutant discharge into sewers	82					
			Av-CookOil-Sewer	Avoidance of cooking oil discharge into sewers	83	B22				
			Av-LeftO-Sewer	Avoidance of food leftover discharge into sewers	84			52.		
			Av-Deterg-Use	Avoidance (reduction) of detergent use	85	B23			GC1	
		Av-Pol-PubWt		Avoidance of pollutant discharge to public water bodies	86					
			Eh-Clean-Wt	Enhancement of cleaning up water bodies	87					
			Av-Fertilizer-Use	Avoidance (reduction) of fertilizer use	88					
			Av-AgroChem-Use	Avoidance (reduction) of agrochemical use	89					
Rd-RS-Consp				**Reduction of resource consumption**	90					
	Wt-Sav			Water saving	91					23.
		Av-WtRun		Avoidance of water running	92	B15-17, 20		14.		
			Av-WtRun-Tooth	Avoidance of water running during toothbrushing	93	B15			WA4	
			Eh-Jagged-Dish	Enhancement of jagged water use for dishwashing	94	B19			WA5	
			Eh-Wipe-Dish	Enhancement of wiping before washing dishes	95					
		P-WtSav-Pd		Purchase of water-saving product	96					
			P-WtSav-Ldry	Purchase of water-saving laundry machine	97					
			P-WtSav-DishW	Purchase of water-saving dishwasher	98	B55				
			P/Eh-WatSav-Toilet	Purchase/enhancement of water-saving toilets	99	B18				
		Eh-RU-Wt		Enhancement of water reuse	100					
			Eh-RU-BathWt-Ldry	Enhancement of bathwater reuse for laundry	101					
			Eh-RU-BathWt-Gdn	Enhancement of bathwater reuse for garden	102					

(continued)

Table 1.10 (continued)

Main[a] target	Abbrev. in this book			Behavior	No. for this book	References[a]				
		Subcategory				1	2	3	4	5
	Category	Subcategory I	Subcategory II			Lee et al. (2013)	Kurisu and Bortoleto (2011)	Kaiser et al. (2003)	Barr et al. (2005)	Aoki et al. (2010)
		Av-Wt-Leak		Avoidance of water leakage (repair of leakage)	103					
		Ap-Wt-Load		Appropriate loading selection	104					
			Eh-FuL-Ldry	Enhancement of full load use of laundry	105	B21		3.	EN3	22.
			Av-Dail-Towel	Avoidance of daily towel change (at hotels)	106			5.		
			Ap-DishW-Load	Appropriate load size selection for dishwasher	107					
		Ap-Wtring		Appropriate watering	108				WA8	
			Eh-Wtring-Cool	Enhancement of watering garden/lawn during cool time	109					
			Ap-Sprinkler-Use	Appropriate sprinkler use	110				WA7	
			In-Rain-Harv	Installation of rainwater harvesting	111					46.
	Rd-Ws			Reduction of waste generation	112					
		Eh-RU-Pd = Av-Disp-Pd		Enhancement of reusable product = avoidance of disposable products	113	B33	B4			
					114					
			Eh-RU-Bottle	Enhancement of reusable/returnable glass bottles	115		B11	29.		
			Eh-RU-Cup	Enhancement of reusable cups and tumblers/my cup	116	B27	B12		W1	4.
			Eh-RU-ShopBag	Enhancement of reusable shopping bags/my bag	117	B51	B2	30.32.	GC5	
			Eh-RU-ToothB	Enhancement of (bringing) reusable toothbrush (at hotels)	118					
			Eh-RU-BookC	Enhancement of reusable book cover	119					
			Eh-RU-Paper	Enhancement of backing paper use	120	B32	B6		W2	37.
			Eh-RU-Container	Enhancement of reusable food storage containers (bags)	121	B31	B7			
			Eh-RU-KitCloth	Enhancement of reusable kitchen cloth	122		B8			
			Eh-RU-Battery	Enhancement rechargeable battery	123			43.		
		Eh-RU-ByOthers		Enhancement of reuse by others	124		B10			
			Eh-RU-Shop	Enhancement of recycling shop use	125		B17			

			Eh-Donat-Cloth	Enhancement of clothes donation	126	B26			W8	
			Eh-Donat-Furnit	Enhancement of donation/giving away of furniture	127				W7	41.
			Eh-Donat-AppL	Enhancement of donation/giving away of appliances	128					41.
			Eh-Bazz	Enhancement of bazaar	129					3.
			Eh-FleaM	Enhancement of flea market	130					
		Eh-LongT-Use		Enhancement of long-time use	131					8.
			Eh-RP	Enhancement of repair	132	B45	B5			8.
			P-LongLife-Pd	Purchase of longer-lifetime products	133					
		Eh-RC		Enhancement of recycling	134					
			Ap-RC-Seg	Appropriate segregation of recyclable materials	135	B24		49.	W3-6	1.
			Ap-RC-AppL	Appropriate recycling of appliances	136					
			Eh-RC-MilkP	Enhancement of milk pack recycling	137	B25				2.
			Eh-RC-PTray	Enhancement of plastic tray recycling	138					2.
			Eh-RC-Paper	Enhancement of paper recycling	139	B25		48.		
			Eh-RC-Oil	Enhancement of oil recycling	140					
			P-RC-Pd	Purchase of recycled products	141	B43			GC8, GC9	6.
		P-Refill-Pd		Purchase of refillable products	142	B46	B9	34.		13.
			P-Refill-Shamp	Purchase of refillable shampoo/liquid body soap	143					
			P-Refill-Deterg	Purchase of refillable detergent	144					
			P-Refill-Pen	Purchase of refillable pens	145					
		Av-Pack		Avoidance of package	146		B1		GC4	
			Av-Unnec-Pack	Avoidance of unnecessary package	147	B52	B15			
			P-Meas-Pd	Purchase products sold by measure	148					
		Av-Unnec-Pd		Avoidance of unnecessary products	149					
			P –Nec-Pd	Purchase products only when necessary	150	B44	B16			7.

(continued)

Table 1.10 (continued)

Main[a] target	Abbrev. in this book			Behavior	No. for this book	References[a]				
		Subcategory				1	2	3	4	5
	Category	Subcategory I	Subcategory II			Lee et al. (2013)	Kurisu and Bortoleto (2011)	Kaiser et al. (2003)	Barr et al. (2005)	Aoki et al. (2010)
			Av-Unnec-DM	Avoidance of unnecessary direct mail	151					
			Av-Unnec-ShopBag	Avoidance of unnecessary shopping bag	152			32.		11.
		Eh-RD-FoodWs		Enhancement of food waste reduction	153					24.
			Av-Food-LeftO	Avoidance of food leftovers	154					
			Eh-LResidue-Cook	Enhancement of low-residue cooking	155	B28				
			Eh-Comp	Enhancement of composting	156	B29	B13	50.	W9, W10	28., 47.
		Av-Paper-Use		Avoidance (reduction) of paper use	157					34.
			Eh-DoubleP	Enhancement of double printing	158	B32				35.
			Av-Paper-BookC	Avoidance of paper book cover	159					
			P-Digital-NewsP	Purchase of digital/online newspapers	160					
			P-Digital-Book	Purchase of digital books	161					
		Av-Litter		Avoidance of littering	162					
			Eh-Clean-Litter	Enhancement of cleanup of litter	163					

Rd-Dist-NE = Eh-Pro-NE			**Reduction of disturbance of natural environment = enhancement of natural environment protection**	164 165					
	Av-OvExp		Avoidance of overexploitation	166					
		Av-OvExp-Marine	Avoidance of overexploitation of marine products	167					
		Av-OvExp-Fish	Avoidance of overexploitation of fish	168					
		Av-Juv-Fish	Avoidance of juvenile fish catch	169					
		Av-OvExp-Anim	Avoidance of overexploitation of animals	170					
		Av-OvExp-Plant	Avoidance of overexploitation of plants	171					
	Pro-Bio		Protection of biodiversity	172					
		Av-Foreign-Species	Avoidance of bringing foreign species	173					
		Av-Pet-Release	Avoidance of pet (animals, fish, insects) release into the wild	174					
		Av-Foreign-Plant	Avoidance of bringing foreign plants/seeds to other places	175					
		Pro-Endan-Species	Protection (cultivation) of endangered species	176					
		Pro-Habitat	Protection of habitat	177					
		Eh-Biotope	Enhancement of construction of biotope	178					
		Av-Upermitted-NE	Avoidance of entering unpermitted natural environment	179			55.-57.		
		P-Biodeg-Pd	Purchase of biodegradable products	180			40.		
		Ap-Forest	Appropriate forest management	181					
		Ap-Swid-Agri	Appropriate swidden agriculture	182					
		Av-Unnec-TreeLog	Avoidance of unnecessary tree logging	183					
		Eh-Tree-Plant	Enhancement of tree plantation	184					
		Eh-Forest-Manage	Participation on secondary forest management (cutting of underbrush, raking up fallen leaves, etc.)	185					
		Eh-Nat-Trust	Enhancement of national trust	186					

(continued)

Table 1.10 (continued)

Main[a] target	Abbrev. in this book			Behavior	No. for this book	References[a]				
		Subcategory				1	2	3	4	5
	Category	Subcategory I	Subcategory II			Lee et al. (2013)	Kurisu and Bortoleto (2011)	Kaiser et al. (2003)	Barr et al. (2005)	Aoki et al. (2010)
Others										
	P-Env-Pd			Purchase of environment-friendly products	187					
		P-Food-Env		Purchase of environment-friendly foods	188					
			P-Food-Local	Purchase of foods locally produced	189				GC6	9.
			P-Food-Season	Purchase of foods in season	190			42.		
			P-Food-FairTrade	Purchase of fair trade foods	191				GC10	
			P-Food-Organic	Purchase of organic foods	192	B47			GC3	10.
			P-Food-LAgroChem	Purchase of foods with lower agrochemical use	193					
			P-Food-Certif	Purchase of foods that are environmentally certified	194					
			P-Food-Trace	Purchase of foods with traceability	195					
		P-EcoLabel-Pd		Purchase of products with eco-labels	196	B42		46.		6.
		Av-UnEco-Comp-Pd		Avoidance of unecological companies' products	197			63.		
		Av-OverEnv-Load-Pd		Avoidance of over-environmental loading products	198					
			Av-Bleach-Pd	Avoidance of bleached products	199			44.		
	Endow-Env-Act			Endowment for environmental activities	200			60.		

[a]Behavior number in each study is shown

(Rd-GHGs), reduction of **air pollutants** (Rd-Air-Pol), reduction of **water pollutants** (Rd-Wt-Pol), reduction of **resource consumption** (Rd-RS-Consp), reduction of **disturbance of nature** (Rd-Dist-NE), and others.

Under these main targets, 12 categories are proposed: **eco-house/building** (Eco-H), **energy saving** (En-Sav), **enhancement of low-carbon society** (Eh-LCarbon), **appropriate transportation** (Ap-Transp), **appropriate combustion** (Ap-Comb), **avoidance of pollutant discharge to water** (Av-Pol-Wt), **water saving** (Wt-Sav), **reduction of waste generation** (Rd-Ws), **avoidance of overexploitation** (Av-OvExp), **protection of biodiversity** (Pro-Bio), **purchase of environment-friendly products** (P-Env-Pd), and **endowment for environmental activities** (Endow-Env-Act). These categories are standard in many places.

Under each category, subcategory I shows the rough categorization of PEBs, and subcategory II shows more detailed individual PEBs. These subcategories can be modified by users.

1.3.3 Influential Factors on PEB List

This list of possible PEBs can be changed and should be modified according to the "**place**" and "**time**." Some behaviors cannot be conducted in certain places because of their circumstances. For example, PET bottled drinking water can be avoided in developed countries to reduce environmental loadings, such as waste generation and greenhouse gas emission, whereas it should be recommended in some developing regions to avoid health risks from other water sources. Cultural and political situations and affordability should be also taken into account. "Time" is another factor. The level of technological development can influence the feasible PEBs. The possible options can be changed by the technology available at the time. As seen in the example shown in Fig. 1.5, when only paper pack-type vacuum cleaners are available, the possible PEB would be to use manual sweepers. However, if energy-saving cleaner robots are available, using the robots instead of conventional vacuum cleaners can be a PEB. These factors, to some extent, overlap with personal factors, such as religion, gender, income, and so on. From the list, people can select the possible PEBs based on their personal circumstances.

Figure 1.6 shows the conceptual figure of influential factors. When researchers or policymakers determine the possible PEB list, they should consider the surrounding condition at their target time and place.

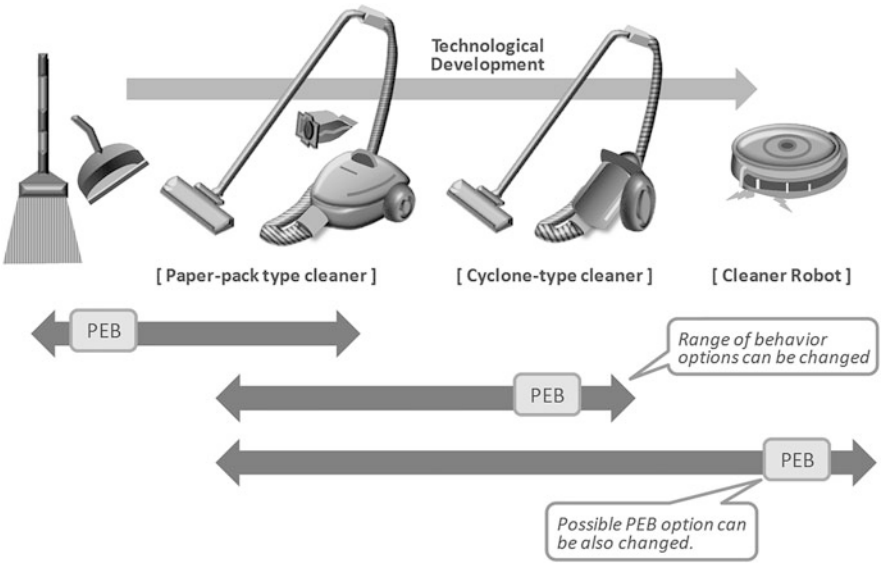


Fig. 1.5 Technological development can change the options of PEBs

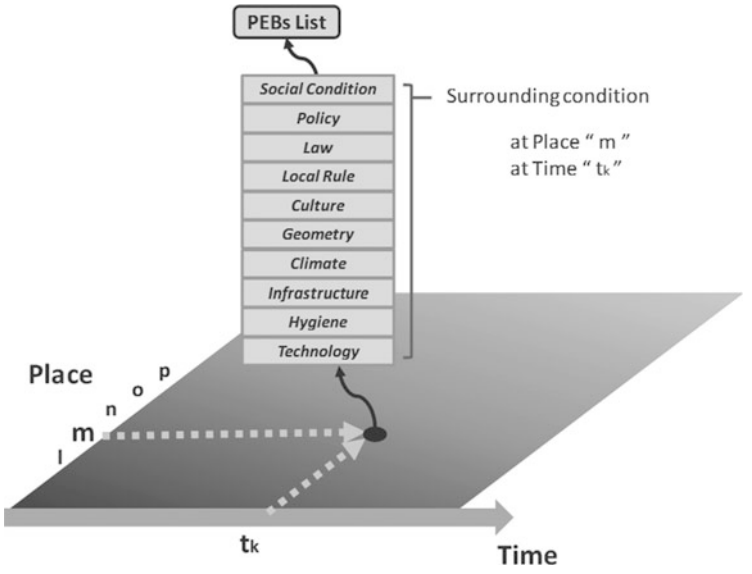
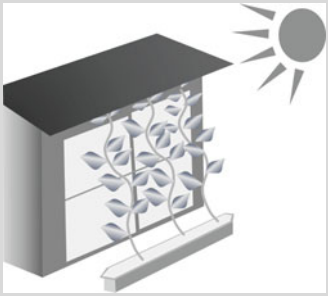


Fig. 1.6 Influential factors to determine the PEB list



Column 1.2: Unique Energy-Saving Campaigns for Summer in Japan

Japan, which has quite hot and humid summers, has run several individual campaigns to save the energy from the use of conditioners.

Green Curtain

One such project that has been proposed is called "Green Curtain."

Many organizations have encouraged citizens to grow climbing plants with large leaves, such as cucumbers and bitter gourds, to shade the walls or windows of buildings in summer. This can lower the indoor temperature and decrease air conditioner use. This campaign has often been featured in schools as one of their environmental education programs.

Cool Biz

Since 2005, the Japanese Ministry of Environment (MOE) has promoted casual business dressing to reduce air conditioner use in offices.

The campaign, called "Cool Biz," has become widespread and various clothing items targeting "(Super-) Cool Biz" come onto the market every summer.

References

Aoki E, Kurisu K, Nakatani J, Hanaki K (2010) Citizen's consciousness, perceived effectiveness and practice of environmental behavior. In: The 9th international conference on ecobalance, B3-1330

Bamberg S (2003) How does environmental concern influence specific environmentally related behaviors? A new answer to an old question. J Environ Psychol 23:21–32

Barr S, Gilg A, Ford N (2005) Defining the multi-dimensional aspects of household waste management: a study of reported behavior in Devon. Resour Conserv Recycl 45:172–192

Defra (Department for Environment Food and Rural Affairs, UK) A Framework for pro-Environmental Behaviours – Annexes. http://archive.defra.gov.uk/evidence/social/behaviour/documents/behaviours-jan08-annexes.pdf

Hines JM, Hungerford HR, Tomera AN (1987) Analysis and synthesis of research on responsible environmental behavior: a meta-analysis. J Environ Educ 18(2):1–8

Kaiser FG, Fuhrer U (2003) Ecological behavior's dependency on different forms of knowledge. Appl Psychol 52(4):598–613

Kaiser FG, Doka G, Hofstetter P, Ranney MA (2003) Ecological behavior and its environmental consequences: a life cycle assessment of a self-report measure. J Environ Psychol 23:11–20

MOE (Ministry of the Environment, Japan), Twenty-five recommended actions in "Challenge 25 Campaign". http://www.challenge25.go.jp/about/25action/index.html#challenge01 (in Japanese)

Kurisu KH, Bortoleto AP (2011) Comparison of waste prevention behaviors among three Japanese megacity regions in the context of local measures and socio-demographics. Waste Manag 31:1441–1449

Lee H, Kurisu K, Hanaki K (2013) Influential factors on Pro-Environmental Behaviors – a case study in Tokyo and Seoul. Low Carbon Economy 4:104–116

Stern PC (2000) Toward a coherent theory of environmentally significant behavior. J Soc Issues 56 (3):407–424

Thøgersen J (2004) A cognitive dissonance interpretation of consistencies and inconsistencies in environmentally responsible behavior. J Environ Psychol 24:93–103

US-EPA (United states Environmental Protection Agency) Protecting the environment >at home and in the garden. http://www.epa.gov/epapages/epahome/home.htm

Van Liere KD, Dunlap RE (1978) Moral norms and environmental behavior: an application of Schwartz's norm-activation model to yard burning. J Appl Soc Psychol 8(2):174–188

Chapter 2
Influential Factors on PEBs

Abstract In conducting PEBs, some factors can work as barriers while others act as accelerators. This chapter summarizes these barriers and accelerators and also explains the influence of psychological factors on PEBs. In the first section (2.1), various reasons to conduct and not to conduct PEBs are listed, and the relationships between the reasons and influential factors are shown. In the second section (2.2), the psychological factors, such as norm, attitude, affect, and cognitive dissonance, are explained. The influence of other factors, such as cost and benefit and knowledge, is explained in the following sections (2.3 and 2.4). In addition to the influence of sociodemographics, such as gender, age, education, and income, on the PEBs and environmental attitudes (Sect. 2.5), the influence of personality is also shown in Sect. 2.6. In the final section (2.7), the influence of situational factors, such as contextual and institutional factors, is explained.

The relationships between these factors can be illustrated by various models, which are described in more detail in Chap. 3.

Keywords Accelerator • Barrier • Norm • Attitude • Knowledge • Sociodemographics • Personality • Situational factors

2.1 Barriers and Accelerators to PEBs

Various studies have reported reasons to conduct or to not conduct PEBs. Table 2.1 summarizes these reasons in relation to possible influential factors. Some reasons are common for all PEBs, while others are specific to certain PEBs. Lee et al. (2013) have categorized PEBs based on these reasons using multiple correspondence analysis (Fig. 2.1). For example, as seen in Fig. 2.1, the behavior of purchasing organic foods (B47 in Lee et al. 2013; no.192 in Table 1.10) is conducted mainly because organic foods are recognized as being good for health ([v] in Table 2.1). The reason for it not being conducted is because of the additional cost compared to ordinary foods ([j]). In their study, Lee et al. concluded that one of the main reasons to conduct PEBs was financial "saving" ([j]).

Steg and Vlek (2009) summarized influential factors on PEBs. As shown in Table 2.2, they divided the factors into **intrapersonal** and **contextual**. They focused not only on the psychological factors but also on surrounding conditions,

K. Kurisu, *Pro-environmental Behaviors*, DOI 10.1007/978-4-431-55834-7_2

Table 2.1 Possible reasons to conduct/not to conduct the target PEB

	Factor	Reasons to conduct	Reasons not to conduct
		Because...	
a	Norm	It is a **rule**	It is **not a rule**
b		It is expected by **other people**	It is not expected by other people
c		It is being done by **other people**	**Nobody** is doing it
d		It is **moral**	It is **amoral**
e	Attitude	It is **environment friendly**	It is **not environment friendly**
f		It is **necessary** behavior	It is **not necessary** behavior
g		It is **good** behavior	It is **not good** behavior
h	Affect	It is **cool**	Is **not cool**
i		I **like** it	I do **not like** it
j	Cost and Benefit	It **saves money**	It **costs [too much] money**
k		It is **beneficial**	It is **not beneficial**
l		**Time** is saved	It is **time consuming**
m		It is **not bothersome**	It is **bothersome**
n	Knowledge	I **know** the **meaning** of the behavior	I **do not know** the **meaning** of the behavior
o		I **know** the **procedure**	I do **not know** the **procedure**
p		I **know** the **effectiveness**	I do **not know** the **effectiveness**
q	Ability	It is **easy** to do	It is **difficult** to do
r	Habit	It is a **habit**	Can be **forgotten**
s	Opportunity	There are many **chances** to conduct	There are **no chances** to conduct
t	Surrounding condition	There are many **products** to **choose from**	There is **no choice** of **products**
u		There are **sufficient facilities**	There are **insufficient facilities**
v	Sub-effect	Is **good** for **health**	Is **not good** for **health**
w		It is **comfortable**	Is **not comfortable**

such as preparedness of facilities or equipment. In Table 2.1, these factors are categorized from [s] to [u].

In the following sections, definitions and characteristics of each factor in Table 2.1 are explained in detail.

2.2 Psychological Factors

The most popular influential psychological factors on PEBs are explained in this section. Other specific psychological factors (e.g., risk awareness, perceived behavioral control, and others) are addressed in Chap. 3 along with behavioral model explanations.

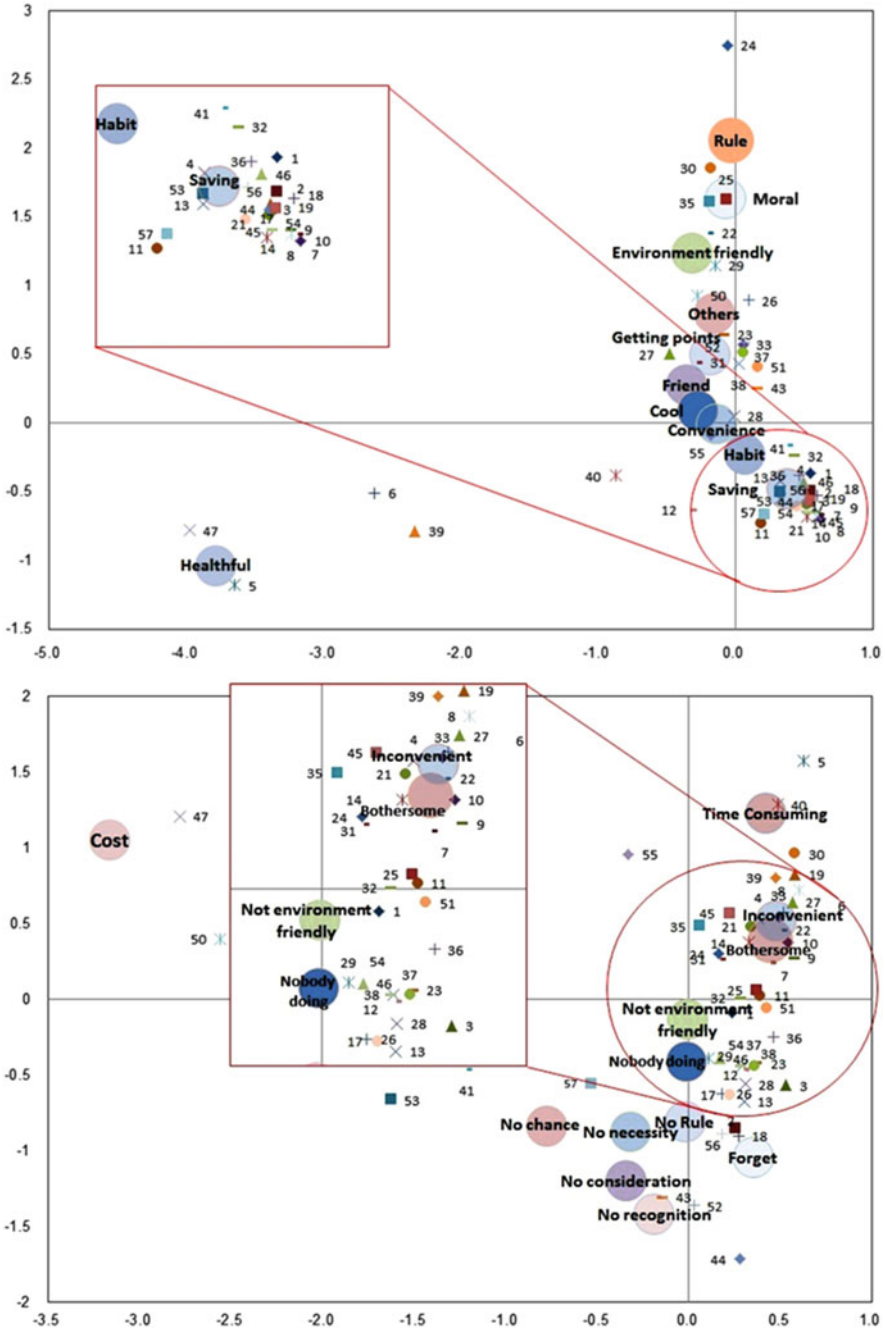


Fig. 2.1 Categorization of PEBs by reason in Seoul: *top*, reasons to conduct; *bottom*, reasons not to conduct (Lee et al. 2013; reused from *Journal of Low Carbon Economy*, which allows free use of materials). For each PEB number, please see Table 1.10

Table 2.2 Influential factors on PEBs

Steg and Vlek (2009)		Categorization in Table 2.1
Intrapersonal factors	Cost and benefit evaluation	j–m
	Norm	a–d
	Affect	h–i
	Attitude	e–g
	Habit	r
Contextual factors	Physical infrastructure	u
	Technical facilities	u
	Availability of products	t
	Product characteristics	

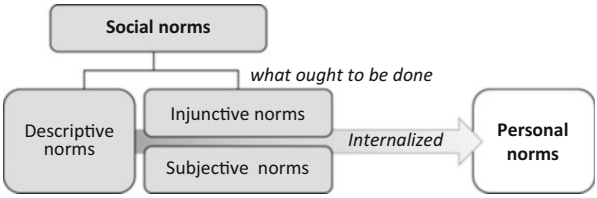


Fig. 2.2 Categorization of norms (Based on Cialdini et al. 1990; Thøgersen 2006)

2.2.1 Norm

"Norm" is considered to be one of the important factors in deciding people's behaviors. The basic dictionary definition of norm is:

> An accepted standard or a way of being or doing things
> (Cambridge Academic Content Dictionary)

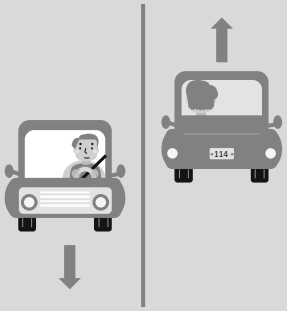
> A generally accepted standard of behaviour within a society, community, or group
> (Oxford Dictionary of Psychology 3rd ed.)

The basic categorization of norms into **social** and **personal** is shown in Fig. 2.2. Although the definition of social norms is not uniform, it can be thought of in general terms as the **behavioral standards shared in a group or society**.

According to Cialdini et al. (1990), social norms are categorized into "what **ought to be done**" (**injunctive**) and "what **is done**" (**descriptive**). Gibbs (1965) describes them as "collective evaluations [which] relate to how one ought to behave" and "collective expectations [which] refer to predictions as to what persons will do." According to Cialdini (2007), "**[i]njunctive social norms** refer. . . to one's perception of **what others believe to be appropriate conduct**." In other words, injunctive norms refer to "rules or beliefs as to what constitutes **morally approved and disapproved** conduct" (Cialdini et al. 1990). On the other hand, the **descriptive norms** refer to **what others do**. As mentioned in Cialdini et al. (1990), "what is approved is often what is typically done, [therefore] it is easy to confuse these two meanings of norms." Essentially, the big difference between these two is that **sanctions** often accompany injunctive norms (see Column 2.1).

Column 2.1: Injunctive Norm vs. Descriptive Norm

The abstract definition of a norm is sometimes quite difficult to understand. An **injunctive norm** is the standard that is **approved** by most people. It is also accompanied by **sanctions**. For example, in some countries, driving on the right-hand side is the approved standard, and anyone breaking this rule faces sanction. In the case, when you conduct this behavior to keep the rule, it can be based on the injunctive norm.



Alternatively, if you find many people to bring their own shopping bags to use in supermarkets and conduct this behavior to follow the other people's behaviors, it can be based on the **descriptive norm**.

The **subjective norm** is subjective perception of social norms and is defined as perception of expectation from others. As mentioned by Park and Smith (2007), "[t]here is some question about the distinctiveness of the subjective norms from the TPB [Theory of Planned Behavior (for details, see 3.1.3)] and the descriptive and injunctive norms from the SNA [social norm approach]." However, many studies have **ascribed the subjective norms** from the TPB **to the injunctive norms** from the **SNA**. Therefore, Ajzen (2006) recommended that in addition to items for subjective norms, items for descriptive norms should be included in questionnaires to aid understanding of the influences of the different two social norms on a behavior.

When a social norm is internalized, a **personal norm** is formed. Personal norms can be **internalized moral rules**, regarded as the perception of correctness or incorrectness of the target behavior. As shown in the next chapter, in several behavioral models, personal norms are considered to be one of the influential factors that determine PEBs. Schwartz (1977) especially proposed the norm-activation model (see Sect. 3.1.1.1 and Fig. 3.1), where personal norm activation is considered as an essential preceding step for altruistic behaviors.

2.2.2 Attitude

"Attitude" is another important factor to explain a wide range of behaviors, including PEBs. There has been a long history of attitude studies dating back to

the early twentieth century. Louis Leon Thurstone (1887–1995) proposed a scale to measure attitude in the late 1920s (Thurstone 1928, 1929). He described attitude as "the sum total of a man's inclinations and feelings, prejudice or bias, preconceived notions, ideas, fears, threats, and convictions about any specified topic." In the 1930s, Gordon Willard Allport (1897–1967), who is famous for studies on personality and prejudice, also conducted several studies on attitude.

Vernon and Allport (1931) tested six types of attitude first proposed by Eduard Spranger (1882–1963), these being: "(1) the theoretical, or interest in the discovery of truth; (2) the economic, or interest in the useful; (3) the aesthetic, or interest in form and harmony; (4) the social, or interest in, and love of, people; (5) the political, or interest in power; and (6) the religious, or desire for comprehension of, and unity with, the cosmos as a whole" (cited from Duffy 1940).

The **ABC (tripartite) model** for attitude was proposed by Harry Charalambos Triandis (b1926), which showed three components: **(A) affect**, **(B) behavior**, and **(C) cognition** (Triandis 1971). Rajecki (1982) explained that "the affective component is essentially the evaluative element in an attitude, on the basis of which the attitude holder judges the object to be good or bad," "behavior represents an intentional element in attitudes," and "cognitions are basically beliefs about the attitudinal object." This ABC model has been widely adopted.

Fishbein and Ajzen (1975) defined "attitude" as "a learned predisposition to respond in a consistently favorable or unfavorable manner with respect to a given object" (Fishbein and Ajzen 1975). They pointed three important features of attitude involved in the above sentence: **consistency**, **predisposition**, and **learned**.

Environmental attitude (EA) has been defined by Hines et al. (1987) as "the individual's feelings, pro or con, favorable or unfavorable, with regard to particular aspects of the environment or objects related to the environment." EA can be divided into two levels: **general environmental attitude** and **attitude toward the PEB**. The former is usually considered as **environmental concern**, which represents the actor's concern with regard to environmental problems. The latter is the actor's specific attitude toward the target behavior. It represents whether an actor recognized the behavior positively or negatively. The attitude toward the behavior can be a more influential factor than general EA on the target behavior.

As shown by the meta-analyses of Hines et al. (1987) and Bamberg and Möser (2007), EA can be one of the significant determinants for PEBs (the details are shown in Sect. 3). However, there are also criticisms about the **gaps between attitude and behavior**. Blake (1999) shows three barriers lying between EA and PEB, **individuality**, **responsibility**, and **practicality**, as shown in Fig. 2.3. In addition to internal barriers, such as individuality, the influence of situational factors, such as practicality, is one of the reasons explaining the gap (see also Sect. 3.1.3).

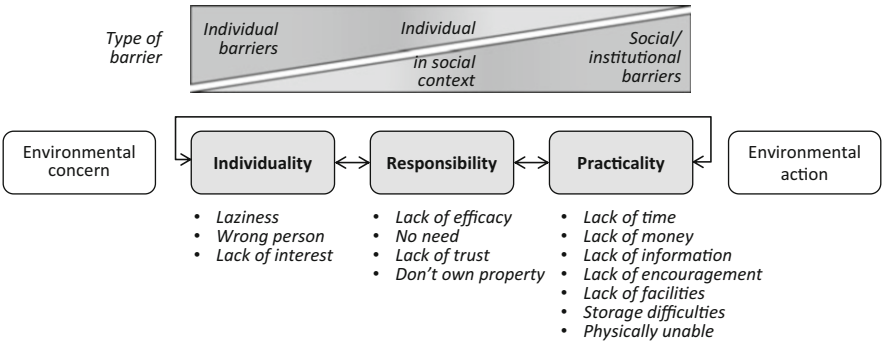


Fig. 2.3 Barriers between environmental concern and action (Blake 1999; reused by permission from *Local Environment* © Taylor & Francis)

2.2.3 Affect

"Affect" has been incorporated into "attitude" in many studies. As Fishbein and Ajzen (1975) stated, "affect is the most essential part of the attitude" and Rajecki (1982) selected affect as one of the three essential components of attitude as well as the ABC attitude model (see 2.2.2). However, Cohen (1990) proposed disentangling affect from attitude. The dictionary definition of affect is as follows:

> Emotion or subjectively experienced feeling, such as happiness, sadness, fear, or anger.
> (Oxford Dictionary of Psychology 3rd ed.)

Cohen et al. (2008) explained that affect is an **internal feeling state**. The influences of affect on behaviors have been investigated mainly in the field of consumer behavior research.

In terms of PEB, the influence of affect has been particularly discussed with regard to car possession and use. Steg (2005) observed that "[a]ffective motives refer to emotions evoked by driving a car, i.e., driving may potentially affect people's mood and they may anticipate these feelings when making travel choices." He measured affect using two aspects shown by Russell and Lanius (1984): "pleasure" and "arousal" (Fig. 2.4). He showed that car use is mainly derived from symbolic and affective motives instead of instrumental motives.

The influence of affect can be stronger in cases where other inner benefits, besides environmental benefits, such as comfort, cuteness, coolness, and so on, are associated with the target PEB. As seen in Fig. 2.1, for example, reasons to use a dishwasher (B55 in Lee et al. 2013) are coolness and comfort; therefore, affective influence may be large for this behavior.

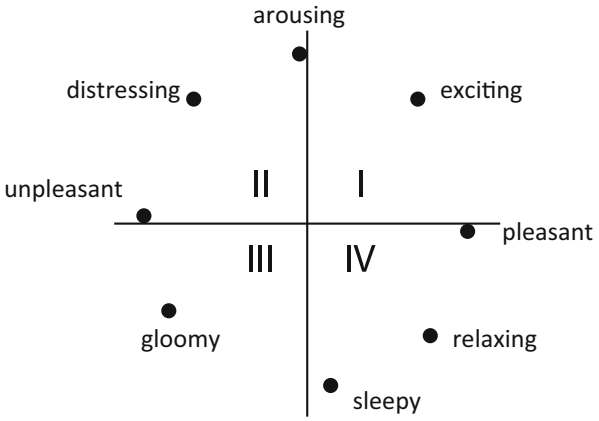


Fig. 2.4 Structural representation of the affective appraisal of environments (Russell and Lanius 1984; reused by permission from *Journal of Environmental Psychology* © Elsevier)

Table 2.3 Effect of monetary cost on PEBs

Act as	Condition	Example
Barrier	Monetary cost is needed for the target PEB	Environmentally conscious products are often more expensive than others
Accelerator	Monetary cost can be saved by the target PEB	Tap water saving results in reduced cost

2.2.4 Cognitive Dissonance

Leon Festinger (1919–1989) proposed the theory of **cognitive dissonance**, which explains the consistency of people's attitudes and behaviors (Festinger 1957). The existence of dissonance makes people uncomfortable; therefore, they tend to **avoid inconsistency** in their attitudes, beliefs, and behaviors.

Thøgersen (2004) discussed that some PEBs share motivational roots and there is a spillover effect from one PEB to another. He tried to explain the correlations of PEBs by cognitive dissonance; people want to keep a consistency in their behaviors, thus practice or intention of one PEB can enhance the practice or intention of another similar PEB.

2.3 Cost and Benefit

2.3.1 Monetary Cost

Monetary cost is one of the critical factors determining PEBs. As shown in Sect. 2.1, Lee et al. (2013) revealed that one of the main reasons to conduct and not to conduct PEBs is monetary cost. As shown in Table 2.3, the monetary cost can act as an accelerator as well as a barrier. If people can save money through PEBs, monetary cost can act as accelerator. One example of cost saving acting as an

accelerator is the significant effect of introducing a charge system for disposable shopping bags on waste reduction, as shown by Kurisu and Bortoleto (2011). On the other hand, people often avoid PEBs that require significant monetary cost.

2.3.2 Time and Effort

In addition to monetary cost, other costs, such as time and effort, can be also influential factors. As seen in Fig. 2.1, many PEBs are placed around the reasons not to conduct them such as "bothersome" and "inconvenient" (Lee et al. 2013). For example, "avoiding discharging used cooking oils" (B21 in Lee et al. 2013; no. 83 in Table 1.10) is placed in the area covered by "bothersome" and "inconvenient" in Fig. 2.1, because discharging used cooking oils into sewers is much easier than collecting and storing them or using an oil absorbent.

2.4 Knowledge

Kaiser and Fuhrer (2003) mentioned that "knowledge" is a **necessary condition** but **not a satisfactory condition** to conduct PEBs. If we don't have enough knowledge about the target behavior, we cannot conduct the behavior. However, even if we have enough knowledge about the behavior, we do not always conduct the behavior.

Kaiser and Fuhrer (2003) categorized environmental knowledge into four types: (1) **declarative**, (2) **procedural** (i.e., action- related), (3) **effectiveness**, and (4) **social**.

Declarative knowledge can be defined as:

> Awareness and understanding of factual information about the world. . ..
> (Oxford Dictionary of Psychology 3rd ed.)

It represents what is the environmental phenomenon or behavior; for instance, what is the ozone depletion phenomenon.

When people act out a behavior, they need to know how to do it. This is the so-called procedural knowledge. Declarative and procedural knowledge are sometimes bound as a single knowledge form (Kaiser and Fuhrer 2003). The influence of procedural knowledge on PEBs has been well investigated for recycling. If people don't know where the segregation boxes are placed or how to segregate, they cannot appropriately conduct the recycling behaviors. This is the reason why the provision of procedural information can foster people's recycling behaviors after a recycling policy is introduced.

Knowledge about effectiveness is knowledge about outcomes of the target behavior. People want to know how much benefit they can get: how much energy is saved or by how much greenhouse gases are reduced by their behaviors. Knowing about the effectiveness of their behaviors can enhance people's behaviors. This

knowledge can be related to psychological variables, such as "awareness of consequences (AC)" in Schwartz's norm-activation model (see Sect. 3.1.1) and "beliefs about consequences of the behavior" in the theory of reasoned action (TRA) model by Fishbein and Ajzen (see Sect. 3.1.2).

2.5 Sociodemographics

Sociodemographics can have direct effects on PEBs and also have indirect effects on PEBs through the influences on psychological factors, such as on environmental attitude (EA).

There have been various studies conducted about relationships between PEBs and sociodemographics; however, we cannot find consistent tendencies because the **influence of sociodemographics varies according to time, social situation, and target PEB**. Besides, it has also been pointed out by many studies that the explained variance for PEBs by sociodemographics is quite small. One outstanding study by Van Liere and Dunlap (1980) concluded that "younger, well-educated, and politically liberal persons tend to be more concerned about environmental quality than older, less educated, and politically conservative counterparts" based on their review of 21 studies from 1968 to 1978 (Table 2.4). However, the results of this review reflect the tendencies of the time (1970s) in developed countries.

Gatersleben et al. (2002) analyzed the influence of sociodemographics and attitudinal variables on PEBs. Their results showed that larger households and older, lower-income people and people with a higher level of education performed more PEBs.

Although the **sociodemographic influence on PEBs may be small and not have been consistently reported in previous studies**, this section explains some influential sociodemographics on EA and PEBs and illustrates some previous outcomes.

2.5.1 Gender

2.5.1.1 Gender Influence on EA

Consistent evidence for the influence of gender on EA has not been found in previous studies (Van Liere and Dunlap 1980). Some researchers reported that males have higher concern than females (Arcury and Christianson 1990), while opposite results have been also shown by other studies (Blaikie 1992; Stern et al. 1993; Schahn and Holzer 1990; Ebreo et al. 1999).

Blaikie (1992) cited one aspect reported by Blocker and Eckberg as follows:

> Blocker and Eckberg (1989) found that women were no more concerned than men about general environmental issues, but were significantly more concerned about local specific issues. In addition, Schahn and Holzer (1990) noted women were more environmentally concerned in those topical areas that refer to household behavior, whereas men knew more about environmental problems.

Table 2.4 Relationships between EA and sociodemographics shown by 1970s studies (Reviewed by Van Liere and Dunlap 1980; modified; reused by permission from *Public Opinion Quarterly* © Oxford University Press)

		(1)							
Ref.		Age	Educ.	Inc.	Occ.	Res. (2)	Gender (3)	Party (4)	Ideol. (5)
(a)	Recycling index	n	p	–	–	–	n	–	–
	Env. future orientation	n	p	–	–	–	n	–	–
(b)	Awareness of env. prob.	n	p	–	–	p	–	p	p
	Support for env. reforms	n	p	–	–	p	–	p	p
(c)	Ameliorative dimension	–	p	–	–	–	–	p	p
	Redirective dimension	–	p	–	–	–	–	n	p/n
(d)	Env. concern (1973)	n	p	p	p	n	p	p	–
	Env. concern (1974)	n	p	p	p	p	n	p	p
	Env. concern (1975)	n	p	p	p	p	p	p	p
	Env. concern (1976)	n	p	p	p	p	p	p	p
(e)	Env. concern index	NR	NR	NR	NR	–	–	p	–
(f)	Awareness of env. prob.	n	p	–	–	–	–	–	–
(g)	Env. ideol. – production	n	p	n	p	–	–	–	–
	Env. ideol. – consumption	n	p	n	p	–	–	–	–
(h)	Env. concern	n	p	p	–	p	–	NR	p
(i)	Import. of pure env.	n	p	–	–	–	–	+	+
	Attainment of pure env.	n	p	–	–	–	–	+	+
	Conservation scale	n	p	–	–	–	–	+	+
	Pollution scale	n	p	–	–	–	–	+	+
	Power plant scale	n	p	–	–	–	–	+	+
	Overpopulation scale	n	p	–	–	–	–	+	+
	Pop. control scale	n	p	–	–	–	–	+	+
(j)	Population scale	n	p	p	n	p	n	n	p
	Pollution scale	n	p	n	p	p	p	p	p
	Resource cons. scale	n	p	n	p	p	p	p	p
	NEP scale	n	p	n	n	p	p	p	p
	Env. funding scale	n	p	n	p	p	p	p	p
	Env. regulation scale	n	p	n	n	p	p	p	p
	Personal behavior scale	p	p	n	p	p	p	p	p
	Public behavior scale	p	p	p	p	n	p	n	p

(continued)

Table 2.4 (continued)

Ref.		(1) Age	Educ.	Inc.	Occ.	Res. (2)	Gender (3)	Party (4)	Ideol. (5)
(k)	Env. behavior index	n	p	–	p	–	–	–	p
(l)	Env. as a prob. (1968)	–	p	p	–	n	–	–	–
	Env. as a prob. (1969)	–	p	p	–	n	–	–	–
	Env. as a prob. (1970)	–	p	p	–	p	–	p	–
(m)	Env. concern scale	NR	p	n	–	–	–	–	p/p
(n)	Pollution value index	n	p	p	p	p	–	+	p
(o)	Air poll. in state	n	p	–	–	p	–	–	–
	Air poll. in community	n	p	–	–	p	–	–	–
	Water poll. in state	–	p	–	–	p	–	–	–
	Water poll. in community	–	p	–	–	p	–	–	–
(p)	Air poll. in state	n	p	–	–	p	–	–	–
	Air poll. in community	n	p	–	–	p	–	–	–
	Water poll. in state	n	p	–	–	n	–	–	–
	Water poll. in community	n	p	–	–	p	–	–	–
(q)	Env. most impt. prob. (1970)	n	–	–	–	p	p	n	–
	Env. most impt. prob. (1972)	n	–	–	–	–	p	n	p
(r)	Env. concern	n	p	p	–	p	n	–	–
(s)	Env. concern	–	p	–	p	–	p	–	–
(t)	Support env. protection	n	p	p	p	–	–	–	–
(u)	Env. concern	n	p	p	–	p	n	–	–

(a) Arbuthnot and Lingg (1977), (b) Buttel and Flinn (1976), (c) Buttel and Johnson (1977), (d) Grossman and Potter (1977b), (e) Koenig (1975), (f) Martinson and Wilkening (1975), (g) Malkis and Grasmick (1977), (h) Springer and Constantini (1974), (i) Tognacci et al. (1972), (j) Van Liere and Dunlap (1978), (k) Weigel (1977), (l) Buttel and Flinn (1974), (m) Constantini and Hanf (1972), (n) Dillman and Christenson (1972), (o) Harris (1970a), (p) Harris (1970b), (q) Hornback (1974), (r) McEvoy (1972), (s) Murch (1974), (t) Murdock and Schriner (1977), (u) National Wildlife Federation (1972)

(1) n, negative correlation; p, positive correlation; – , not analyzed; +, significant differences were found

(2) p means urban residents are more concerned than rural residents

(3) p means females are more concerned than males

(4) p means democrats are more concerned than conservatives

(5) p means liberals are more concerned than conservatives (anti-laissez faire liberalism/welfare state liberalism)

2.5.1.2 Gender Influence on PEBs

The meta-analysis of four PEB studies by Hines et al. (1987) showed insignificant correlations between gender and PEBs (see Table 3.1), and some studies have also shown no gender influence on PEBs. However, other studies have shown significant relationships between gender and PEBs.

Lee et al. (2013) reported that, out of 57 PEBs, the practice rate of females was statistically higher than that of males in 33 PEBs in Seoul and 37 PEBs in Tokyo. They explained this as being because most of the PEBs related to household affairs, which females are usually more engaged in. Aoyagi-Usui et al. (2003) showed that Japanese women were more likely to be positive than men in energy-saving and green-consumer behaviors. Scott and Willtis (1994) also showed that females were more likely to be green consumers. Saphores et al. (2006) demonstrated that women were much more willing to recycle e-waste. Barr (2003) showed that females were more likely to conduct waste prevention behaviors than males, whereas there was no gender influence on recycling behaviors in Exeter, England.

Opposite results are also seen in other studies; Bortoleto et al. (2012) showed a higher practice rate in males in three out of ten of waste prevention behaviors in Sao Paulo. The study by Aoyagi-Usui et al. (2003) showed different results from Japan for the Netherlands, where women were less likely to be positive than men in political and energy-saving behaviors.

2.5.2 Age

2.5.2.1 Age Influence on EA

Three influences on age have been pointed out: "**aging**," "**cohort**," and "**period**" (Blaikie 1992). "Aging" means that people come to think of the society with age, while "cohort" means that people are influenced by what year they were born. The combination of these two aspects can be considered as "period."

Blaikie (1992) investigated the age influence on people's ecological world views. He showed that a middle-aged cohort had the highest ecological world view and explained this because the target age cohort had spent their youth in the late 1960s and early 1970s in Australia and was most susceptible to developing high environmental awareness. His study explained the age influence as "cohort" influence. On the other hand, many studies showed significant correlation between age and EA, meaning "aging/antiaging" influence on EA. Positive correlation was shown by Ebreo et al. (1999) in Champaign–Urbana, USA, where older people demonstrated more concern about nature-related attributes than younger people. Although there are some studies showing positive correlations between age and EA, many studies showed that younger people have more environmental concerns (Van Liere and Dunlap 1980; Arcury and Christianson 1990); this fact represents some antiaging effect; it means that higher awareness in youth can be lost by aging.

Based on these different aspects of age influence, we should carefully interpret our results about the relationships between age and EA.

2.5.2.2 Age Influence on PEBs

Hines et al. (1987) concluded based on 10 previous papers that younger people were slightly more likely to engage PEBs than older people (see Table 3.1). However, many papers show opposite tendencies. Barr (2003) reported that older people were more likely to conduct waste prevention and recycling behaviors. Vining and Ebreo (1990) showed the same tendency for recycling. Kurisu and Bortoleto (2011) showed older people's higher practice rate in 13 out of 18 of waste prevention behaviors in three Japanese megacities. Lee et al. (2013) also showed that older people tended to practice PEBs more than younger people in Seoul and Tokyo. Whitmarsh (2009) demonstrated that older people were more likely to buy energy-saving light bulbs and turn off unused lights in Hampshire, England.

There were some exceptions in these studies. Lee et al. (2013) and Whitmarsh (2009) showed that younger people were more likely to use public transportation (no. 67 in Table 1.10) than older people because of their better mobility and the necessity of commuting. Kurisu and Bortoleto (2011) showed that respondents in their 60s showed significantly lower practice rates than respondents of other ages for "own cup use" (no. 116 in Table 1.10). The reason could be that "the trend of using my cup or tumbler at offices and coffee shops (e.g., Starbucks) has spread especially among younger ages in Japan." They also showed that people in their 30s and 40s showed a higher practice rate of "recycling shop use" (no. 125 in Table 1.10) than others, because they had young children and would often use recycling shops and free markets to donate clothes and toys or buy temporary necessary equipment.

As seen in this section, there are some contradictions in age influences on EA and PEBs. Younger people may have a higher environmental consciousness and passion, as shown by some studies; however, this cannot connect with actual behaviors. There is a gap between attitude and actual behavior (see Sect. 2.2.2). One possible reason for this is the influence of situational factors, but other uncertainties can also exist. For predicting PEBs, attitude toward the target behavior is a more reliable determinant than general environmental attitude (EA).

2.5.3 Education and Income

Educational and income levels are sometimes integrated into one social-level factor; these are therefore explained together in this section. However, it should be carefully investigated before interpretation of your results as to whether correlations between income and age or income and education exist for your target

samples. If there is a strong correlation, you should interpret carefully which factor is likely to be the main determinant for the target behavior (see Column 4.4).

2.5.3.1 Education and Income Influences on EA

Van Liere and Dunlap (1980) showed the consistent influence of educational level on EA; a higher educational level showed a higher EA, as seen in Table 2.4. O'Connor et al. (1999) also showed a positive correlation between educational level and intention of PEBs. On the other hand, the opposite tendency was seen by Ebreo et al. (1999), who showed that people with higher education had a lower level of nature-related attributes.

Unlike education, the influence of income on EA has not been consistent in previous studies (Van Liere and Dunlap 1980).

2.5.3.2 Education and Income Influences on PEBs

Hines et al. (1987) reported average positive correlations between income and PEBs as well as education level and PEBs (see Table 3.1). This suggests that people with a higher income and a higher level of education are slightly more likely to engage in PEBs. Scott and Willtis (1994) also showed that higher education and higher income were associated with higher PEBs.

Bortoleto et al. (2012) showed that individuals with a graduate level of education were more inclined to engage in home composting than other educational levels. They also showed that those with higher incomes were more likely to engage in waste prevention behavior by reusing things and taking their own bags to supermarkets. Oskamp et al. (1991) showed that recyclers have higher family incomes than non-recyclers. Their results also showed slightly higher education level in recyclers, but it was not statistically significant. Similarly, Whitmarsh (2009) showed insignificant correlation between education and energy conservation behaviors.

2.6 Personality

2.6.1 Influence on EA

Borden and Francis (1978) discussed the influence of personality on EA. They characterized the environmentally concerned person as someone who has **high personal control, high future perspective**, and **high responsibility** and **low authoritarianism and protestant ethics, low generalism** (rather than being a thing specialist), and **low androgyny** (rather than having a traditional sex

orientation). As seen in Van Liere and Dunlap (1980), liberalism was considered as one of the influential personality traits on EA at that time.

2.6.2 *Influence on PEBs*

Some studies have reported the influence of personality on PEBs. Arbuthnot (1977) evaluated the influential factors on the use of recycling centers. He revealed that recyclers showed lower scores on the "general **conservatism**" and "lack of **personal control**" factors. It indicated that the recyclers were more **liberal** and relied on their abilities to have control over events. Scott and Willtis (1994) also showed that liberalists were more likely to conduct PEBs. However, the influence of personality would be an indirect effect through EA in these cases. Besides, the influential personality on PEBs can change with the times; when pro-environmental activities were not common, being popular only for liberal people, liberality was one of the important personalities to determine the PEBs. However, when environmental issues become quite common for most people, liberality is not an influential factor.

"**Locus of control**" was first proposed by Julian Rotter (1916) as the personality measure about how much people think outcomes depend on their own actions (Rotter 1966). Locus of control is a bipolar concept, consisting of "**external control**" and "**internal control**." The belief that events can be controlled by external forces, such as fate or gods, is a belief in external control. If people think events can be driven by their own behaviors, that is a belief in internal control. This aspect has been considered as one of the influential factors on PEBs. Hines et al. (1987), for instance, showed that locus of control is one of the personality factors that determine the intention of PEBs (see Sect. 3.2.5.1).

Other general personality aspects, such as cultural theory, are explained in Chap. 4, where questionnaire items are shown.

2.7 Situational Factors

As shown in Table 2.2, in addition to intrapersonal factors, contextual factors, such as preparedness of facilities or equipment and product availability, can be also influential factors on PEBs.

Oskamp et al. (1991) showed that recyclers were invariably **homeowners**. Ebreo et al. (1999) also showed a significant influence of housing type on their EA and recycling behaviors. For recycling, for instance, storage space for segregated materials is needed; therefore, house type and size can be important influential factors. Again for space reasons, composting behavior has been shown to be influenced by house type (Tucker and Speirs 2001). Kurisu and Bortoleto (2011) demonstrated that people living in **detached houses** showed significantly higher

practice rates for composting behavior than those living in other housing types. Similarly, installation of eco-facilities, such as solar panels and wood stoves, can be also influenced by house type.

Lee et al. (2013) explained that the higher practice rate of recycling secondhand clothes in Seoul (B26 in Lee et al. 2013; no. 126 in Table 1.10) than in Tokyo was because **collection boxes** were placed beside daily curbside waste collection boxes in Seoul, making the practice very easy, whereas people in Tokyo needed to take old clothes to department stores or recycling shops. Saphores et al. (2006) showed similar results for e-waste; they showed that in California the closer a drop-off e-waste center, the higher the probability of willingness to recycle. Thus, installation of recycling boxes has been considered as one of the influential factors on recycling behavior.

Institutional factors can explain regional differences between PEB practices. In regions where public transportation is not well provided, people cannot select a public transportation option. Kurisu and Bortoleto (2011) compared the waste prevention behaviors in three megacity regions in Japan. They showed extremely high practice rate of using own shopping bags (no. 117 in Table 1.10) in Aichi prefecture where the charging of plastic shopping bags occurred in most cities and towns. The same effect of introducing a **charging system** for disposable shopping bags has been reported in several studies (Ueta and Koizumi 2001; Convery et al. 2007; Lee et al. 2013). Instead of a charging system, some regions have reward systems, such as **subsidies** and **deposits**, which can also enhance PEBs. For example, if shops charge deposit money for beer or milk bottles, people tend to return the bottles to claim back their deposit and the reuse rate is enhanced (no. 117 in Table 1.10). When subsidies for eco-facilities, such as solar panels and composting machines, exist in a region, it can enhance the installation of those facilities there.

In the case of product selection, **availability** is an important influential factor. For instance, no matter how much you might want to use refillable products, you are unlikely to use them if the closest supermarket doesn't offer refillable items so would have to travel further afield.

Kollmass and Agyeman (2002) also pointed out **social and cultural** influences. They hypothesized that "cultures in small, highly populated countries such as Switzerland and The Netherlands tend to be more resource conscientious than societies in large, resource-rich countries, such as the USA." Ando et al. (2010) compared PEBs between Japan and Germany and pointed out that Japanese subjective norm influences were stronger than German ones. Many other studies also showed that Japanese people care so much about what others think in their culture; the subjective norm effect of this on behaviors is much larger than in other cultures (Abrams et al. 1998; Ando et al. 2007; Lee et al. 2013). On the other hand, Pieters (1989) showed an insignificant influence of social norms on recycling in the Netherlands, the reason being explained by the cultural background and value system. Zheng (2010) reported different environmental consciousness and PEB patterns in East Asian cities. They also examined the influence of different value systems on environmental consciousness in East Asian countries (Zheng

et al. 2006). Hence, when we conduct a cross-national study, we need to consider not only institutional factors but also cultural and value differences.

References

Abrams D, Ando K, Hinkle S (1998) Psychological attachment to the group: cross-cultural differences in organizational identifications and subjective norms as predictors of workers' turnover intentions. Personal Soc Psychol Bull 24:1027–1039

Ajzen I (2006) Constructing a TpB questionnaire: conceptual and methodological considerations. Available at: http://www.unibielefeld.de/ikg/zick/ajzen%20construction%20a%20tpb%20questionnaire.pdf

Ando K, Ohnuma S, Chang EC (2007) Comparing normative influences as determinants of environmentally-conscious behavior between the U.S. and Japan. Asian J Soc Psychol 10:171–178

Ando K, Ohnuma S, Blobaum A, Matthies E, Sugiura J (2010) Determinants of individual collective pro-environmental behaviors: comparing Germany and Japan. J Environ Inf Sci 38 (5):21–32

Aoyagi-Usui M, Vinken H, Kuribayashi A (2003) Pro-environmental attitude and behaviors: an international comparison. Hum Ecol Rev 10(1):23–31

Arbuthnot J (1977) The roles of attitudinal and personality variables in the prediction of environmental behavior and knowledge. Environ Behav 9(2):217–232

Arcury TA, Christianson EH (1990) Environmental worldview in response to environmental problems: Kentucky 1984 and 1988 compared. Environ Behav 22:387–407

Bamberg S, Möser G (2007) Twenty years after Hines, Hungerford, and Tomera: a new meta-analysis of psycho-social determinants of pro-environmental behavior. J Environ Psychol 27:14–25

Barr (2003) Strategies for sustainability: citizens and responsible environmental behavior. Area 35 (3):227–240

Blaikie WH (1992) The nature and origins of ecological world views: an Australian study. Soc Sci Q 73(1):144–165

Blake J (1999) Overcoming the 'value.action gap' in environmental policy: tensions between national policy and local experience. Local Environ 4(3):257–278

Blocker TJ, Eckberg DL (1989) Environmental issues and women's issues: general concerns and local hazards. Soc Sci Q 70:586–593

Borden RJ, Francis JL (1978) Who cares about ecology? Personality and sex differences in environmental concern. J Pers 46(1):190–203

Bortoleto AP, Kurisu KH, Hanaki K (2012) Model development for household waste prevention behavior. Waste Manag 32(12):2195–2207

Cialdini RB (2007) Descriptive social norms as underappreciated sources of social control. Psychometrica 72(2):263–268

Cialdini RB, Reno RR, Kallgren CA (1990) A focus theory of normative conduct: recycling the concept of norms to reduce littering in public places. J Pers Soc Psychol 58(6):1015–1026

Cohen JB (1990) 7. Attitude, affect, and consumer behavior. In: Moore BS, Isen AM (eds) Affect and social behavior. Cambridge University Press, Cambridge, pp 152–206

Cohen JB, Pham MT, Andrade EB (2008) The nature and role of affect in consumer behavior. In: Haugtvedt CP, Herr PM, Kardes FR (eds) Handbook of consumer psychology (marketing and consumer psychology). Psychology Press, New York, pp 297–348

Convery F, Mcdonnell S, Ferrera S (2007) The most popular tax in Europe? Lessons from the Irish plastic bags levy. Environ Resour Econ 38:1–11

Duffy E (1940) A critical review of investigations employing the Allport-Vernon Study of Values and other tests of evaluative attitude. Psychol Bull 37(8):597–612
Ebreo A, Hershey J, Vining J (1999) Reducing solid waste: linking recycling to environmentally responsible consumerism. Environ Behav 31(1):107–135
Festinger L (1957) A theory of cognitive dissonance. Stanford University Press, Stanford
Fishbein M, Ajzen I (1975) Belief, attitude, intention, and behavior: an introduction to theory and research. Addison-Weseley, Reading (out of print, accessible online at http://people.umass.edu/aizen/f&a1975.html)
Gatersleben B, Steg L, Vlek C (2002) measurement and determinants of environmentally significant consumer behavior. Environ Behav 34(3):335–362
Gibbs JP (1965) Norms: the problem of definition and classification. Am J Sociol 70(5):586–594
Hines JM, Hungerford HR, Tomera AN (1987) Analysis and synthesis of research on responsible environmental behavior: a meta-analysis. J Environ Educ 18(2):1–8
Kaiser FG, Fuhrer U (2003) Ecological behavior's dependency on different forms of knowledge. Appl Psychol 52(4):598–613
Kollmass A, Agyeman J (2002) Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? Environ Educ Res 8(3):239–260
Kurisu KH, Bortoleto AP (2011) Comparison of waste prevention behaviors among three Japanese megacity regions in the context of local measures and socio-demographics. Waste Manag 31:1441–1449
Lee H, Kurisu K, Hanaki K (2013) Influential factors on pro-environmental behaviors – a case study in Tokyo and Seoul. Low Carbon Econ 4:104–116
O'Connor RE, Bord RJ, Fisher A (1999) Risk perceptions, general environmental beliefs, and willingness to address climate change. Risk Anal 19(3):461–471
Oskamp S, Harrington MJ, Edwards TC, Sherwood D, Okuda SM, Swanson DC (1991) Factors influencing household recycling behavior. Environ Behav 23(4):494–519
Oxford Dictionary of Psychology (3rd ed), (2009) Andrew, M Colman (eds) Oxford University Press, 882 p
Park HS, Smith SW (2007) Distinctiveness and influence of subjective norms, personal descriptive and injunctive norms, and societal descriptive and injunctive norms on behavioral intent: a case of two behaviors critical to organ donation. Hum Commun Res 33:194–218
Pieters R (1989) Attitudes and behavior in a source-separation program: a garbology approach. Eburon, Delft, 207p. https://pure.uvt.nl/portal/files/990269/ATTITUDE.PDF
Rajecki DW (1982) Attitudes, themes and advances. Sinauer Associates Inc., 302 p
Rotter JB (1966) Generalized expectancies for internal versus external control of reinforcement. Psychol Monogr: Gen Appl 80(1):1–28
Russell JA, Lanius UF (1984) Adaptation level and the affective appraisal of environments. J Environ Psychol 4:119–135
Saphores J-DM, Nixon H, Ogunseitan OA, Shapiro AA (2006) Household willingness to recycle electronic waste- an application to California. Environ Behav 38(2):183–208
Schahn J, Holzer E (1990) Studies of individual environmental concern: the role of knowledge, gender, and background variables. Environ Behav 22(6):767–786
Scott D, Willtis FK (1994) Environmental attitudes and behavior: a Pennsylvania survey. Environ Behav 26(2):239–260
Schwartz SH (1977) Normative influences on altruism. In: Berkowitz L (ed) Advances in experimental psychology, vol 10. Academic Press, pp 221–279
Steg L (2005) Car use: lust and must. Instrumental, symbolic and affective motives for car use. Transp Res A 39:147–162
Steg L, Vlek C (2009) Encouraging pro-environmental behaviour: an integrative review and research agenda. J Environ Psychol 29:309–317
Stern PC, Dietz T, Kalof L (1993) Value orientations, gender, and environmental concern. Environ Behav 25(3):322–348

Thøgersen J (2004) A cognitive dissonance interpretation of consistencies and inconsistencies in environmentally responsible behavior. J Environ Psychol 24:93–103
Thøgersen J (2006) Norms for environmentally responsible behaviour: an extended taxonomy. J Environ Psychol 26:247–261
Thurstone LL (1928) Attitudes can be measured. Am J Sociol 33(4):529–554
Thurstone LL (1929) Theory of attitude measurement. Psychol Rev 36(3):222–241
Triandis HC (1971) Attitude and attitude change. Wiley, New York, 232 p
Tucker T, Speirs D (2001) Understanding home composting behaviour – a technical monograph. University of Paiseley, Scotland. ISBN 1-903978-07-6
Ueta K, Koizumi H (2001) Reducing household waste – Japan learns from Germany. Environment 43(9):20–32
Van Liere KD, Dunlap RE (1980) Social bases of environmental concern: a review of hypotheses, explanations and empirical evidence. Public Opin Q 44:181–197
Vernon PE, Allport GW (1931) A test for personal values. J Abnorm Soc Psychol 26(3):231–248
Vining J, Ebreo A (1990) What makes a recycler? A comparison of recyclers and non-recyclers. Environ Behav 22(1):55–73
Whitmarsh L (2009) Behavioural responses to climate change: asymmetry of intentions and impacts. J Environ Inf Sci 29(1):13–23
Zheng Y (2010) Association analysis on pro-environmental behaviors and environmental consciousness in main cities of East Asia. Behaviormetrika 37(1):55–69
Zheng Y, Yoshino R, Murakami M (2006) An analysis on attitudes toward nature and environment in East Asia – main factors in formation of environmental consciousness-. Behaviormetric Soc Japan 33(1):55–68 (in Japanese)

Chapter 3
Behavior Model Development for Understanding PEBs

Abstract Various models have been proposed to aid understanding of the key factors for PEBs and the relationships between them. This chapter explains some of the more well-known general behavior models that can be applied to PEBs, such as Schwartz's model and the theory of planned behavior (TPB) model first. Then, models specific to PEBs, such as value–belief–norm (VBN) model, motivation–opportunity–ability (MOA) model, and two-phase model, are explained. Besides, since many works have been conducted to investigate the determinants for PEBs, the motivation to compile and assess the preceding works naturally rises. The meta-analyses of preceding works are also shown in this chapter and finally the empirical models which refer to several theories empirically show the relationships involving not only sociopsychological variables but also sometimes sociodemographic variables. The aim of these trials is not to establish a new theory but to show the applicability of previous theories and to understand the influential factors on the target PEB. In the final section, several examples of these trials are shown.

Keywords Psychological model • Theory of planned behavior • Altruistic behavior model • Meta-analysis • Empirical model

3.1 Models for General Behaviors

The models originally proposed not only for PEBs but also for other behaviors are explained in this section. The most popular behavior model applied to PEBs is the TPB model proposed by Icek Ajzen. In addition, the concept of altruistic behavior proposed by Shalom H. Schwartz, which has been widely applied to PEBs, is also explained in this section.

3.1.1 Altruistic Behavior Model

Shalom H. Schwartz proposed conceptual behavioral models for altruistic behaviors in the late 1960s and 1970s. His target behaviors were acts for the welfare of

K. Kurisu, *Pro-environmental Behaviors*, DOI 10.1007/978-4-431-55834-7_3

others – that is, altruistic behaviors. PEBs are recognized as altruistic behaviors; therefore, this model concept has been widely applied to various PEBs.

3.1.1.1 Norm-Activation Model (Schwartz 1968a/b, 1970a/b, 1977)

Schwartz proposed the concept of the norm-activation model (NAM) for altruistic behaviors, such as helping others. His hypothesis is that moral norm (personal norm) activation is needed for connection between personal norms and the target behavior. He proposed that two conditions are needed for the activation of personal norms: **awareness of consequences (AC)** and **ascription of responsibility (AR)**. Schwartz (1968a, b, 1970a, b) first proposed one of the variables as AR, which was translated to **responsibility of denial (RD)** later in Schwartz (1977). This refers to cost or other situational factors. He explained that the **defense** process is considered important for norm activation; therefore, the description as RD is more reasonable than as AR (Schwartz 1977). Schwartz's key concept is shown in Fig. 3.1. For activation of personal norms, AC is needed, while RD weakens the norm activation.

Schwartz also describes the sequential four processes for altruistic behaviors as follows:

I. Activation steps: perception of need and responsibility. . .
II. Obligation step: norm construction and generation of feelings of moral obligation
. . .Activation of pre-existing or situationally constructed personal norms
III. Defense steps: assessment, evaluation, and reassessment of potential responses
. . .Assessment of costs and evaluation of probable outcomes. . .
. . .Reassessment and reduction of the situation by denial. . .
IV. Response step. . .Action or inaction response

(Schwartz 1977; p. 241)

Schwartz published the main parts of his 1967 PhD in two papers the following year (Schwartz 1968a, b). Several more books and papers followed. For knowing the key concept of Schwartz's work and ideas, the chapter "Normative influences

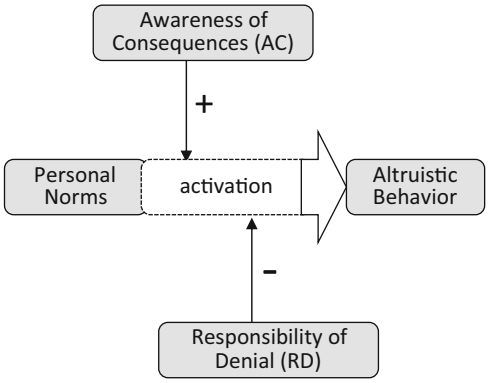


Fig. 3.1 Concept of norm activation as proposed by Schwartz (1977)

on Altruism" (Schwartz 1977) in *Advances in Experimental Social Psychology* (volume 10) is recommended.

3.1.1.2 Normative Decision-Making Model (Schwartz and Howard 1981)

Schwartz and Howard (1981) proposed the normative decision-making model for altruistic/helping behavior as shown in Fig. 3.2. In this model, they have four stages anteceding the behavior: "attention," "motivation," "evaluation," and "defense."

The attention stage consists of three steps: "need," "effective action," and "ability." Firstly, the actor perceives the characteristics of the situation and judges whether help is needed. Secondly, the actor mentally chooses appropriate action options. Thirdly, the actor judges their ability to conduct the potential actions. If these steps are not activated, "normative exit" occurs and the decision-making process ends prior to norm construction.

When the actor recognizes that they have enough ability to conduct the potential actions, three types of implications are considered: "nonmoral," "moral," and "social." The nonmoral implications are the physical and material costs needed for the actions. The "moral" implications represent the activation of personal norms through attention steps by internalization of the actor's values. In addition, the perceived social norms also influence the behavior decision. If motivation is not adequately generated by these three aspects, a normative exit occurs.

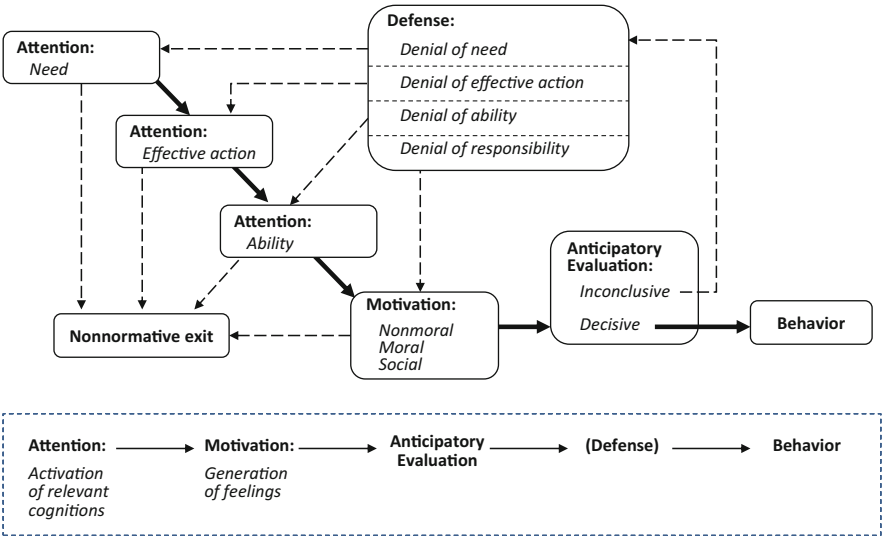


Fig. 3.2 Altruistic (normative) decision-making model (Schwartz and Howard 1981; reuse is kindly permitted by Prof. Shalom H. Schwartz) **Arrows* are modified from the original figure. The *solid lines* show the main norm-activation stream, whereas the *dotted lines* show the possible escapes from the main streamline

After motivation is generated, the anticipated costs and benefits of the outcomes are evaluated. Based on the evaluation, when moral and cost–benefit considerations aspire to the same helping behavior, a decision is reached and the defense step is omitted. On the other hand, if there is a trade-off between the moral evaluation and cost–benefit evaluation, the defense step is generated to resolve the conflict.

As seen in Fig. 3.2, four types of denial, corresponding to each step of attention stage and motivation stage, can be generated. By generation of the denial, the recognition of each step can be replaced to weaken the conflicts.

Thus, when each step of the stream shown in solid lines in Fig. 3.2 is activated, the helping behaviors are held through normative decision. Conversely, the behavioral decision can be avoided through escapes from the mainstream as shown by the dotted lines.

3.1.2 Theory of Reasoned Action: TRA (Fishbein and Ajzen 1975)

Fishbein and Ajzen (1975) proposed the theory of reasoned action (TRA) model as shown in Fig. 3.3. This model assumes that the behavior is determined by the intention, which is influenced by two variables: "**attitude toward the behavior**" and the "**subjective norm**" (see Sect. 2.2.1). Two antecedents of these attitudes are involved: "**behavioral belief**" and "**normative belief**."

This model is suitable for application to PEBs and various studies have been conducted based on it. In this model, the behavior is determined just by the intention, and other influences of the circumstances are not considered. This

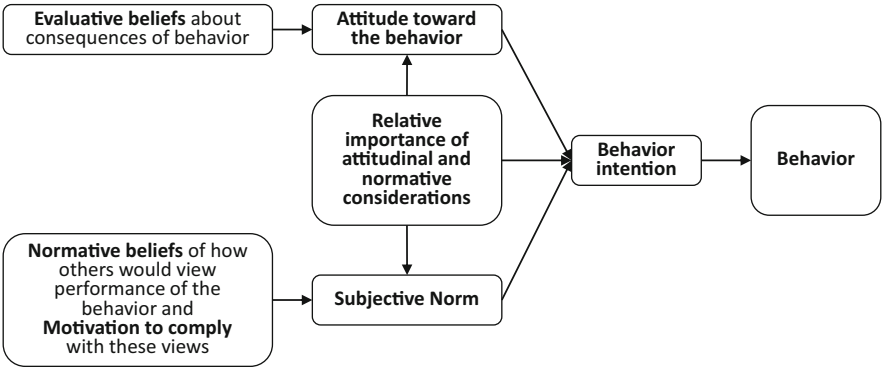


Fig. 3.3 Theory of reasoned action (TRA) model (Ajzen and Fishbein 1980; reused from Kollmass and Agyeman 2002; by permission from Environmental Education Research © Taylor & Francis)

means that the model can be used only when the target behavior is under the **volitional control**. For example, even if a person wants to conduct a behavior, they might abandon it because of lack of money, knowledge, time, or ability to conduct the behavior. Hence the TRA model cannot be applied when the behavior is not controlled just by intention but also by other situational factors.

3.1.3 Theory of Planned Behavior: TPB (Ajzen 1991)

For improving the limitations of the TRA, Ajzen (1991) proposed the theory of planned behavior (TPB) as shown in Fig. 3.4. He introduces a new variable, "**perceived behavioral control (PBC)**," into this model that represents the actor's perception of how much they can control the behavior. The PBC expresses the actor's perception of their ability, knowledge, affordability, available time, and so on. A similar concept can be expressed as "**self-efficacy**," which is defined as belief in one's own capacity to organize the target behavior.

The TPB model has been widely applied not only to PEBs but also to various behaviors. Godin and Kok (1996) reviewed 58 studies dealing with health-related behaviors and concluded that the TPB model worked well, especially for the intention prediction. Amitage and Conner (2001) reviewed 185 studies and showed that TPB was able to explain 27 and 39 % of the variance in behavior and intention, respectively.

Hansen et al. (2004) compared TRA and TPB models for online grocery buying and TPB showed a better model fit than TRA. Madden et al. (1992) compared the model fit between the TRA and TPB for ten behaviors, such as "exercising regularly" and "doing laundry." The TPB explained more variance than the TRA, especially for the behaviors that were perceived as uncontrollable, such as "getting a good night's sleep."

Davies et al. (2002) showed various categories of studies where TPB was applied.

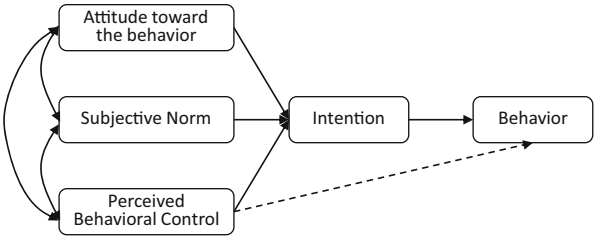


Fig. 3.4 Theory of planned behavior (TPB) model (Ajzen 1991; reused by permission from *Organizational Behavior and Human Decision Processes* © Elsevier)

3.2 Models for PEBs

3.2.1 VBN Model (Stern et al. 1999; Stern 2000)

Stern (2000) categorized PEBs into four types: "environmental activism," "nonactivist behaviors in the public sphere," "private-sphere behaviors," and "behaviors in organizations." They showed belief and norm steps to determine the behaviors as shown in Fig. 3.5 (Stern et al. 1999; Stern 2000). This is called the value–belief–norm (VBN) theory, which was developed based on the value theory, Schwartz's norm-activation model (see Sect. 3.1.1.1), and the new environmental paradigm (NEP) (Dunlap and Van Liere 1978; see Sect. 4.2.2.1) perspective. The four steps antedate the behaviors: (1) **personal values**, (2) **NEP**, (3) **awareness of consequences (AC) and ascription of responsibility (AR) beliefs**, and (4) **personal norms**.

The personal values consist of three types: "biospheric," "altruistic," and "egoistic." The PEB stream starts mainly from the general personality (especially altruistic personal values) and moves to a more environment-focused attitude (NEP). The personal norms are activated from the beliefs that are also mediated by AC and AR (see Sect. 3.1.1.1 for details). When the personal norms are sufficiently activated, it is connected to the behaviors.

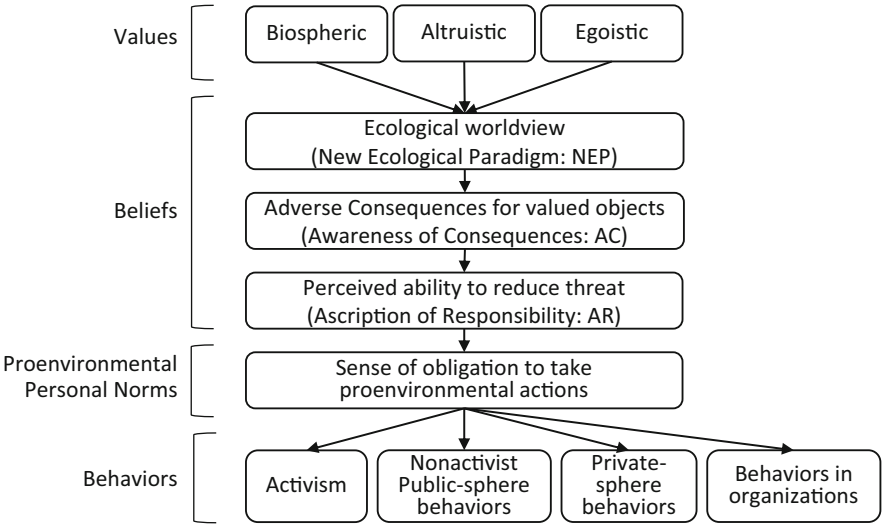


Fig. 3.5 Value–belief–norm (VBN) theory (Stern 2000; modified; reused by permission from *Journal of Social Issues* © John Wiley and Sons)

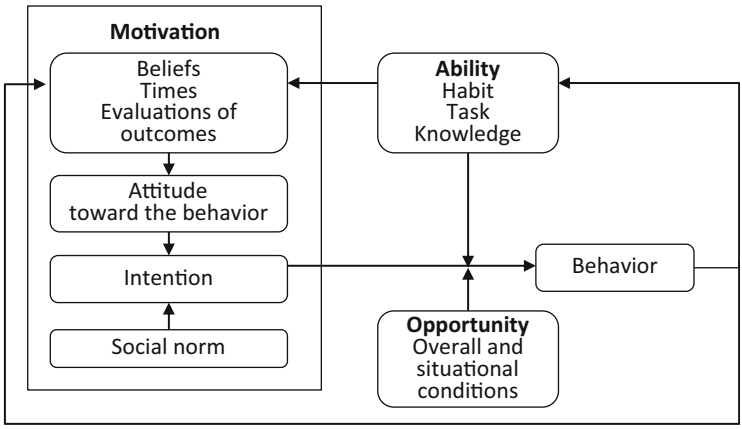


Fig. 3.6 Motivation–opportunity–ability (MOA) model (Ölander and Thogerson 1995; reused by permission from *Journal of Consumer Policy* © Springer)

3.2.2 MOA Model (Ölander and Thøgerson 1995)

Ölander and Thogerson (1995) focused on three determinants, such as motivation, opportunity, and ability, for consumer behavior with an impact on the environment. As shown in Fig. 3.6, they proposed the **motivation–opportunity–ability** (MOA) model based on TRA and TPB models. Attitudes and social norm are determinants for intention, while opportunity and ability (similar to PBC in TPB) influence the process between the intention and actual behavior.

3.2.3 Two-Phase Model (Hirose 1994)

Hirose (1994) proposed the two phases of intentions, namely, "**goal intention**" and "**behavior intention**" as shown in Fig. 3.7. The "goal intention" is defined as the "intention to contribute to solving an environmental problem." Three determinants are proposed for the "goal intention," such as "perceived **seriousness**," "**ascription of responsibility (AR)**," and "belief in the **effectiveness**."

The latter part of the model is the formation of "behavior intention," which is directly connected with the target "behavior." Three determinants, such as "**feasibility** evaluation," "**cost–benefit** evaluation," and "**social norm** evaluation," are proposed as determinants of the "behavior intention." The factor of "feasibility" is similar to PBC in the TPB model. It is assumed that the final decision to conduct the behavior is influenced by situational factors, such as feasibility and cost and benefit. The "social norm evaluation" corresponds to "subjective norm" in TPB model.

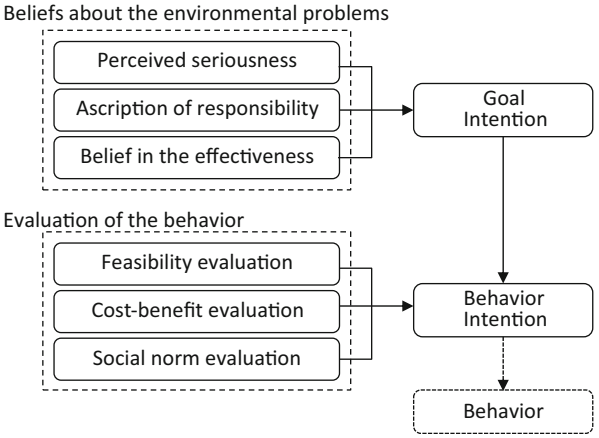


Fig. 3.7 Hirose's two-phase model (Hirose 1994; reused by permission from *Japanese Journal of Social Psychology* © The Japanese Society of Social Psychology)

Hirose's model has been widely used in many PEB studies, especially in Japan. Some modification and extension of this model has been also undertaken in Japan and in other countries.

3.2.4 Model of PEB (Kollmuss and Agyeman 2002)

Kollmass and Agyeman (2002) reviewed precedent papers and summarized and described the key factors on PEB in detail (see "Recommended Books and Papers" at the end of this book). They also demonstrated their own model, where influential barriers on PEB are shown with other influential factors in the diagram (Fig. 3.8).

They explained that significant influence on PEB can happen when internal and external factors act synergistically and that old behavior patterns can be a big barrier to PEBs.

3.2.5 Meta-analysis

Since many works have been conducted to investigate the determinants for PEBs, the motivation to compile and assess the preceding works naturally rises. In this section, the meta-analyses of preceding works conducted by Hines et al. (1987) and Bamberg and Möser (2007) are shown.

3.2.5.1 Hines et al. (1987)

Hines et al. (1987) evaluated 128 studies and searched for the influences of "cognitive variables," "psychosocial variables," and "demographic variables" on

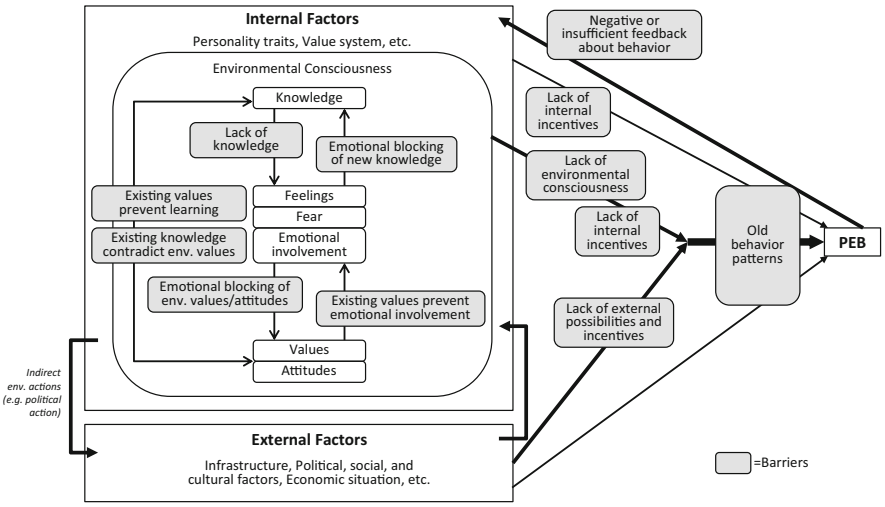


Fig. 3.8 Model of pro-environmental behavior (Kollmass and Agyeman 2002; reused by permission from *Environmental Education Research* © Taylor & Francis)

Table 3.1 Summary of meta-analysis findings for descriptive studies (Table 1 in Hines et al. 1987; reused by permission of *The Journal of Environmental Education* © Taylor & Francis)

Variable		Corrected correlation coefficient	Corrected standard deviation	Number of values based on[a]
Psychosocial	Verbal commitment	.491	.121	14
	Locus of control	.365	.224	51
	Attitude	.347	.121	6
	Personal responsibility	.328	.195	17
Cognitive	Knowledge	.299	.122	11
Demographic	Educational level	.185	.084	10
	Income	.162	−.118	6
	Economic orientation	.160	.084	10
	Age	−.151	.121	4
	Gender	.075	.224	14

[a]Several studies reported data on more than one variable

PEBs. They conducted the analysis and synthesis of the extracted information by using the Schmidt–Hunter meta-analysis procedures and summarized the findings as shown in Table 3.1. The influences of demographic variables are explained in

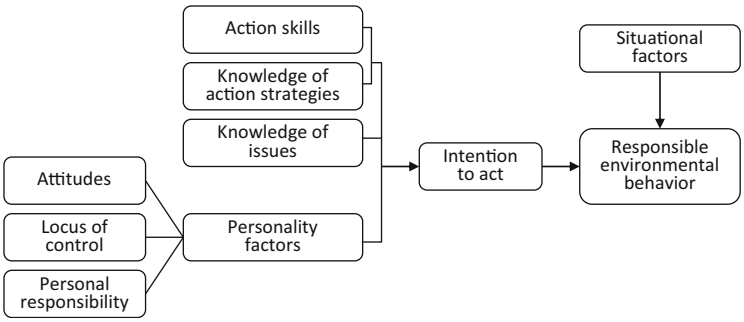


Fig. 3.9 Model of PEBs proposed through meta-analysis (Hines et al. 1987; reused by permission from *The Journal of Environmental Education* © Taylor & Francis)

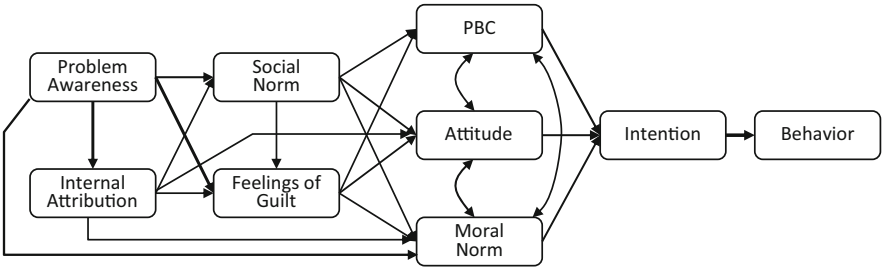


Fig. 3.10 Meta-analytic structural equation model for PEBs (Bamberg and Möser 2007; modified; reused by permission from *Journal of Environmental Psychology* © Elsevier) The line widths correspond to each path's coefficient value

Chap. 2 Sect. 2.5. Verbal commitment, locus of control, attitude, personal responsibility, and knowledge displayed positive influences on PEBs.

They then proposed the PEB model based on these results and on additional data from Hines's PhD thesis. As seen in Fig. 3.9, PEB is determined by intention and situational factors. The determinants for intention are skills, knowledge, and personality factors consisting of attitudes, locus of control, and personal responsibility.

3.2.5.2 Meta-analytic SEM by Bamberg and Möser (2007)

Bamberg and Möser (2007) collected the behavior models applying NAM, TPB, and similar models to PEBs that appeared in peer-reviewed journals from 1995 to 2006. They used 57 samples from 46 studies and conducted meta-analytic structural equation modeling. Figure 3.10 shows their results. Behavior is determined by intention, and 52 % variance of the intention was explained by three antecedents: PBC, attitude, and moral norm (personal norm). "Social norm" and "feeling of guilt" determine these three variables. In addition, "internal attribution" has direct influences on "attitude" and "moral norm." "Internal attribution" and "problem

awareness" show influences on "social norm" and "feeling of guilt." They also found the influence from "problem awareness" to "internal attribution." In this model, the direct influence of PBC on behavior proposed by the TPB model was not confirmed statistically. The results also showed that social norm is a more indirect determinant of intention, whereas personal norm has a direct influence on intention.

3.3 Empirical Models for Specific Categories of PEBs

Many researchers have tried to show the relationships between PEBs and other variables. They usually refer to several theories and empirically show the relationships, which involves not only sociopsychological variables but also sometimes sociodemographic variables. The aim of these trials is not to establish a new theory but to show the applicability of previous theories and to understand the influential factors on the target PEB. In this section, several examples of these trials are shown.

3.3.1 Model for Recycling Behavior

3.3.1.1 MacCarty and Shrum (2001)

MacCarty and Shrum (2001) focused on the influences of individualism, collectivism, and locus of control (scale items are shown in Chap. 4, Table 4.12) on recycling behaviors. They used 534 samples from a postal mail survey in an area where curbside recycling was available in a Midwestern state in the USA. They applied structural equation modeling (SEM; see Sect. 4.5.5) to their proposed model. The largest influence on the recycling behaviors was "inconvenience of recycling." They also showed that lower economic status correlated with higher inconvenience of recycling.

3.3.1.2 Barr (2003)

Barr (2003) undertook a study in Exeter, UK, in 1999 and selected five waste minimization, five reuse, and 10 recycling behaviors, constructing the path diagram separately for recycling behaviors and waste minimization behaviors using the 673 responses received. The diagram for recycling behaviors is shown in Fig. 3.11. He included not only the sociopsychological factors but also demographic factors in his model.

The recycling behavior was mainly determined by "recycling intention," "local waste knowledge," "convenience," and "curbside bin." "Knowledge" and "curbside bin" representing the procedural knowledge (explained in Sect. 2.4) and situational factor (Sect. 2.7), respectively, were extracted as important factors to determine the

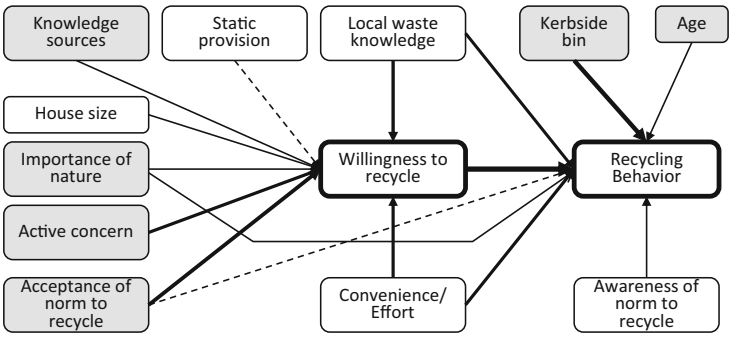


Fig. 3.11 Path diagram for recycling behavior (Barr 2003; modified; reused by permission from *Area* © John Wiley and Sons). The line widths correspond to each path's coefficient value. *Grayed* variables are common variables in recycling and minimization models

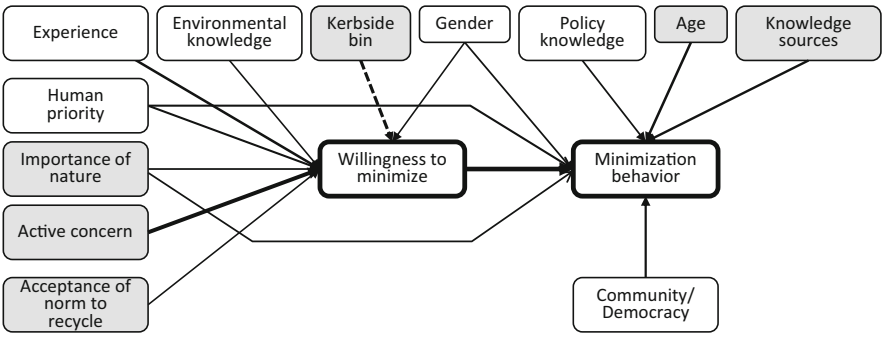


Fig. 3.12 Path diagram for minimization behavior (Barr 2003; modified; reused by permission from *Area* © John Wiley and Sons). The line widths correspond to each path's coefficient value. *Grayed* variables are common variables in recycling and minimization models

recycling behavior. "Convenience" had a significant influence on both the intention and behavior. According to Lee et al. (2013), as seen in Fig. 2.1, the main reason not to conduct "segregation of recyclable materials" behavior (B24 in Lee et al. 2013) was due to "inconvenience" and it being "bothersome." These results indicated that convenience is an important factor for recycling behavior. The results also showed that higher influences of "active concern," "acceptance of norm to recycle," and "local waste knowledge," as well as "convenience," were at work on the intention to recycle.

3.3.2 Model for Waste Prevention Behavior

3.3.2.1 Barr (2003)

Barr (2003) also constructed a model for waste minimization behavior, as shown in Fig. 3.12. The structure was different from recycling. Except for the several common variables, such as "importance of nature," "active concern," "acceptance of norm to recycle," "knowledge sources," and "curbside bin," the number and type of variables are different.

This model also revealed that those with previous "experience" of recycling were more likely to be willing to minimize their waste. This indicated that there may be a spillover effect of recycling on other waste-related actions, such as reusing and reducing.

3.3.2.2 Bortoleto et al. (2012)

Bortoleto et al. (2012) built a model for waste prevention behavior based on TPB and other recycling models. They collected the samples from Sao Paulo in Brazil and conducted the structural equation modeling (SEM). As shown in Fig. 3.13, the finalized model showed that the PBC and personal norms were significant determinants for waste prevention behavior. Unlike the TPB model, the insignificant influence of subjective norms was explained as the **non-visibility** of waste prevention behaviors, which are usually conducted inside households. They also proposed the influence of general environmental attitudes on the specific attitudes toward the target behavior and on PBC.

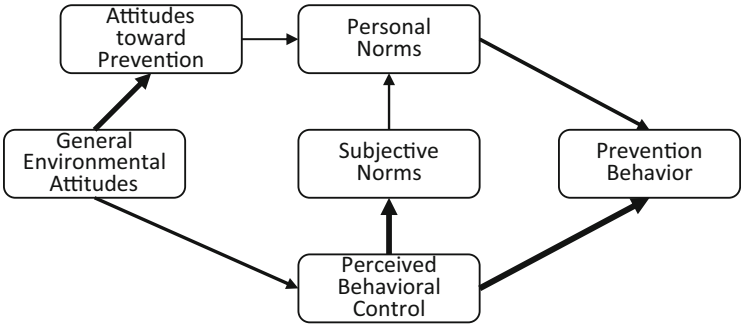


Fig. 3.13 Model for waste prevention behavior (Bortoleto et al. 2012; modified; reused by permission from *Waste Management* © Elsevier). The line widths correspond to each path's coefficient value

3.3.3 *Model for Energy-Saving Behavior (Black et al. 1985)*

Black et al. (1985) focused on household energy adaptations, such as "capital investment in energy efficiency," "low-cost efficiency improvements," "minor curtailments," and "ambient temperature setting." In 1980, they surveyed 478 electricity consumers in Massachusetts, USA, and gave the path diagram for each adaptation.

Figure 3.14 shows the diagram about "ambient temperature" setting in households and "low-cost efficiency improvements." Some arrows between sociodemographics would not show cause–effect relationships but would show correlations. As seen in these figures, personal norm had a direct influence on the target behavior. Social norm and energy concern were antecedents of personal norm. The constructs were similar between the two behaviors; however, the different relationships between the variables were also seen.

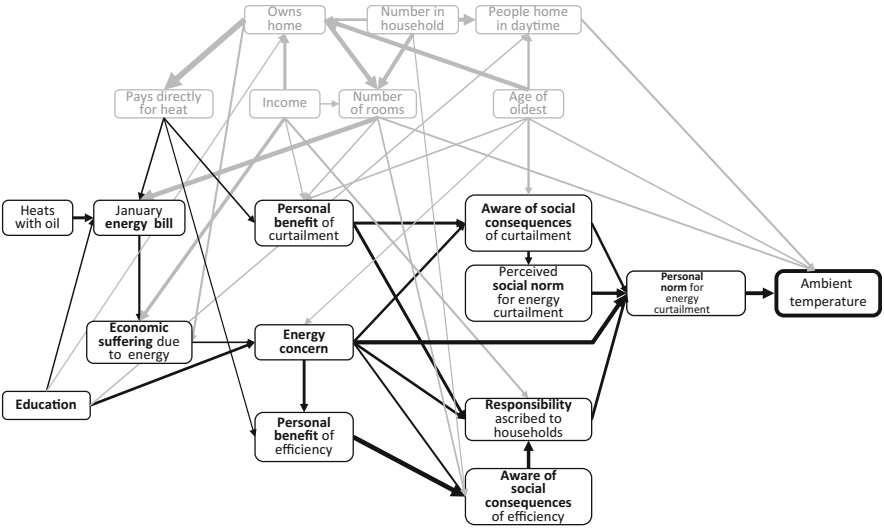


Fig. 3.14 (continued)

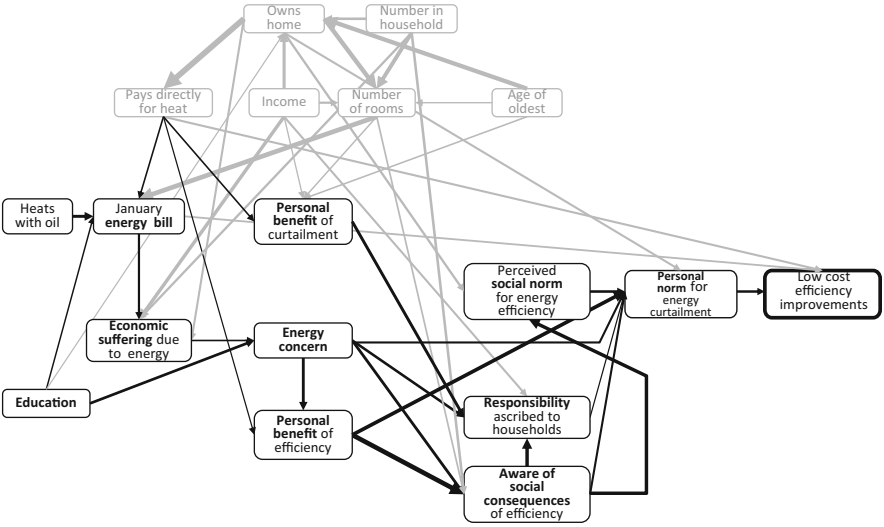


Fig. 3.14 Models for ambient temperature setting in household (*upper*) and low-cost efficiency improvement (*lower*) (Black et al. 1985; modified; reused from *Journal of Applied Psychology* © American Psychological Association, which allows free use of limited number of figures and tables). The position of each variable has been rearranged. The line widths correspond to each path's coefficient value. Sociodemographic variables are shown in *gray*

References

Ajzen I (1991) The theory of planned behavior. Organ Behav Hum Decis Process 50:179–211

Ajzen I, Fishbein M (1980) Understanding attitudes and predicting social behavior. Prentice Hall, Englewood Cliffs

Amitage CJ, Conner M (2001) Efficacy of the theory of planned behaviour: a meta-analytic review. Br J Soc Psychol 40:471–499

Bamberg S, Möser G (2007) Twenty years after Hines, Hungerford, and Tomera: a new meta-analysis of psycho-social determinants of pro-environmental behavior. J Environ Psychol 27:14–25

Barr S (2003) Strategies for sustainability: citizens and responsible environmental behavior. Area 35(3):227–240

Black JS, Stern PC, Elworth JT (1985) Personal and contextual influences on household energy adaptations. J Appl Psychol 70(1):3–21

Bortoleto AP, Kurisu KH, Hanaki K (2012) Model development for household waste prevention behavior. Waste Manag 32(12):2195–2207

Davies J, Foxall GR, Pallister J (2002) Beyond the intention–behaviour mythology an integrated model of recycling. Mark Theory 2(1):29–113

Dunlap RE, Van Liere KD (1978) The "New Environmental Paradigm". J Environ Educ 9 (4):10–19

Fishbein M, Ajzen I (1975) Belief, attitude, intention, and behavior: an introduction to theory and research. Addison-Weseley, Reading (out of print, accessible online at http://people.umass.edu/aizen/f&a1975.html)

Godin G, Kok G (1996) The theory of planned behavior: a review of its applications to health-related behaviors. Am J Health Promot 11(2):87–98

Hansen T, Jensen JM, Solgaard HS (2004) Predicting online grocery buying intention: a comparison of the theory of reasoned action and the theory of planned behavior. Int J Inf Manag 24:539–550

Hines JM, Hungerford HR, Tomera AN (1987) Analysis and synthesis of research on responsible environmental behavior: a meta-analysis. J Environ Educ 18(2):1–8

Hirose Y (1994) Determinants of environment-conscious behavior. Jpn J Soc Psychol 10(1):44–55 (in Japanese)

Kollmass A, Agyeman J (2002) Mind the Gap: why do people act environmentally and what are the barriers to pro-environmental behavior? Environ Educ Res 8(3):239–260

Lee H, Kurisu K, Hanaki K (2013) Influential factors on pro-environmental behaviors – a case study in Tokyo and Seoul. Low Carbon Econ 4:104–116

MacCarty JA, Shrum LJ (2001) The influence of individualism, collectivism, and locus of control on environmental beliefs and behavior. J Public Policy Mark 20(1):93–104

Madden TJ, Ellen PS, Ajzen I (1992) A comparison of the theory of planned behavior and the theory of reasoned action. Personal Soc Psychol Bull 18(3):3–9

Ölander F, Thogerson J (1995) Understanding consumer behavior as a prerequisite for environmental protection. J Consum Policy 18:345–385

Schwartz SH (1968a) Awareness of consequences and the influence of moral norms on interpersonal behavior. Sociometry 31(4):355–369

Schwartz SH (1968b) Words, deeds and the perception of consequences and responsibility in action situations. J Pers Soc Psychol 10(3):232–242

Schwartz SH (1970a) Moral decision making and behavior. In: Macaulay J, Berkowitz L (eds) Altruism and helping behavior. Academic Press, New York, pp 127–141

Schwartz SH (1970b) Elicitation of moral obligation and self-sacrificing behavior. J Pers Soc Psychol 15(4):283–293

Schwartz SH (1977) Normative influences on Altruism. In: Berkowitz L (ed) Advances in experimental psychology, vol 10. Academic Press, pp 221–279

Schwartz SH, Howard J (1981) 9. A normative decision-making model of altruism. In: Rushton JP, Sorrentino RM (eds) Altruism and helping behavior. Lawrence Erlbaum Associates Inc, Hillsdale

Stern PC (2000) New environmental theories: toward a coherent theory of environmentally significant behavior. J Soc Issues 56(3):407–424

Stern PC, Dietz T, Abel T, Guagnano GA, Kalof L (1999) A value-belief-norm theory of support for social movements: the case of environmentalism. Hum Ecol Rev 6(2):81–97

Chapter 4
How to Survey PEBs

Abstract To know the current condition of people's environmental attitudes and practice rates of PEBs, questionnaire surveys are possible ways to collect data. In this chapter, the basic elements of questionnaire surveys are explained. In the first section (4.1), the ways to prepare the question items are explained. Then, in Sect. 4.2, the scales, especially about the scales for environmental attitudes and personalities, are explained. In this section, you can find various items previously proposed by many studies to measure environmental attitudes. Besides, two personalities which can have some relationships with environmental attitudes, such as "cultural theory" and "locus of control," are explained and items to measure these personalities are also shown. In Sect. 4.3, the points which you should have in mind when you decide the wording of questions are explained. In Sect. 4.4, various methods of questionnaire surveys, such as interviews and postal surveys, are explained, and the details of online questionnaire are particularly explained. Finally, after getting the data, you need some statistical analyses. In the final section (4.5), the basic data handling ways including statistical analyses are explained.

Keywords Questionnaire survey • Online questionnaire • Environmental attitudes • Personality • Scales • Statistical analysis

4.1 Preparing Questionnaires

When compiling a questionnaire, researchers and students are often tempted to just put in whatever questions that come to their mind. This can make the questionnaire difficult to use or the results difficult to analyze. The recommended procedure for preparing a questionnaire is shown below. The skeleton of the questionnaire can be formed by answering the following four questions in order:

(1) **Target**:
What do you want to reveal?
(2) **Hypothesis**:
What is the key hypothesis for the target behavior/phenomenon?

K. Kurisu, *Pro-environmental Behaviors*, DOI 10.1007/978-4-431-55834-7_4

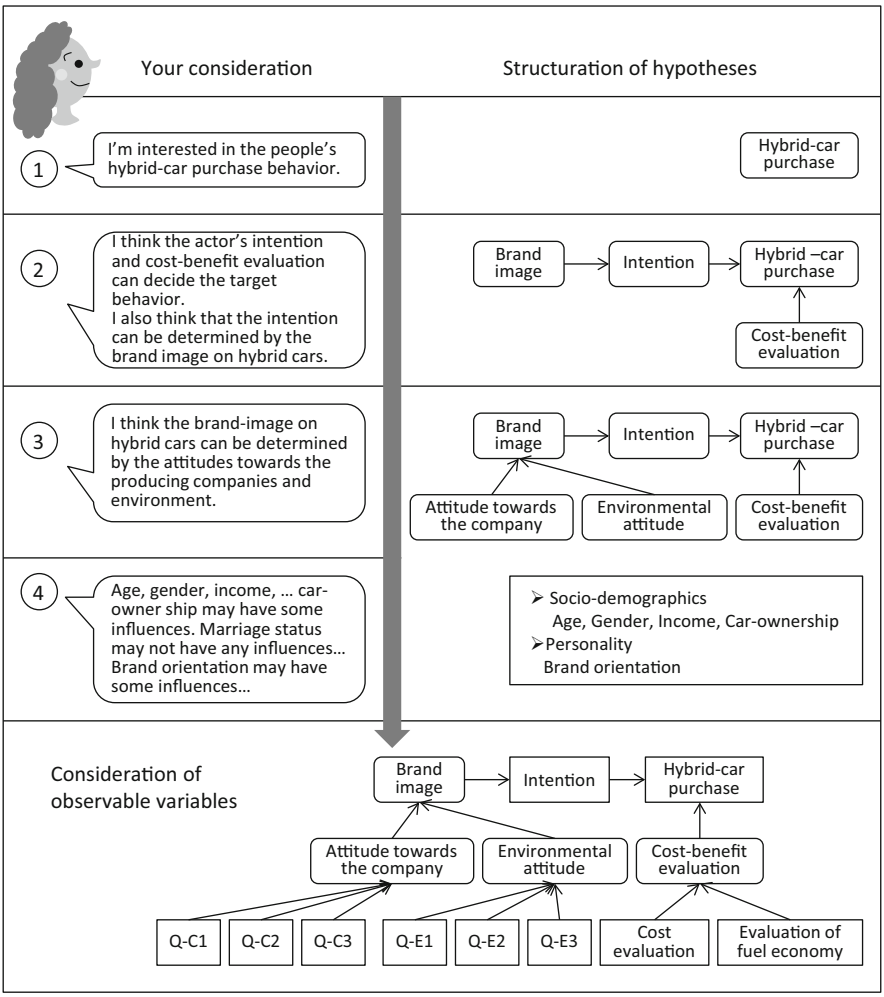


Fig. 4.1 Example of questionnaire preparation procedure

(3) **Factors**:
What are the key factors that determine the key hypothesis?
(4) **Sociodemographics and personality**:
What are the influential factors of sociodemographics and personality?

This procedure is illustrated in Fig. 4.1. Drawing the hypothetical structure as shown in the right-hand side of the figure is strongly recommended for designing a meaningful questionnaire.

The important first step is to be clear about your target behavior or phenomenon. You need to consider what is the current problem or hot phenomenon you are really interested in. Using the example in Fig. 4.1, if you are interested in a *hybrid-car purchase*, this can be considered as your target behavior.

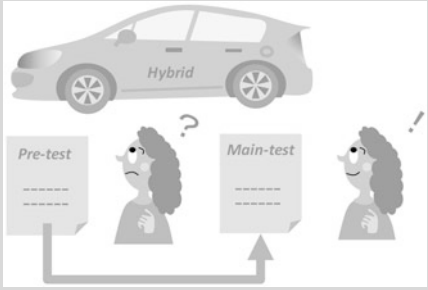
For the second step, you should consider what hypothesis you can build for the target behavior. The key factors determining the target behavior should be placed in your model and cause–effect relationships drawn. In the case of Fig. 4.1, the key hypothesis is that the behavior is determined by *intention* and *cost–benefit evaluation* and the *intention* is determined by *brand image*. Based on the key hypothesis, the cause–effect relationships can be drawn.

For the third step, you can add other influential factors to your model. In the example case, it is assumed that the *brand image* is determined by *attitude toward the company* and *environmental attitude*. Based on these assumptions, two variables determining the *brand image* can be added.

Variables of sociodemographics and personalities might be involved in the model. However, it is reasonable to consider them separately from the model. When you want to enhance people's behavior based on the model, you can try to increase or decrease the psychological factor scores, but sociodemographics and personalities cannot be changed. The differences in factor scores or path intensities between different sociodemographics or personalities can be discussed based on the model consisting of changeable factors. The influential sociodemographics and personalities should be considered at this step and really meaningful aspects should be involved in the questionnaire.

Finally, based on the resultant structure, observable variables should be considered for each constituent. In the example case, *hybrid-car purchase* behavior can be measured directly by asking the respondents' actual behavior. Therefore, this variable is considered to be an *observable* variable. On the other hand, the environmental attitude can be a latent constituent, and several observed variables (Q-E1, Q-E2, and Q-E3 in Fig. 4.1) should be used to assess it. A question can be designed for each observed variable.

Column 4.1: Pretesting Can Be Useful to Construct a Key Hypothesis



Pretests are usually used to check whether or not questions and wordings are appropriate for respondents to correctly and easily answer the questionnaire. Pretests can also be used in cases when surveyors cannot identify the key factors of their targets. For example, if you are interested in buying a hybrid car but cannot identify the important aspects influencing the behavior, it is helpful to conduct a pretest. In the pretest, instead of depending on the key hypothesis, a wide range of aspects of hybrid-car purchasing should be asked. In order to understand

(continued)

Column 4.1 (continued)

something you cannot pin down, open questions can be useful. You can know the important aspects through questions about how people think about hybrid cars, what importance people put on particular aspects of the car purchase, and so on. Based on the pretest, an appropriate key hypothesis and answer options can be prepared.

4.2 Scales

For designing a questionnaire, you need to prepare question sets for each variable in your model and consider ways of asking. In this section, the popular scaling techniques are explained and various well-known scales for measuring environmental attitudes are described. Of course, you need to consider the appropriate question items for your own particular purposes, and some modification from previously proposed scales will be needed, but the scales shown here can give you some ideas for designing your own items.

4.2.1 Scaling Techniques

Louis Leon Thurstone (1887–1995) proposed the **method of equal-appearing intervals** (**Thurstone scale**) for measuring the attitude. The absolute score of each item is decided by various raters. After that, the items that show scores in an equal interval are extracted. The items are randomly shown to respondents and approval or disapproval on each item is sought. The mean value of the approved item scores is determined as the respondent's attitude score. This Thurstone scale is more adapted for measuring the **absolute evaluation** of each respondent.

By contrast, the **Likert scale** developed by Rensis Likert (1903–1981) is more adapted for measuring the **relative evaluation**. He proposed the five-point scale consisting of "strongly agree" to "strongly disagree" with scores ranging from 5 to 1 being applied to the answers. Multiple items are shown to a respondent, and the score of each respondent is estimated by a summation of the scores based on their selection. Likert scale is the most popular scale used for questionnaire surveys.

See Column 4.2 for more on the number point issue. The issue of score calculation is explained in Sect. 4.5.4.1.

4.2.2 Environmental Attitude Scales

Environmental attitude (EA) is often considered to be the same as "environmental concern"; however, the term "environmental attitude" is used here because

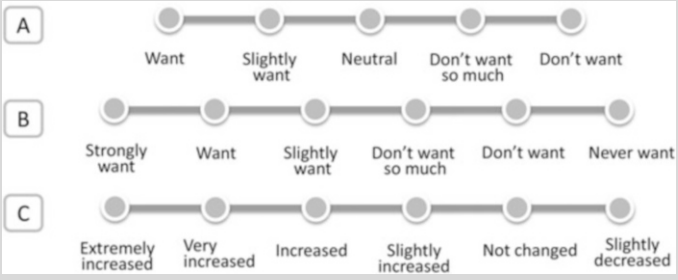
environmental concern is viewed as a more general attitude (Banberg 2003). EA was considered to be a one-order constituent measured by "concerned" vs. "not concerned," as found in the traditional New Environmental Paradigm (NEP) scale. Following that, the multi-order concept for EA has been considered in various studies. In this section, starting from NEP, various scales developed for measuring EA are shown.

4.2.2.1 New Environmental/Ecological Paradigm (NEP) Scale

The **New Environmental Paradigm (original NEP)** scale was proposed by Dunlap and Van Liere 1978 and has been most widely used to assess environmental attitudes. The development of the original NEP scale and New Ecological Paradigm (renewed NEP) scale (Dunlap et al. 2000) is described in detail along with the state of Dunlap's mind at the time in Dunlap (2008).

The original NEP scale is shown in Table 4.1. It showed sufficient internal consistency (see 4.5.4.1), and Dunlap recommended this as a single dimension scale getting the total score by summation (Dunlap 2008). However, Albrecht et al. (1982) have shown three dimensions for this NEP: "balance of nature" (2, 5, 8, and 12 in Table 4.1), "limits to growth" (1, 9, 11, and 7), and "man over nature" (4, 3, 6, and 10). The three dimensions have been also supported by Galler and Lasley (1985).

Column 4.2: How Many Points Should a Scale Have?



The original Likert scale had five points; however, you can modify the number of points based on your target respondents and target issues. Japanese people, for instance, will tend to select the center ("neutral" in the example) point avoiding the extreme points. Therefore, if you prepare the 5-point scale (A), answers will often be concentrated on the middle three points and you will not get enough variation of the answers. To avoid this problem, we often use a six-point scale (B) consisting of three positive points and three negative points excluding the central point. This is just an example, but you should

(continued)

Column 4.2 (continued)

consider the design of scales based on your target. If you want to see the people's perception change after environmental education, positive change can be naturally expected. In this case, to know the degree of positive change in detail rather than the negative changes, you can make more positive points than negative ones (C).

After the first proposal, Dunlap made a **short version of NEP scale** by "put[ting] together a set of six items including two with original wording and four that represented minor to fairly significant revisions of the original wording. . ." (Dunlap 2008). This was not published, but John Pierce, who shared the information with Dunlap, used the short version of NEP in his study as shown in Table 4.2 (Pierce et al. 1987).

Table 4.1 Original NEP scale

1.	We are approaching the limit of the number of people the earth can support
2.	The balance of nature is very delicate and easily upset
3.	Humans have the right to modify the natural environment to suit their needs
4.	Mankind was created to rule over the rest of nature
5.	When humans interfere with nature, it often produces disastrous consequences
6.	Plants and animals exist primarily to be used by humans
7.	To maintain a healthy economy, we will have to develop a "steady-state" economy where industrial growth is controlled
8.	Humans must live in harmony with nature in order to survive
9.	The earth is like a spaceship with only limited room and resources
10.	Humans need not adapt to the natural environment because they can remake it to suit their needs
11.	There are limits to growth beyond which our industrialized society cannot expand
12.	Mankind is severely abusing the environment

Dunlap and Van Liere (1978), reused with permission from the Journal of Environmental Education © Taylor and Francis

Table 4.2 Short version of NEP scale developed by Dunlap and van Liere

2.	The balance of nature is very delicate and easily upset by human activities
9.	The earth is like a spaceship with only limited room and resources
6.R	Plants and animals do not exist primarily to be used by humans
3.*	Modifying the environment for human use seldom causes serious problems
11.*	There are no limits to growth for nations like the USA (Japan)
4.*	Mankind is created to rule over the rest of nature

Pierce et al. (1987), reused with permission from the Journal of Politics © University of Chicago Press

R reverse questions from the original, * wording and concept is modified

Table 4.3 Alternative Environmental Paradigm bipolar scale

	Dominant paradigm	Alternative environmental paradigm
Core values	Material (economic growth)	Nonmaterial (self-actualization)
	Natural environment valued as resource	Natural environment intrinsically valued
	Domination over nature	Harmony with nature
Economy	Market forces	Public interest
	Risk and reward	Safety
	Rewards for achievement	Incomes related to need
	Differentials	*Egalitarian
	Individual self-help	Collective/social provision
Polity	Authoritative structures (expert influential)	Participative structures (citizen/worker involvement)
	Hierarchical	*Nonhierarchical
	Law and order	*Liberation
Society	Centralized	Decentralized
	Large scale	Small scale
	Associational	Communal
	Ordered	*Flexible
Nature	Ample reserves	Earth's resources limited
	Nature hostile/neutral	Nature benign
	Environment controllable	Nature delicately balanced
Knowledge	Confidence in science and technology	Limits to science
	Rationality of means	Rationality of ends
	Separation of fact/value, thought/feeling	Integration of fact/value, thought/feeling

Cotgrove (1982), Table 2.1, p. 27; reused with permission from © John Wiley & Sons Ltd.

Before Dunlap et al. (2000) revised the NEP scale; the most influential work was done by Cotgrove (1982). He focused on the antagonism between industry and environment and proposed the bipolar scale called the "**Alternative Environmental Paradigm**" (Table 4.3). Dunlap's opinion and evaluation of Cotgrove's work can be seen in the following:

> I believe that learning of Cotgrove's (1982) innovative work initially deepened my depression, as I felt that Van Liere and I had jumped the gun, trying to measure the NEP before its comprehensive challenge to the DSP [Dominant Social Paradigm by Pirages and Ehrlich in 1974] had become more apparent. However, I was definitely intrigued by the use of bipolar items that forced respondents to make choices between the two paradigms, rather than measuring the NEP and DSP separately, with summated rating scales, as Van Liere and I had done (Dunlap and Van Liere 1984)
>
> (Dunlap 2008)

Dunlap et al. proposed the **New Ecological Paradigm (renewed NEP)** in 2000. It consists of 15 items as shown in Table 4.4. Seven items are kept from the original NEP scale (Dunlap and Van Liere 1978), but the revised NEP covers a much wider range of ecological world views and pro- and anti-items are involved in a balanced manner. The terminology was also revised to fit with the times.

Table 4.4 New ecological paradigm scale

A[a]	B[a]	Item
1.	1.	We are approaching the limit of the number of people the earth can support
2.	3.	Humans have the right to modify the natural environment to suit their needs
3.	5.	When humans interfere with nature, it often produces disastrous consequences
4.		Human ingenuity will insure that we do NOT make the earth unlivable
5.	12.	Humans are severely abusing the environment
6.		The earth has plenty of natural resources if we just learn how to develop them
7.		Plants and animals have as much right as humans to exist
8.		The balance of nature is strong enough to cope with the impacts of modern industrial nations
9.		Despite our special abilities humans are still subject to the laws of nature
10.		The so-called ecological crisis facing humankind has been greatly exaggerated
11.	9.	The earth is like a spaceship with only limited room and resources
12.	4.	Humans were meant to rule over the rest of nature
13.	2.	The balance of nature is very delicate and easily upset
14.		Humans will eventually learn enough about how nature works to be able to control it
15.		If things continue on their present course, we will soon experience a major ecological catastrophe

Dunlap et al. (2000), reused with permission from the Journal of Social Issues © John Wiley and Sons

[a]*A* item number in 2000, *B* item number in 1978

4.2.2.2 Ecocentric, Anthropocentric, and Environmental Apathy Scale (Thompson and Barton 1994)

Thompson and Barton (1994) developed 33 items to measure "**ecocentrism**," "**anthropocentrism**," and general "**apathy**" about the environmental issues. According to their words, "the ecocentric scale expressed appreciating nature for its own sake, positive effect and stress reduction associated with being out in nature, and seeing a connectedness between humans and animals. The ... anthropocentrism items reflected a concern with environmental issues primarily because of their effects on human quality of life and survival. General apathy about the environment was measured ... reflecting a lack of interest in environmental issues, and a general belief that problems in this area have been exaggerated." Their items are shown in Table 4.5.

4.2.2.3 Ecological World View Scale (Blaikie 1992)

Blaikie (1992)) tested 24 items and proposed 17 items excluding seven items as shown in Table 4.6. They constructed their scale using the NEP scale of Dunlap and Van Liere (1978) (2, 3, 5, 6, 8, 10 in Table 4.1), the DSP (Dominant Social Paradigm) scale by Dunlap and Van Liere (1984), and the Richmond and Baumgart (1981) scale and tested it for the students of the Royal Melbourne Institute of Technology ($n = 390$) and residents of the Melbourne metropolitan area ($n = 410$) in Australia.

Table 4.5 Ecocentric (ECO), anthropocentric (ANTHR), and environmental apathy (APATH) scales

Scale	No.[a]	Item
ECO	1	One of the worst things about overpopulation is that many natural areas are getting destroyed for development
	2	I can enjoy spending time in natural settings just for the sake of being out in nature
	5	Sometimes it makes me sad to see forests cleared for agriculture
	7	I prefer wildlife reserves to zoos
	12	I need time in nature to be happy
	16	Sometimes when I am unhappy I find comfort in nature
	21	It makes me sad to see natural environments destroyed
	26[b]	Nature is valuable for its own sake
	28[b]	Being out in nature is a great stress reducer for me
	30[b]	One of the most important reasons to conserve is to preserve wild areas
	32[b]	Sometimes animals seem almost human to me
	33[b]	Humans are as much a part of the ecosystem as other animals
ANTHR	4	The worst thing about the loss of the rain forest is that it will restrict the development of new medicines
	8[c]	The best thing about camping is that it is a cheap vacation
	11	It bothers me that humans are running out of their supply of oil
	13[c]	Science and technology will eventually solve our problems with pollution, overpopulation, and diminishing resources
	14	The thing that concerns me most about deforestation is that there will not be enough lumber for future generations
	19[c]	One of the most important reasons to keep lakes and rivers clean is so that people have a place to enjoy water sports
	22	The most important reason for conservation is human survival
	23	One of the best things about recycling is that it saves money
	24	Nature is important because of what it can contribute to the pleasure and welfare of humans
	27[b]	We need to preserve resources to maintain a high quality of life
	29[b]	One of the most important reasons to conserve is to ensure a continued high standard of living
	31[b]	Continued land development is a good idea as long as a high quality of life can be preserved
APATH	3	Environmental threats such as deforestation and ozone depletion have been exaggerated
	6	It seems to me that most conservationists are pessimistic and somewhat paranoid
	9	I do not think the problem of depletion of natural resources is as bad as many people make it out to be

(continued)

Table 4.5 (continued)

Scale	No.[a]	Item
	10	I find it hard to get too concerned about environmental issues
	15	I do not feel that humans are dependent on nature to survive
	17	Most environmental problems will solve themselves given enough time
	18	I don't care about environmental problems
	20	I'm opposed to programs to preserve wilderness, reduce pollution, and conserve resources
	25	Too much emphasis has been placed on conservation

Thompson and Barton (1994); reused with permission from the Journal of Environmental Psychology © Elsevier
[a]Original question number in Thompson and Barton (1994)
[b]The items not involved in their Study 1 but were added in their Study 2
[c]These items were not involved in the calculation of ANTHR in their Study 2 to maintain the internal reliability of the scale

Table 4.6 Ecological world view scale

No.[a]	Item	Original scale		
Use/abuse of the natural environment		NEP[b]	DSP[c]	[d]
a	Humans have the right to modify the natural environment to suit their needs	3.		
d	Human beings were created or evolved to dominate the rest of nature			
v	Plants and animals exist primarily to be used by humans	6.		
Precariousness of the natural environment				
e	The balance of nature is very delicate and is easily upset	2.		
g	Humans must live in harmony with nature in order for it to survive	8.		
k	Humans need not adapt to the natural environment because they can remake it to suit their needs	10.		
Conservation of the natural environment				
r	The remaining forests in the world should be conserved at all costs			B-c
u	When humans interfere with nature, it often produces disastrous consequences	5.		
Sacrifices for the environment				
o	People in developed societies are going to have to adopt a more conserving lifestyle in the future			
p	Controls should be placed on industry to protect the environment			A-H
Confidence in science and technology				
f	Through science and technology we can continue to raise our standard of living		√	
n	We cannot keep counting on science and technology to solve our problems		√	
s	Most problems can be solved by applying more and better technology		√	

(continued)

Table 4.6 (continued)

No.[a]	Item	Original scale		
Problems of economic growth				
c	Rapid economic growth often creates more problems than benefits		√	
x	To ensure a future for succeeding generations, we have to develop a no-growth economy			
Conservation of natural resources				
l	Governments should control the rate at which raw materials are used to ensure that they last as long as possible			B-f
t	Industry should be required to use recycled materials even when it costs less to make the same products from new raw materials			B-g
Excluded items				
b	Priority should be given to developing alternatives to fossil and nuclear fuel as primary energy sources			C-6
h	A community's standards for the control of pollution should not be so strict that they discourage industrial development			A-N
i	Science and technology do as much harm as good		√	
j	Because of problems with pollution, we need to decrease the use of the motor car as a major means of transportation			
m	The positive benefits of economic growth far outweigh any negative consequences		√	
q	Most of the concern about environmental problems has been over-exaggerated			C-2
w	The government should give generous financial support to reach related to the development of solar energy			C-3

Blaikie (1992); reused with permission from Social Science Quarterly © John Wiley & Sons Ltd.
[a]Original question number in Blaikie (1992)
[b]Dunlap and Van Liere (1978)
[c]Dunlap and Van Liere (1984)
[d]Richmond and Baumgart (1981)

They extracted seven subscales: "use/abuse of the natural environment," "precariousness of the natural environment," "conservation of the natural environment," "sacrifices for the environment," "confidence in science and technology," "problems of economic growth," and "conservation of natural resources." They reported that the results measured by this scale were similar between the students and citizens.

4.2.2.4 ENV Scale (Bogner and Wiseman 1999)

Bogner and Wiseman (1999) revised their previous scale consisting of 69 items (Bogner and Wiseman 1996) and tested the structure of EA. They extracted two factors called "**prevention**" and "**utilization**" based on the items showing factor loadings above 0.3. They extracted five sub-factors under the above two factors: three under "prevention," such as "intent of support," "care with resources," and

Table 4.7 ENV scale

Prevention	
Intent of support	
38	If I ever get extra pocket money, I will donate some money to an environmental organization
40	Environmental protection costs a lot of money. I am prepared to help out in a fund-raising effort
78	When I am older I am going to join and actively participate in an environmentalist group should I already not be a member
48	I often try to persuade others that the environment is an important thing
Care with resources	
65	I always switch the light off when I don't need it anymore
76	Whenever possible, I take a shower instead of a bath in order to conserve water
33	I make sure that during the winter the heating system in my room is not switched on too high
77	I purposefully walk short distances rather than asking for a lift in order to protect the atmosphere
Enjoyment of nature	
88	I have a sense of well-being in the silence of nature
45	I really like to be able to go on trips into the countryside – for example, to forests or fields
86	I specially love the soft rustling of leaves when the wind blows through the treetops
24	I would really enjoy sitting at the edge of a pond watching dragonflies in flight
Utilization	
Human dominance	
32	Construction of motorways and bypass roads is so important that it justifies the removal of forests and meadows
79	In order to feed human beings, nature must be cleared, so that, for example, grain can be grown
53	Since mosquitoes develop in ponds, it would be better to drain these and reclaim them for agriculture
44	People should keep open-air swimming ponds free from creepers and climbing plants
Altering nature	
27	Grass and weeds growing between pavement stones really look untidy
83	Weeds may be destroyed because they inhibit the full development of useful and ornamental plants
20	A real nature fan brings home beautiful and rare plants when he/she has been out in the countryside
31	I prefer a well-cared lawn to a wild meadow where flowers grow in an unordered way

Bogner and Wiseman (1999), reused with permission from European Psychologist © 1999 Hogrefe & Huber Publisher

"enjoyment of nature," and two factors under "utilization" such as "human dominance" and "altering nature." The significant items they showed are listed in Table 4.7.

They used obstacle rotation, which means no correlation between the two factors. Criticism of this assumption of no correlation between the two factors was raised by Milfont and Duckitt (2004) as explained in the following subsection.

4.2.2.5 Milfont and Duckitt (2004)

Milfont and Duckitt (2004) tested 99 items picked up from the above EA scales (Dunlap and Van Liere 1978; Thompson and Barton 1994; Blaikie 1992; and Bogner and Wiseman 1999), and the two higher-order factors proposed by Bogner and Wiseman (1999), namely, "prevention" and "utilization," were examined.

They extracted ten first-order factors based on 77 items (given in their paper) which showed ten factor loadings above 0.3: "enjoyment of nature," "external control/effective commitment," "intent of support," "anthropocentric concern," "rejection of exemptionalism/confidence in science and technology," "ecocrisis/limits to growth/nature's balance," "human dominance/altering nature," "care with resources," "antianthropocentrism," and "necessity of development."

Based on these ten factors, they extracted two higher-order factors equal to "prevention" and "utilization." Their results showed significantly negative correlation between "prevention" and "utilization," while Bogner and Wiseman (1999) had assumed no correlation between them. Milfont and Duckitt (2004) pointed that the no correlation between "prevention" and "utilization" shown by Bogner and Wiseman (1999) was caused by their wording in measuring the two factors; they used positive wording for "prevention" and negative wording for "utilization." The respondents used in the two studies were also different; Milfont and Duckitt (2004) used psychology students aged 17–48 years, while Bogner and Wiseman (1999) used secondary school pupils aged 11–18 years. These aspects may also have influenced the different results.

4.2.3 Other Psychological Factors

Unlike EA, there is not a common scale for each of the other psychological factors. However, you can refer the previous studies for the general wordings and apply them to your target. Table 4.8 shows one example about the items for recycling behaviors shown by Hopper and Nielsen (1991).

Icek Ajzen, who proposed the TPB, offers questionnaire items and examples for TPB at his website (http://people.umass.edu/aizen/tpb.html). This can help surveyors design items for each TPB variable.

4.2.4 Personality

When designing your questionnaire, you should have a hypothesis about which personalities have an influence on your target behaviors and variables in your model. Based on the hypothesis, you can search the previously applied scales and modify them for your purpose. There are so many possible scales, but two scales are shown here: cultural theory and locus of control.

Table 4.8 Examples of items for psychological factors

Target factor	Item
Social norm	Friends expect recycling
	Expect friends to recycle
	Neighbors expect recycling
	Expect neighbors to recycle
Personal norm	How much does it bother you to throw away newspaper?
	How much does it bother you to throw away glass?
	How much does it bother you to throw away aluminum?
	How much does it bother you to throw away paper?
	How much does it bother you to throw away motor oil?
	How much does it bother you to throw away cardboard?
	How much personal obligation to recycle newspaper?
	How much personal obligation to recycle cans?
	How much personal obligation to recycle glass?
Awareness of consequences (AC)	Recycling helps conserve natural resources
	Recycling helps reduce litter
	Recycling helps save energy
	Recycling helps reduce use of landfills/dumps

Hopper and Nielsen (1991), reused with permission from Environment and Behavior © SAGE Publications

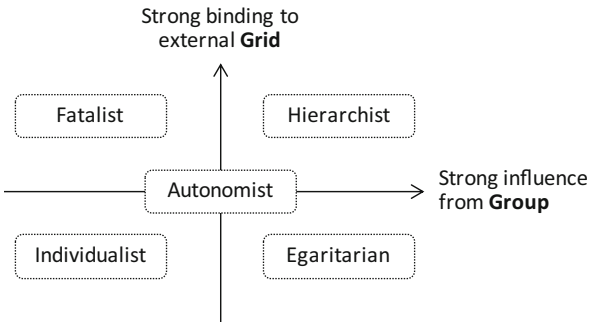


Fig. 4.2 Five ways of life based on cultural theory (Thompson et al. 1990, reused with permission from © Westview Press)

4.2.4.1 Cultural Theory

Cultural theory has been widely used in relation to risk perceptions. The five personalities (**hierarchist, egalitarian, individualist, fatalist,** and **autonomist**) proposed by the theory can also represent people's attitudes to nature and environment. Hence, this concept can be also useful for understanding people's PEBs.

Cultural theory was proposed by Thompson et al. (1990) and suggests five ways of life based on two dimensions called **Group** and **Grid** proposed by Mary Douglas (Douglas and Wildavsky 1983) as shown in Fig. 4.2. According to Douglas and Wildavsky (1983), "**Group** means the outside boundary that people have erected

between themselves and the outside world. **Grid** means all the other social distinctions and delegations of authority that they use to limit how people behave one another." In other words, the axis of "Group" means how much a person is involved in a group, and the axis of "Grid" refers how much personal behavior is limited by outside regulations.

Hofstetter (1998) discussed the use of this concept for differentiating the damage factors by personalities in life cycle impact assessment (LCIA), and this concept has been introduced in one of the popular LCIA methodologies, "Eco-Indicator 99" (for details, see Chap. 5). The difference of the four personalities in **relation to nature and environment** can be seen as shown in Table 4.9. For example, in the case of their view of resources, an individualist thinks that resources are abundant, while an egalitarian thinks they are depleting and a hierarchist thinks them scarce. These differences of perceptions can be seen in personalities described by the cultural theory.

For measuring the cultural biases based on the cultural theory, Marris et al. (1998) showed 28 items modified from the "British Edition" of "Dake's Cultural Biases Questionnaire" (Dake 1991). They discussed the relationships between the cultural biases and risk perceptions on various issues, such as ozone depletion and nuclear power as well as war and car driving. The items are shown in Table 4.10. These items can be modified to adjust for target regions and used for discussing the relationships with PEBs.

4.2.4.2 General/Environmental Locus of Control

As explained in Chap. 2 (2.6), Rotter (1966) proposed the locus of control, which is the personality tool about how much people think outcomes depend on their own actions or on external forces. He uses 23 items based on 60 items previously developed and finally illustrated 29 forced-choice items by adding six filler items as shown in Table 4.11. Respondents are asked to choose the "a" or "b' item.

MacCarty and Shrum (2001) used the sociopolitical control scale developed by Paulhus (1983) as locus of control, which can influence a recycling behavior. Ten items as shown in Table 4.12 were proposed. Using this scale, they put forward the model (3.3.1.1), where locus of control has a significant influence on perception of the importance of recycling.

4.3 Wording

In designing a questionnaire, the wording can decide the quality of answers. Surveyors should always pay attention to how accurately respondents understand the question point and how easily they answer the question. To avoid any misunderstandings regarding the questions, the following points are recommended:

Table 4.9 Typical attitudes of Egalitarian, Individualist, and Hierarchist

	Archetypes			
Predictions[a]	Hierarchist	Egalitarian	Individualist	Fatalist
Myth of nature	Perverse/ tolerant	Ephemeral	Benign	Capricious
Future generations	Resilient	Fragile	Self-sufficient	–
View of resources	Scarce	Depleting	Abundant	Lottery
Engineering aesthetic	High-tech virtuosity	Frugal and environmentally benign	Appropriate (as cheap and cheerful as possible)	–
Energy future	Middle of the road (technical fix)	Low growth (radical change now)	Business as usual	What you don't know...
Desired system properties	Controllability (through inherent orderliness)	Sustainability (through inherent fragility)	Exploitability (through inherent fluidity)	Copeability (through inherent chaos)
Attitude to nature	Regulatory	Attentive	Adaptive	–
Attitude toward humans	Restrict behavior	Construct egalitarian society	Channel rather than change	
Consumption style	Traditionalist: strong links to past and others	Naturalist: rejection of artificiality and excess	Cosmopolitan: neophiliac and wide ranging	Isolated: traditionalist but with weak connections to past and to others
Pollution solution	Change nature to confirm to society	Change society to confirm to nature	Market incentives (transferable rights to pollute, etc.)	–
Search and change behavior	High on search; low in (internal) change	High on search; high on (external) change	"Satisficing"; enough search for enough change	No search; fatalistic acceptance of change
Concept of human nature	Sinful	Born good, malleable	Self-seeking	March of destiny
View of needs and resources	Can manage resources but not needs	Can manage needs but not resources	Can manage needs and resources	Cannot manage needs or resources
Attitude to needs/ resources	Increase resources	Need-reducing strategy	Manage needs and resources upward limits of skills	Devise short-term responses to cope with erratic mismatches of needs and resources
Salient risks	Loss of control (i.e., of public trust)	Catastrophic, irrev., and inequitable developments	Threats to the functioning of the market	

(continued)

Table 4.9 (continued)

Predictions[a]	Archetypes			
	Hierarchist	Egalitarian	Individualist	Fatalist
Attitude toward risk	Risk accepting	Risk aversive	Risk seeking	–
Risk handling style	Rejection and absorption	Rejection and deflection	Acceptance and deflection	Acceptance and absorption

Hofstetter (1998), Table 3.1, p. 55–56, reused with permission from Springer eBook © Springer
[a]Hofstetter's original table shows 60 items, and among those 17 aspects are picked up and shown here

Table 4.10 Cultural bias items (Marris et al. 1998; reused with permission from Risk Analysis © Springer)

Hierarchy	1.	I think there should be more discipline in the youth of today
	2.	I would support the introduction of compulsory national service
	3.	I am more strict than most people about what is right and wrong
	4.	I think it is important to carry on family traditions
	5.	I value regular routines highly
	6.	I think being on time is important
Individualism	1.	In a fair system people with more ability should earn more
	2.	A free society can only exist by giving companies the opportunity to prosper
	3.	If a person has the get-up-and-go to acquire wealth, that person should have the right to enjoy it
	4.	It is just as well that life tends to sort out those who try harder from those who don't
	5.	Making money is the main reason for hard work
Egalitarianism	1.	If people in this country were treated more equally, we would have fewer problems
	2.	The government should make sure everyone has a good standard of living
	3.	Those who get ahead should be taxed more to support the less fortunate
	4.	I would support a tax change that made people with large incomes pay more
	5.	The world could be a more peaceful place if its wealth were divided more equally among nations
	6.	Racial discrimination is a very serious problem in our society
	7.	What this country needs is a "fairness revolution" to make the distribution of goods more equal
	8.	Most of the meals I eat are vegetarian
	9.	Health requirements are very important in my choice of foods
	10.	I prefer simple and unprocessed foods
Fatalism	1.	There is no use in doing things for people – you only get it in the neck in the long run
	2.	Cooperating with others rarely works
	3.	The future is too uncertain for a person to make serious plans
	4.	I have often been treated unfairly
	5.	A person is better off if he or she doesn't trust anyone
	6.	Most people make friends only because friends are useful to them
	7.	I feel that life is like a lottery

Table 4.11 Locus of control scale

No.[a]	[b]	a	b
1		Children get into trouble because their parents punish them too much	The trouble with most children nowadays is that their parents are too easy with them
2	a	Many of the unhappy things in people's lives are partly due to bad luck	People's misfortunes result from the mistakes they make
3	b	One of the major reasons why we have wars is because people don't take enough interest in politics	There will always be wars, no matter how hard people try to prevent them
4	b	In the long run people get the respect they deserve in this world	Unfortunately, an individual's worth often passes unrecognized no matter how hard he tries
5	b	The idea that teachers are unfair to students is nonsense	Most students don't realize the extent to which their grades are influenced by accidental happenings
6	a	Without the right breaks one cannot be an effective leader	Capable people who fail to become leaders have not taken advantage of their opportunities
7	a	No matter how hard you try, some people just don't like you	People who can't get others to like them don't understand how to get along with others
8		Heredity plays the major role in determining one's personality	It is one's experiences in life which determine what they're like
9	a	I have often found that what is going to happen will happen	Trusting to fate has never turned out as well for me as making a decision to take a definite course of action
10	b	In the case of the well-prepared student, there is rarely if ever such a thing as an unfair test	Many times exam questions tend to be so unrelated to course work that studying is really useless
11	b	Becoming a success is a matter of hard work; luck has little or nothing to do with it	Getting a good job depends mainly on being in the right place at the right time
12	b	The average citizen can have an influence in government decisions	This world is run by the few people in power, and there is not much the little guy can do about it
13	b	When I make plans, I am almost certain that I can make them work	It is not always wise to plan too far ahead because many things turn out to be a matter of good or bad fortune anyhow
14		There are certain people who are just no good	There is some good in everybody
15	b	In my case getting what I want has little or nothing to do with luck	Many times we might just as well decide what to do by flipping a coin
16	a	Who gets to be the boss often depends on who was lucky enough to be in the right place first	Getting people to do the right thing depends upon ability; hick has little or nothing to do with it
17	a	As far as world affairs are concerned, most of us are the victims of forces we can neither understand nor control	By taking an active part in political and social affairs, the people can control world events

(continued)

Table 4.11 (continued)

No.[a]	[b]	a	b
18	a	Most people don't realize the extent to which their lives are controlled by accidental happenings	There really is no such thing as "luck"
19		One should always be willing to admit mistakes	It is usually best to cover up one's mistakes
20	a	It is hard to know whether or not a person really likes you	How many friends you have depends upon how nice a person you are
21	a	In the long run the bad things that happen to us are balanced by the good ones	Most misfortunes are the result of lack of ability, ignorance, laziness, or all three
22	b	With enough effort we can wipe out political corruption	It is difficult for people to have much control over the things politicians do in office
23	a	Sometimes I can't understand how teachers arrive at the grades they give	There is a direct connection between how hard I study and the grades I get
24		A good leader expects people to decide for themselves what they should do	A good leader makes it clear to everybody what their jobs are
25	a	Many times I feel that I have little influence over the things that happen to me	It is impossible for me to believe that chance or luck plays an important role in my life
26	b	People are lonely because they don't try to be friendly	There's not much use in trying too hard to please people, if they like you, they like you
27		There is too much emphasis on athletics in high school	Team sports are an excellent way to build character
28	b	What happens to me is my own doing	Sometimes I feel that I don't have enough control over the direction my life is taking
29	a	Most of the time I can't understand why politicians behave the way they do	In the long run the people are responsible for bad government on a national as well as on a local level

Rotter (1966), reused from Psychological Monographs: General and Applied © American Psychological Association, which allows free use of limited number of figures and Tables

[a]Original number in Rotter (1966)

[b]Originally underlined items in Rotter (1966) which represent external control beliefs. Blanks show filler items which are more ambiguous items

1. Avoid technical terms and use easier expressions
2. Avoid unclear definitions
3. Avoid double-barreled questions
4. Avoid a carry-over effect

Researchers often like to use technical terms and a relatively tight expression. However, some technical terms are not familiar to respondents and make for misunderstandings. On one occasion, we conducted the questionnaire survey asking people's preferences on flood management. We asked about which method they preferred between "1/50-year flood management" and "1/100-year flood

Table 4.12 Sociopolitical locus of control scale

No.[a]	[c]	Item
7.		There is very little we, as consumers, can do to keep the cost of living from going higher (R)
5.	22-a	With enough effort we can wipe out political corruption
2.	12-a	The average citizen can have an influence on government decisions
[b]	12-b	This world is run by the few people in power, and there is not much the little guy can do about it (R)
1.		By taking an active part in political and social affairs we, the people, can control world events
8.		When I look at it carefully, I realize it is impossible to have any really important influence over what politicians do (R)
9.		I prefer to concentrate my energy on other things rather than on solving the world's problems (R)
6.		One of the major reasons we have wars is because people don't take enough interest in politics
10.	29-b	In the long run we, the voters, are responsible for bad government on a national as well as local level
3.	22-b	It is difficult for people to have much control over the things politicians do in office (R)

Paulhus (1983), reused from the Journal of Personality and Social Psychology © American Psychological Association, which allows free use of limited number of figures and tables
[a]Original item number in sociopolitical control scale (Paulhus 1983)
[b]This item is added by MacCarty and Shrum (2001) instead of original No. 4 ("Bad economic conditions are caused by world events that are beyond our control")
[c]Item from Rotter (1966) shown in Table 4.12

management." In the field of civil engineering, "1/50-year flood management" means measures to withstand the size of flood that occurs once in 50 years. Therefore, "1/100-year flood management" means more careful management to withstand a bigger flood that can occur once in 100 years. We expected that people would prefer "1/100-year flood management"; however, we got completely the opposite response. Finally, we realized that people were thinking that "1/50-year flood management" meant that management is conducted just once in 50 years and "1/100-years flood management" means just once in 100 years and therefore that the 50-year option was more frequent and therefore better. It is easy to see from just this one example why simple and clear wording for questions is recommended.

Even if you use simple words instead of technical terms, the meaning can still be understood differently by the respondents, which results in useless data. For example, could you answer the apparently simple question, how many friends do you have? The definition and criteria of "friends" varies among individuals and therefore responses to such a question would give you meaningless data. When you design a question, you should carefully check whether or not all respondents understand the question in the same way.

It is important to follow the principle of one question-one issue. For instance, if you ask the question "What do you think of a person who drinks and smokes?," and the respondent thinks that drinking is OK but smoking is not acceptable, then they face difficulties answering the question. Questions involving more than one issue are called **double-barreled questions** and should be avoided.

The order of questions is also important. There is a possibility that precedent questions have some influence on the questions that follow. This is called a **carry-over effect**. You should carefully check whether or not the precedent questions have any consequences for the following questions.

4.4 Questionnaire Survey

Major survey methods are listed in Table 4.13. The **interview** method is survey by face-to-face interview. Interviewing people on the street or through introduction by an acquaintance means you can almost always get an answer from the interviewee unless you quarrel with the person, so the response rate can be high. However, getting interviewees is often difficult. On the street, only a few people are prepared to stop and cooperate with your survey. Even if you contact potential interviewees through personal introduction, cooperation cannot be guaranteed. Another difficulty with interview surveys if more than one person is doing the interviewing is to maintain the same level of interviewers' skills. Training workshops for interviewers should be held before conducting the main survey.

Table 4.13 Advantages and disadvantages of survey methods

	Advantage	Disadvantage
Interview	High recovery rate from the collected respondents In-depth explanation is possible	Time-consuming Getting large sample is difficult Labor cost causes higher cost Skills of interviewers have significant influences on the results
Postal	Easier to design	Low recovery rate Getting addresses is difficult Sending back bias exists
Web	Sending cost can be avoided Easier to design	Getting respondents is difficult Random sampling cannot be applied
Online	High recovery rate Adjustment to parent population Short survey period Sending back bias is lower	Not applicable to rural area Difficult to get older respondents

One of the most popular methods is the **postal survey**. You can design and print a questionnaire and hand deliver it (**placement method**) or send it through the post. A reply envelope can be enclosed or a surveyor can visit and collect the response sheet. This method is easily applied, but the recovery rate is usually very low (15–40 %). In addition, **sending back bias** can exist. The people who send back their replies may have a higher consciousness of the target issue. Another problem is the difficulty of getting addresses. If you use the placement method, you need not get exact postal mail addresses of respondents; however, if you try to send your questionnaire through the post, you need to get the full addresses of the respondents. For some regions, from the viewpoint of privacy, it requires a high cost or effort to get people's address data. For example, in Japan, users are charged by the length of used time of reading rooms or by the number of selected addresses when they access the Basic Resident Register. The fee is different in different wards and cities, but it often becomes quite expensive when you get a large number of addresses for a low recovery rate.

Another method is the **web survey**. The term "online survey" is sometimes used synonymously, but these methods are differentiated here. In the case of web survey, a surveyor makes a website where respondents visit and answer the questions. Surveyors make websites by their own programming or by using web tools like SurveyMonkey® and Google forms. Like an interview method, this requires the recruitment of respondents; therefore, respondents are limited to the people you requested or people who happen to reach the site because of their interest in the target topic. Hence, the random sampling cannot usually be achieved by this method.

Online questionnaire survey methods have become popular in academic fields as well as in marketing uses. The outline of this method is shown in Fig. 4.3. A researcher designs a questionnaire (1) and asks a survey company to make a web version of the questionnaire (2). Then the company asks the people who register with the company to answer the questionnaire (3). The respondents answer the questionnaire through the web (4), and the company compiles the answers into an Excel or csv file and gives it to the researcher (5). Advantages and disadvantages of online questionnaire surveys are shown in Table 4.13. The respondents gain points in reward for their answers, which are exchangeable for shopping points. Therefore, more general respondents can be arranged through this method avoiding the sending back bias as explained above. The quality of registered respondents is controlled by the web-survey company. This online method is suitable for conducting a large-scale questionnaire survey. A quick and high rate of response can be obtained. An important advantage associated with this method is that respondent distribution can be adjusted by a web-survey company to coincide with the age and gender distributions in the parent population. If you order 2000 samples, you can get 2000 samples for which distribution is adjusted to the parent distribution based on the National Census. Of course, this method cannot be applied to areas where people do not have internet access or are not familiar with computers. From the same reason, getting older respondents is sometimes difficult.

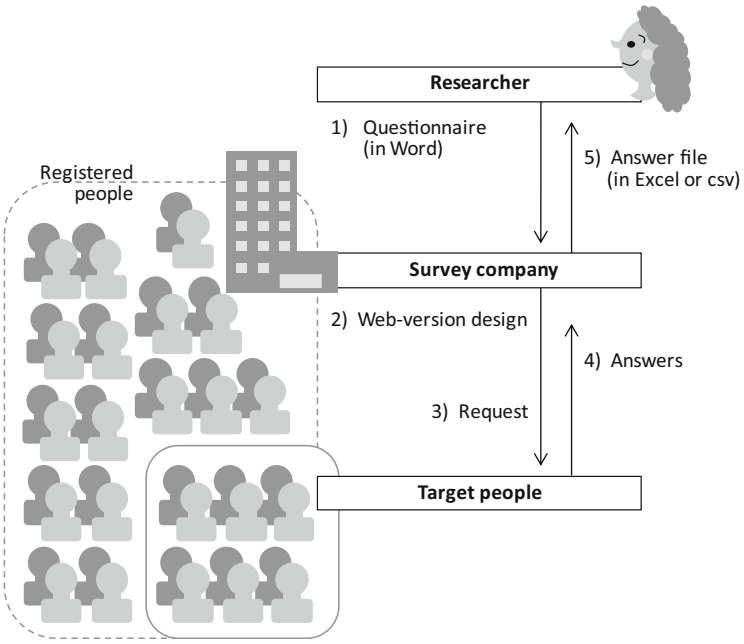


Fig. 4.3 Outline of online questionnaire survey

4.5 Analysis

In this section, popular statistical analyses are explained. The statistical issues that are often misunderstood are described. For theoretical details about statistics, please refer a good textbook (see the "Recommended Books and Papers" section at the end of this book).

4.5.1 Data Types

After you have acquired or coded your data, you should know each data type. Data are categorized into four groups by the measured scale types as shown in Table 4.14.

Nominal scale data have a function of labeling. As seen in the examples, each number just classifies objects. If you code a male as 1 and a female as 2, these numbers have just the function of classification.

Table 4.14 Type of data

Scale	Function	Examples
Nominal	Labeling	ID No. (1101, 1102, ...)
		Coding for gender (male, 1; female, 2)
Ordinal	Labeling + order	Grading (1, 2, 3 . . .)
		Ranking (1, 2, 3 . . .)
Interval	Labeling + order + same interval for one unit	Temperature (15 °C, 30 °C,)
		Likert scale data (1, 2, 3, 4, 5)
Proportional	Labeling + order + same interval for one unit + proportion has meaning	Concentration (15 mg/L, 30 mg/L)
		Length (15 m, 30 m)
		Weight (15 kg, 30 kg)

Ordinal scale data involves the concept of order, for instance, a ranking of 1, 2, 3. . . where 1 is better than 2, 2 is better than 3, and so on. A function of order is involved in this scale. However, we cannot discuss the degree of difference between the numbers. We do not know how large is the difference between rank 1 and rank 2 or how much larger or smaller it is than the difference between rank 2 and rank 3.

On the other hand, in the case of **interval scale** data, we can discuss the difference of numbers. When we see 10 and 25 °C, the difference is 15 °C, and it is same with the difference between 30 and 45 °C. However, proportion of this data has no meaning. In the case of 15 °C, the absolute temperature is $15 + 273 = 288$ (K). Therefore, we cannot say that 30 °C is double 15 °C. Data measured by Likert scale are usually handled as interval data. When we code the data as 1, 2, 3, 4, and 5, we assume that the difference between 1 and 2 is the same as the difference between 4 and 5.

Proportional scale data involves proportional function. We can discuss not only the differences but also the proportions, as seen in the examples in Table 4.14.

4.5.2 Preliminary Check

Before going into the statistical analysis, data distribution should be checked (please see Column 4.3). For applying a parametric test, a normal distribution of the original data is required. You also need to consider whether the whole data can be handled together or if it should be divided into several groups before analysis.

In the case when you want to check whether your acquired data can fit the distribution of parent population or not, the chi-square test is often used.

4.5.3 Basic Statistical Analyses

4.5.3.1 Comparison Between Two Groups

When you want to compare the averages of two groups, you can select the appropriate statistical analyses following the flowchart shown in Fig. 4.4. For applying the popular **Student's t-test** to your data, normal distribution and equal variance are prerequisites.

When two groups are not independent and paired data is obtained, a statistical test (e.g., Student's *t*-test) should be applied to the **difference** between the two groups. An example explaining the reason is shown in Fig. 4.5. In this case, the body weight was measured for each subject before and after the exercise program.

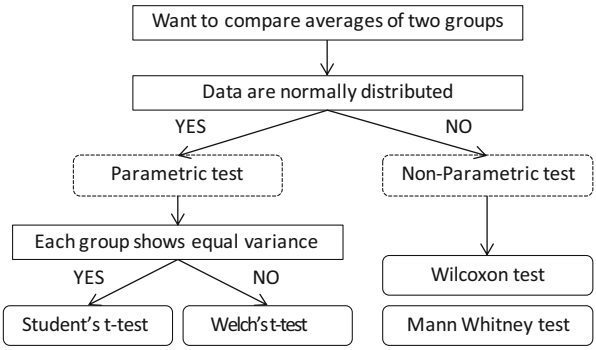


Fig. 4.4 Selection of methodologies for two-group average comparison

	Body weight (kg)		Trend
	Before	After	
A	60.8	59.2	↘
B	55.7	54.7	↘
C	50.4	50.2	↘
D	48.2	47.2	↘
E	75.2	65.6	↘
F	56.4	56.3	↘
G	47.3	47.0	↘
H	65.1	60.0	↘
I	80.3	75.3	↘
J	52.4	52.3	↘

	Body weight (kg)		Trend
	Before	After	
A	60.8	56.3	↘
B	55.7	50.2	↘
C	50.4	52.3	↗
D	48.2	47.2	↘
E	75.2	60.0	↘
F	56.4	59.2	↗
G	47.3	47.0	↘
H	65.1	65.6	↗
I	80.3	75.3	↘
J	52.4	54.7	↗

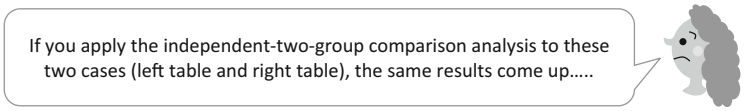
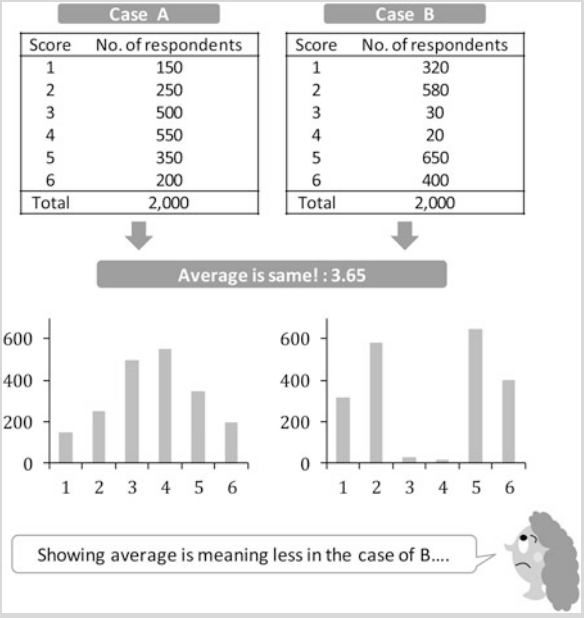


Fig. 4.5 Paired analysis should be applied to comparison of paired group averages

You can find ten subjects (A–J) and two group data ("Before" and "After"). In the table on the left hand, a trend of decreasing weight is seen for all the subjects. On the other hand, in the table on the right hand, some subjects show an increase in body weight and a different trend can be observed.

Thus, the observed effect of the exercise program can be different in the two tables. However, the components of the "After" columns are same between left and right tables, because the underlined components are just shuffled. Therefore, if you apply the statistical test for independent-two-group comparison, these two tables give the same results and the given trend by each table can be neglected. To avoid this problem, paired-data analysis should be applied for paired two-group comparison.

Column 4.3: Check Original Data Distribution Before Calculation!



After getting survey data, what do you do first? Some of you may use Excel and simply calculate the average value of data. But, is it really an appropriate first step? Let us see an example shown in the left figure. The answers shown by the respondents are converted into scores ranging from 1 to 6. Each case has the same number of respondents in total ($n = 2000$). When you calculate the average score of each case, both the cases show the same average values (3.65). However, when you check the original data distribution using histograms, the two cases show completely different shapes. In the case of A, it is meaningful to calculate the average value and have a discussion with it. On the other hand, how about in the case of B? There are almost no answers around the average value. In this case, if you show the calculated average value, it can lead to a misunderstanding of the actual situation.

(continued)

Column 4.3 (continued)

The above case of "average" is one typical example. People often love to use statistical analyses and just want to show "analyzed" data. However, the important first step before statistical analysis is to see the original data distribution. You can know the tendency of answers by checking the original data distribution and can build a hypothesis based on the original data distribution. Statistical analysis can just help checking whether the hypothesis is statistically significant or not.

4.5.3.2 Comparison Between Three or More Groups

When you want to compare the averages of three or more groups, you should apply analysis of variance following the flowchart shown in Fig. 4.6. Similarly, with the two-group case, for using the parametric test, **ANOVA (analysis of variance)**, normal distribution, and equal variance are prerequisites. However, ANOVA is considered a powerful analytical method; the results are rigid and not influenced so much by the prerequisite. Hence, you can find many papers where ANOVA is adopted without checking the prerequisite. In principle, for a nonparametric test, Kruscal–Wallis analysis of variance can be used.

If you compare the body height of people among three countries, the target factor is just one (country). In such a case, we can call it **one-way ANOVA**. If you have two factors, such as country and gender, the analysis can be called **two-way** ANOVA. In the same manner, when you have multiple factors for comparison, it can be called **multivariate analysis of variance (MANOVA)**. Figure 4.7 shows the concept of two-way ANOVA.

By analysis of variance, it is possible to know whether there is significant difference among the groups or not. However, we cannot exactly locate (between which and which) the difference. To be able to do this, a **post hoc (multiple comparison) test** can be applied.

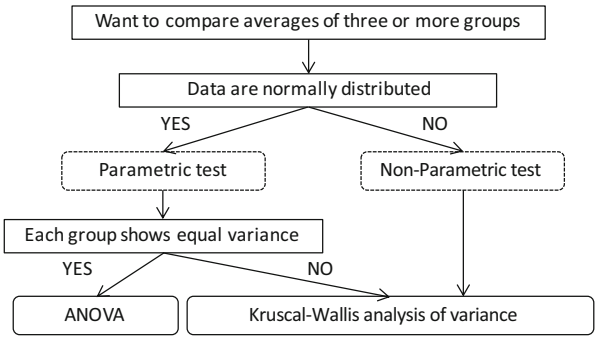


Fig. 4.6 Selection of methodologies for three or more group average comparison

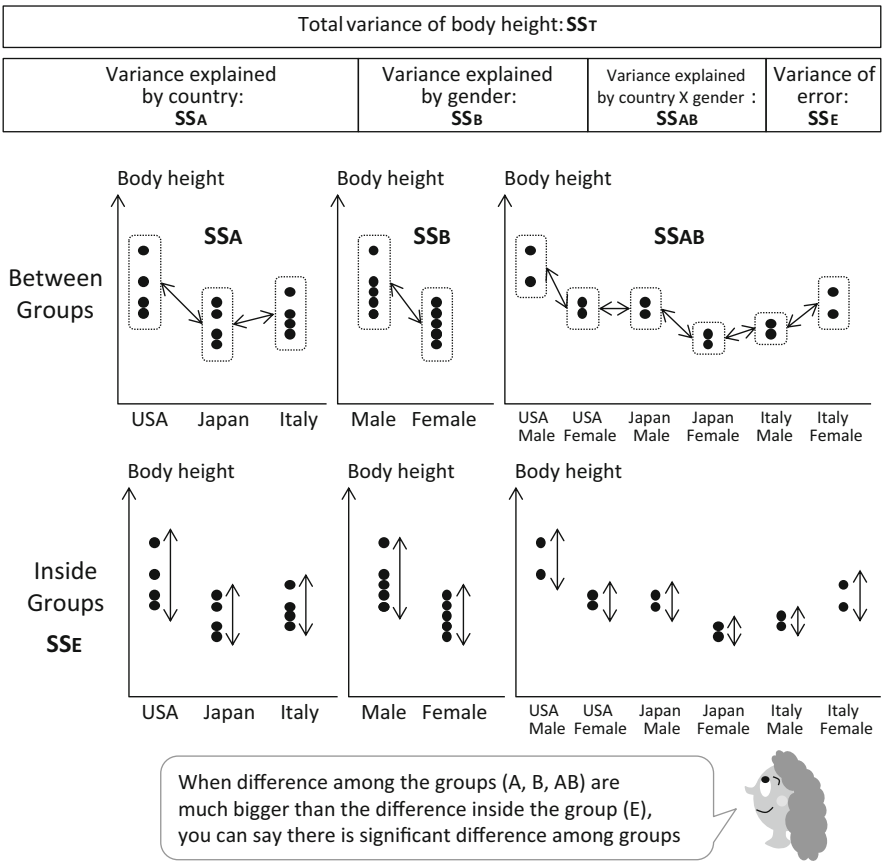


Fig. 4.7 Concept of two-way ANOVA

4.5.3.3 Correlations and Regressions

When you want to know the relationships between two variables, you can investigate the single correlation between the two variables. As with the other statistical analyses, when you want to use the parametric test, **Pearson's correlation**, normal distribution of your data is required. If not, a nonparametric test like **Spearman's rank correlation** should be used.

To know the effect of one variable (X) to another (Y), regression analysis can be conducted. You can construct a model like $Y = aX + b$, and a and b can be determined by minimizing the sum of squares between the original Y and modeled Y^*: $\sum_i \left(Y_i - Y_i^*\right)^2$. The method is called **least-square method.** Another optimization method is called **maximum-likelihood method**, which can determine the coefficient values maximizing the likelihood function (L).

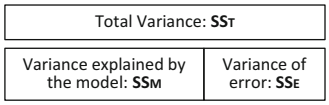


Fig. 4.8 Variance composition of regression analysis

In the regression model, Y is called "**dependent variable**," while X is called "**independent variable**." When multiple independent variables are involved in a model, the analysis is called **multiple regression analysis**. The model is expressed like $Y = a + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \cdots + \beta_m X_m$. The model fitness is often expressed by $\mathbf{R^2}$ **(multiple regression coefficient).** R^2 represents the variance explained by the model in proportion to the total variance as shown in Fig. 4.8.

The total variance (SS_T) consists of variance explained by the model (SS_M) and variance derived from the error (SS_E). Then, R^2 is SS_M/SS_T. Each variance is expressed like the following equations:

$$SS_T = \sum_i^n \left(Y_i - \overline{Y}\right)^2, SS_M = \sum_i^n \left(Y_i^* - \overline{Y^*}\right)^2, SS_E = \sum_i^n \left(Y_i^* - Y_i\right)^2,$$

$$R^2 = \frac{SS_M}{SS_T} = 1 - \frac{SS_E}{SS_T}$$

Here, Y_i is observed Y, Y^* is modeled Y, $\overline{Y}$ is average of observed Y, and $\overline{Y^*}$ is average of Y^*. When the sample number or number of independent variables is large, R^2 can be overestimated and easily becomes significant. To avoid the effect, *adjusted* R^2 (R^{*2}) is used instead of R^2. As shown in the below equation, the effects by the number of samples and number of independent variables are discounted.

$$R^{*2} = 1 - \frac{SS_E/(n - p - 1)}{SS_T/(n - 1)}$$

Here, n is the sample number and p is the number of independent variables.

For multiple regression analysis, each independent variable should be "independent" as its name suggests. The correlation among independent variables is called **multicollinearity**. Multicollinearity creates shared variance between variables, and it can decrease the proportion of the variance explained by the model. In other words, multicollinearity can weaken the power explained by the model. To check multicollinearity, indexes like **VIF (variance inflation factor)** and **condition index** can be used. In the case when VIF is above 2, multicollinearity exists. For the condition index, when the value is below 10, there is no collinearity; when it is between 10 and 30, some collinearity exists; and when it is above 100, high collinearity exists. When you find multicollinearity, or when you can imagine a high correlation between the independent variables, one or some of them should be removed from the model.

When your data involve nominal data like gender, it can be converted into a **dummy variable** and incorporated in the model. If you have two options (e.g., male or female) for one category (gender), you can make one dummy (e.g., male dummy, 1, 0) for it. If you make two dummy variables (male dummy, 1, 0, and female dummy, 1, 0), one of those variables can be determined automatically (e.g., if male dummy is 0, female dummy must be 1) and it creates a problem of collinearity. Therefore, when you have k options for one category, you must make k-1 dummy variables for the category.

In the case of **unstandardized results**, each coefficient (B) represents the change of Y derived from one unit change of X. For example, when the test score (Y points) is explained as $Y = B_1X_1+B_2X_2 + a$, where X_1 is study time (hour) and X_2 is previous test score (points), B_1 represents the test score (Y) increase driven by 1 h increase of study time (X_1). Therefore, B values show various ranges and they cannot be directly compared. On the other hand, in the case of **standardized results**, each coefficient (β) represents the relative importance of each independent variable (X). They show values ranging from -1 to 1 and can be directly compared. If you get $Y = 0.5X_1 + 0.2X_2 + a$ for the above case, you can know that study time (X_1) is more important to get higher test score (Y) than the previous test score (X_2).

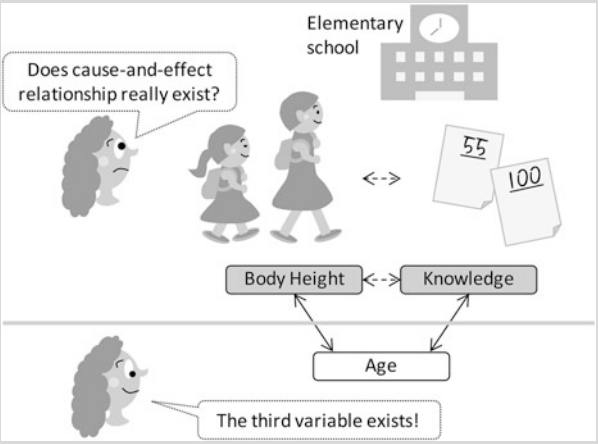
Column 4.4: Cause–Effect Relationships Should Be Carefully Discussed
When you get a higher value of correlation coefficient, you may conclude that there is cause–effect relationship between the two variables. However, instead of jumping to conclusions, you should again consider whether the cause–effect relationship really exists or not.

Spurious correlation *is one of the important issues relating to this topic. As seen in the example below, the correlation you find between the two variables can sometimes be just an apparent one. In this case, a high correlation is found between the body height and knowledge of elementary school students. As a result, you may conclude that taller students have more knowledge. However, can you theoretically explain the phenomenon? In this case, the third variable "age" should be involved to understand the apparent correlation between the body height and knowledge. There exists high correlation between age and body height as well as between age and knowledge. It causes the apparent high correlation between body height and knowledge. This kind of apparent correlation is called spurious correlation.*

Therefore, when you discuss cause–effect relationships, you should carefully check the possibility that the relationship is spurious correlation.

(continued)

Column 4.4 (continued)



4.5.4 Factor Analysis(FA) and Principle-Component Analysis (PCA)

4.5.4.1 How to Handle the Data Obtained by Scales

As shown in Sect. 4.2, to find various aspects, multiple question items are usually used. The summed or average score can be one possible index to represent the acquired data. However, we cannot know whether all items show consistency to represent the index. To check the consistency of items, **Cronbach's α** can be used. The equation is shown below.

$$\boldsymbol{\alpha} = \frac{\mathbf{n}}{\mathbf{n}-1}\left(1 - \frac{\sum \boldsymbol{\sigma}_{\mathbf{i}}^{2}}{\boldsymbol{\sigma}^{2}}\right)$$

Here, n is number of variables; σ_i^2 is variance of variable i; and σ^2 is variance of summation.

This index shows **internal consistency** of the target scale. The Cronbach's α is the most commonly reported measure, with a rule that a scale should have a minimum value of 0.7.

In the case of summation or average, the weight of each item is considered the same. However, for each scale, some items can be more important than others. To take into account the weight of each item, factor analysis (FA) and principle-component analysis (PCA) shown in the next section can be used.

4.5.4.2 What Is Different Between FA and PCA?

Figure 4.9 shows the comparison of FA and PCA. The purpose of FA is to search the latent factors behind the observed variables. Each latent factor (f) has an influence on each observed variable (X). In other words, each observed variable (X) is explained by the latent factors (f) and error (e) part as seen in the equation. The weight of each factor (a) is called factor loading.

As seen in the right-hand side of the Fig. 4.9, the purpose of PCA is to compile the observed variables into several components and to make indexes to represent the observed variables. Therefore, each component (Z) is explained by the observed variables (X) and error (e). The weight of each variable (b) is called principle-component loading. As seen in the top figures in the table, the direction of arrows between the latent variables and observed variables is opposite between FA and PCA, representing the different structures of these methods.

The scores of f and Z are called factor and principle-component scores, respectively. To know the difference of each group's results for the target scale, the estimated average factor/principle-component scores of each group can be useful for comparison.

In principle, FA can be conducted with rotation (see Column 4.5), while PCA is usually conducted without rotation.

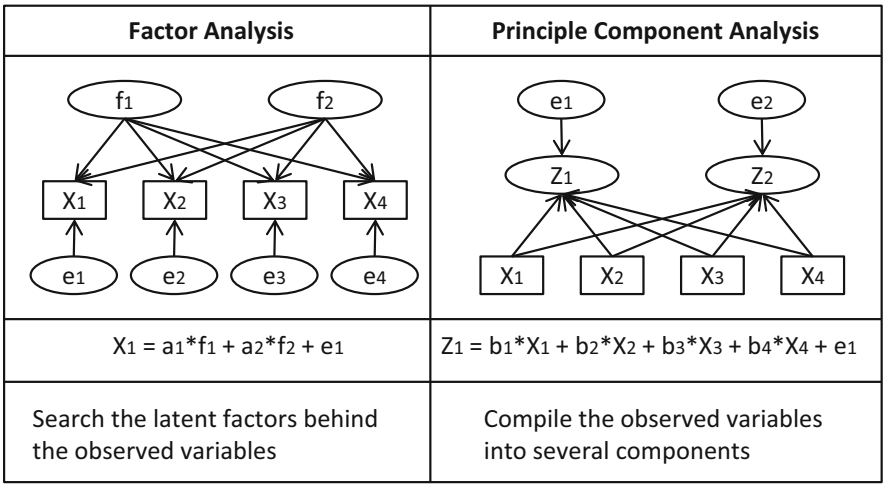
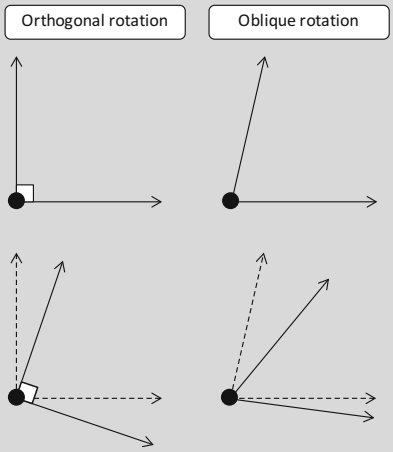


Fig. 4.9 Factor analysis vs. principle-component analysis

Column 4.5: Which Rotation Should Be Used, Orthogonal or Oblique?

When you use FA, you may find it difficult to select a rotation method. There are two methods: orthogonal rotation (e.g., Valimax) and oblique rotation (e.g., Promax). The difference of these rotation methods can be seen in the diagram. The orthogonal rotation assumes no correlations between the factors, while the oblique rotation assumes some correlations between the factors. When you deal with actual events, some correlation can exist between factors; therefore, the oblique rotation is usually selected. However, if no correlation is theoretically assumed, you should use the orthogonal rotation.



4.5.5 *Path Analysis (PA) and Structural Equation Modeling (SEM)*

Structural equation modeling (SEM) and path analysis (PA) are statistical models that seek to explain the relationships among multiple variables. They examine the structure of relationships expressed in a series of equations, similar to a series of multiple regression equations. The case when the **relationships among just the observed variables are investigated is called PA**. It is similar to multiple regression analysis but different in that it can involve the relationships not only between the independent and dependent variables but also among all the variables. The case where the **relationships among not only the observed variables but also the latent variables are investigated is called SEM**. The most distinctive feature of SEM is to describe the relationships among latent variables.

As shown in the Fig. 4.10, by using the SEM or PA, the relationships of variables are visually as well as quantitatively shown. These methods are useful to investigate the hypothetical models, as shown in Chap. 3.

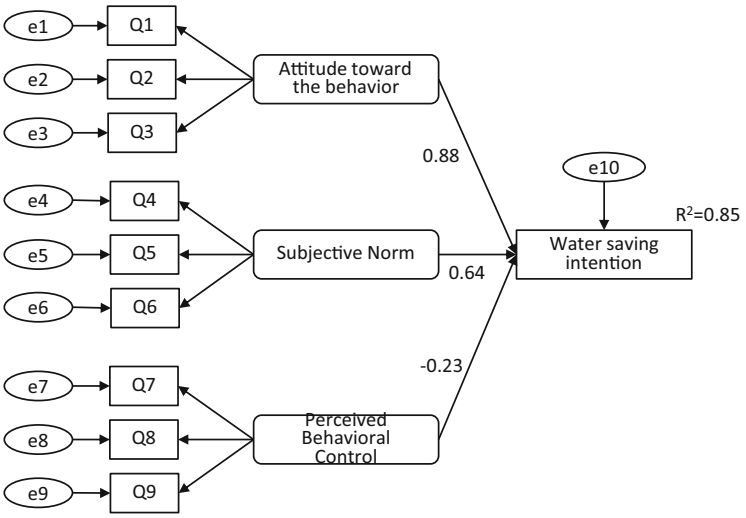


Fig. 4.10 Image of SEM output

References

Albrecht D, Bultena G, Hoiberg E, Nowak P (1982) Measuring environmental concern: the new environmental paradigm scale. J Environ Educ 13:39–43

Banberg S (2003) How does environmental concern influence specific environmentally related behaviors? A new answer to an old question. J Environ Psychol 23:21–32

Blaikie WH (1992) The nature and origins of ecological world views: an Australian study. Soc Sci Q 73(1):144–165

Bogner FX, Wiseman M (1996) Environmental perception of Danish and Bavarian pupils. Towards a methodological framework. Scand J Educ Res 41:53–71

Bogner FX, Wiseman M (1999) Toward measuring adolescent environmental perception. Eur Psychol 4(3):139–151

Cotgrove SS (1982) Catastrophe or Cornucopia: the environment politics and the future. Wiley, New York, 166 p

Dake K (1991) Orienting dispositions in the perception of risk: an analysis of contemporary worldviews and cultural biases. J Cross-Cult Psychol 22:61–82

Douglas M, Wildavsky A (1983) Risk and culture: an essay on the selection of technological and environmental dangers. University of California Press, Berkeley, 224 p

Dunlap RE (2008) The new environmental paradigm scale: from marginality to worldwide use. J Environ Educ 40(1):3–18

Dunlap RE, Van Liere KD (1978) The "new environmental paradigm". J Environ Educ 9(4):10–19

Dunlap RE, Van Liere KD (1984) Commitment to the dominant social paradigm and concern for environmental quality. Soc Sci Q 65:1013–1028

Dunlap RE, Van Liere KD, Mertig A, Jones RE (2000) Measuring endorsement of the new ecological paradigm: a revised NEP scale. J Soc Issues 56(3):425–442

Galler JM, Lasley P (1985) The new environmental paradigm scale: a reexamination. J Environ Educ 17:9–12

Hofstetter P (1998) 3. Modeling the valuesphere by cultural theory. In: Perspectives in life cycle impact assessment: a structured approach to combine models of the technosphere, ecosphere and valuesphere. Springer, 484 p

Hopper JR, Nielsen JM (1991) Recycling as altruistic behavior: normative and behavioral strategies to expand participation in a community recycling program. Environ Behav 23 (2):195–220

MacCarty JA, Shrum LJ (2001) The influence of individualism, collectivism, and locus of control on environmental beliefs and behavior. J Public Policy Mark 20(1):93–104

Marris C, Langford IH, O'Riordan T (1998) A quantitative test of the cultural theory of risk perceptions: comparison with the psychometric paradigm. Risk Anal 18(5):635–647

Milfont TL, Duckitt J (2004) The structure of environmental attitudes: a first- and second-order confirmatory factor analysis. J Environ Psychol 24:289–303

Paulhus D (1983) Sphere-specific measures of perceived control. J Pers Soc Psychol 44:1253–1265

Pierce JC, Lovrich NP Jr, Tsurutani T, Abe T (1987) Culture, politics and mass publics: traditional and modern supporters of the new environmental paradigm in Japan and the United States. J Polit 49(1):54–79

Richmond JM, Baumgart N (1981) A hierarchical analysis of environmental attitudes. J Environ Educ 13:31–37

Rotter JB (1966) Generalized expectancies for internal versus external control of reinforcement. Psychol Monogr Gen Appl 80(1):1–28

Thompson SCG, Barton MA (1994) Ecocentric and anthropocentric attitudes toward the environment. J Environ Psychol 14:149–157

Thompson M, Ellis R, Wildavsky A (1990) Cultural theory. Westview Press, Boulder, 296 p

Chapter 5
Application of Life Cycle Assessment (LCA) to Assess Actual Environmental Burdens Driven by PEBs

Abstract As discussed in Chap. 1, an accurate evaluation of each behavior's environmental footprint is not always necessary. However, if we discuss which behavior is more environment friendly, scientific background data can help us. The quantitatively calculated data can be persuasive, especially when we conduct environmental education programs. For that purpose, life cycle assessment (LCA) can be a powerful tool to assess the total environmental footprint derived from a target behavior.

In this chapter, we provide an overview of LCA using specific topics relating to the application and evaluation of behaviors.

In the first Sect. (5.1), the history and outline of LCA are shown. In Sect. 5.2, the important features to determine the LCA results, such as functional unit and system boundary, are explained. Then in the following Sects. 5.3 and 5.4, the details of life cycle inventory analysis (LCI) and life cycle impact assessment (LCIA) are shown, respectively. LCI is the process of gathering input data on the processes of interest, such as energy and resources, and the output data, such as products and environmental loadings, to create an input–output table. When it comes to LCIA, the impacts derived from the emitted environmental loadings are evaluated. In these sections, the indexes used in the analyses are also explained. I will show a rough example of LCA procedure in Sect. 5.5 and case study about selection of drink containers in Sect. 5.7. These sections can help readers understand the specific procedures of LCA and get output image of LCA results.

Keywords Life cycle assessment (LCA) • Life cycle inventory analysis (LCI) • Life cycle impact assessment (LCIA) • Functional unit • Midpoint approach • Endpoint approach • Case study

5.1 What Is LCA?

Life cycle assessment (LCA) is usually expressed as a "cradle-to-grave" assessment, which means the environmental burdens generated throughout the life cycle of a product or service are evaluated. This includes all phases, from raw material extraction to the product's final disposal (Fig. 5.1). It is defined by ISO (International Organization for Standardization) 14040 (2006) as follows:

K. Kurisu, *Pro-environmental Behaviors*, DOI 10.1007/978-4-431-55834-7_5

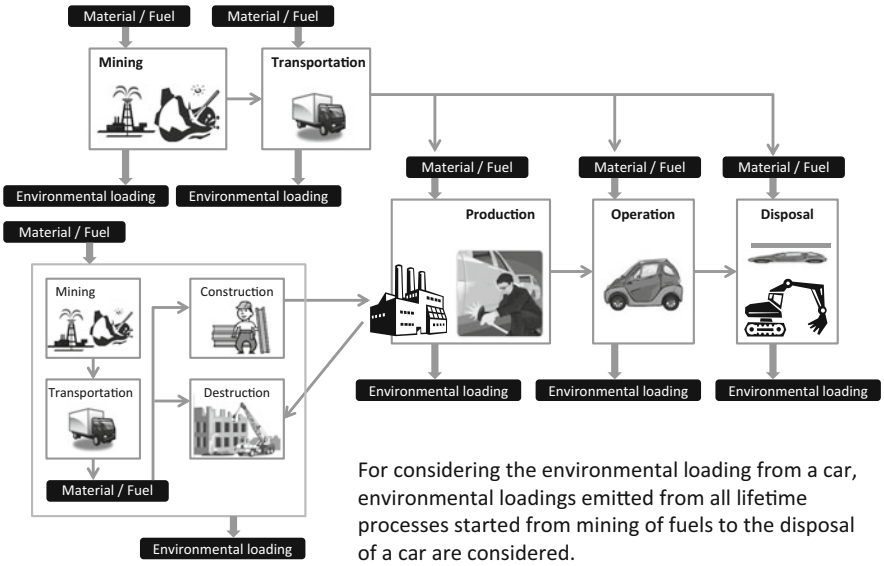


Fig. 5.1 Cradle-to-grave concept of LCA

> [The] compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle.
>
> (ISO 14040: 2006, p. 2)

People usually evaluate the environmental impacts of a product or service by using the apparent environmental burdens, such as energy consumed during the product's operation. However, if a product consumes very little energy while being used by the consumer, it does not necessarily reflect the energy needs of the product throughout its life cycle. For example, resource mining, production, or disposal can be energy intensive for that same product, in which case we cannot conclude that that product is environment friendly. By using LCA, we can evaluate the overall environmental burdens associated with the target product or service, including the latent environmental burdens behind the target product or service as well as the obvious environmental burdens.

5.1.1 History of LCA

Under Coca-Cola's sponsorship, the Midwest Research Institute ran the first LCA trial in 1969. The study compared the environmental burdens of different beverage containers, including single-use bottles, returnable bottles, and cans. The LCA prototype study, called resource and environmental profile analysis (REPA), was actively employed in the USA, starting in the early 1970s (Hunt et al. 1992; Hunt and Franklin 1996).

Trends in international standardization of LCA emerged in the 1990s. In response to the 1992 Earth Summit in Rio, the Technical Committee 207 on Environmental Management was assembled and the standardization of LCA came to be handled within the ISO 14000 family.

Initially, the LCA framework was fragmented between ISO 14040, 14041, 14042, and 14043; however, in order to correct inconsistencies and duplication, it was restructured into ISO 14040 "Principles and Framework" and ISO 14044 "Requirements and Guidelines" in 2006.

5.1.2 Outline of LCA

LCA consists of four steps (Fig. 5.2): (1) goal and scope definition, (2) life cycle inventory analysis (LCI), (3) life cycle impact assessment (LCIA), and (4) interpretation.

First of all, the "**goal and scope**" of the assessment should be clearly defined. At this step, the target product or service is defined, and the **functional unit** and **system boundary** should also be clearly decided (details are explained in Sects. 5.2.1 and 5.2.2).

Life cycle inventory analysis (LCI) is the process of gathering input data on the processes of interest, such as energy and resources used to make the service or product, and the output data, such as products and environmental loadings, to create an input–output table. Here, for example, information regarding CO_2 emitted per kg of the target product can be obtained (see Fig. 5.3).

When it comes to **life cycle impact assessment (LCIA)**, the impacts derived from the emitted environmental loadings are evaluated. There are two approaches called "midpoint" and "endpoint" approaches. In the **midpoint approach**, the impacts can be presented by **impact category** such as global warming, acidification, ozone depletion, eutrophication, and so on. In the **endpoint approach**, impacts can be presented by the **safeguard category**, such as human health and biodiversity. The details of methodologies are shown in Sect. 5.4.

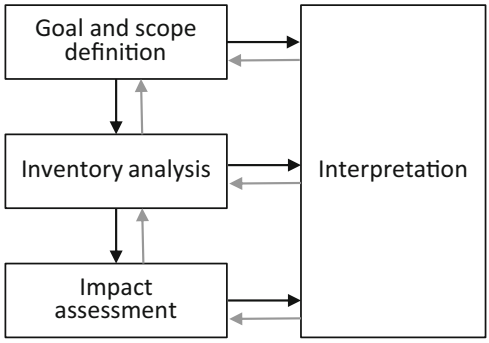


Fig. 5.2 LCA framework (ISO 14040: 2006)

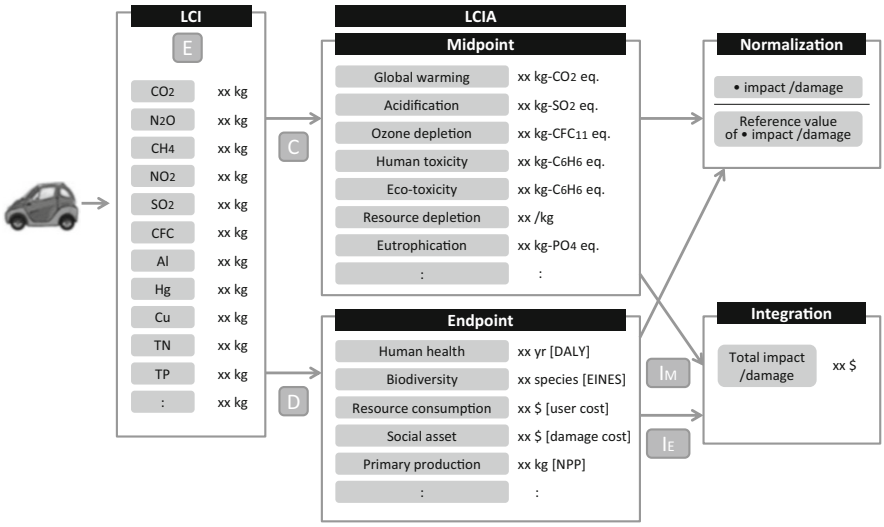


Fig. 5.3 Outline image of LCA steps. *C* characterization factor, *D* damage factor, *I* integration factor

LCI and LCIA are required components for LCA, as stated by ISO 14020, whereas the **standardization** and **integration** are arbitrary components. In the standardization step, the estimated impacts through the midpoint or endpoint approach are divided by their reference values, such as environmental standards and total emissions for a given year, and then the impacts are transformed into dimensionless values. In the integration step, the preference weight of each impact usually estimated by analytical hierarchical process (AHP) or conjoint analysis is taken into account and all impacts are integrated into one value, usually expressed in monetary terms. These processes involve more uncertainty than LCI and LCIA and, therefore, are defined as arbitrary according to ISO 14020.

5.2 Goal and Scope

5.2.1 Functional Unit

Although a target behavior can have several functions, you should decide the target function(s) and decide the functional unit for evaluation. It is also stated in ISO14040 (2006) as follows (in this statement, "product" can be read as "behavior"):

> The functional unit defines the quantification of the identified functions (performance characteristics) of the product.
>
> (ISO 14040: 2006, p. 12)

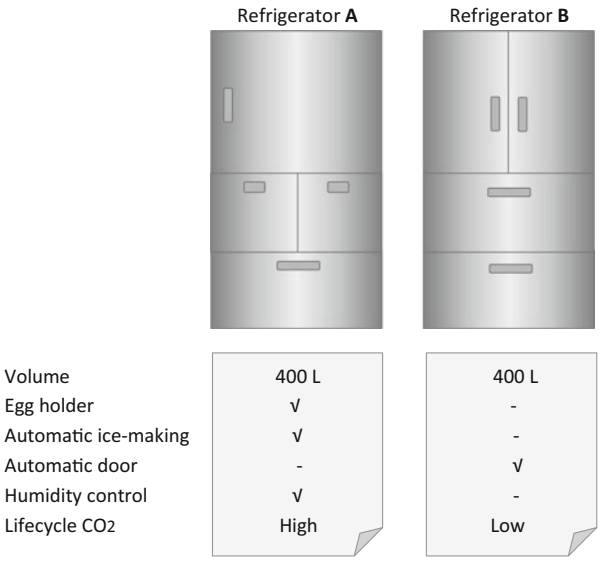


Fig. 5.4 Is it reasonable to compare these fridges?

Whether for products or behaviors, deciding the functional unit is difficult, but critical, for LCA. If you want to compare the products or services under the exact same conditions, you must set a common functional unit. Although the functional unit provides a significant impact on the result, it is an onerous task to set exactly the same functional unit.

For example, when evaluating a refrigerator, you may assume that the function would be "keeping products cool" and that a possible functional unit would simply be the size of the refrigerator, a common size being "400L." When you check the 400-L refrigerators on the market, however, you then realize there are a number of different functions in addition to cooling, such as energy-saving, ice making, humidity control, and so on. Therefore, if you purchase two refrigerators and compare their environmental burdens, as shown in Fig. 5.4, it is quite unreasonable to say that A is worse than B based solely on their environmental impact.

That is why there are two ways to evaluate a product. One is that you decide the functional unit as "400 L" and evaluate the life cycle environmental burdens. After that, you can evaluate the candidates based not only on their environmental burdens but also their other functions, such as egg compartment, automatic door, humidity control, and so on. The other possibility is to take all attributes into account and try to create the same comparison conditions between the products or services. An analyzer can make the conditions the same by taking into account the environmental burdens driven by alternative measures to complement the lacking attributes. For example, to set the same condition of an egg compartment, you can add an external egg carton into the environmental impact assessment of Refrigerator

A. While this does provide some means of equalizing the assessment process, making all attribute conditions the same is usually very difficult.

5.2.2 System Boundary

In order to evaluate the environmental burdens, the target processes should be determined using a system boundary. The system boundary is defined by ISO as follows.

> [A] set of criteria specifying which unit processes are part of a product system.
> (ISO 14040: 2006, p. 5)

As explained in Sect. 5.2.1, in this statement, "product" can be read as "behavior." The area framed by the dotted line in Fig. 5.5 shows an example of a system boundary setting. All processes are included in the calculation; in the case of a car we start from mining the materials and end with the disposal of the final product. Construction and destruction of the factory where the car is produced, however, are excluded from the target processes. The involved and excluded processes should be clearly defined in this step.

When you compare the estimated LCA results between two products or behaviors, it is very important that the **same functional units and system boundaries should be set** for both. As shown in Fig. 5.6, the comparison of CO_2 between A and B (X_1 vs. X_2) is unreasonable, because B has a greater function (2-L volume) than A (1-L volume). The comparison between X_1 from A and X_3 from C is also unreasonable, because X_3 includes processes that cover mining to disposal, while X_1 only includes mining and production processes.

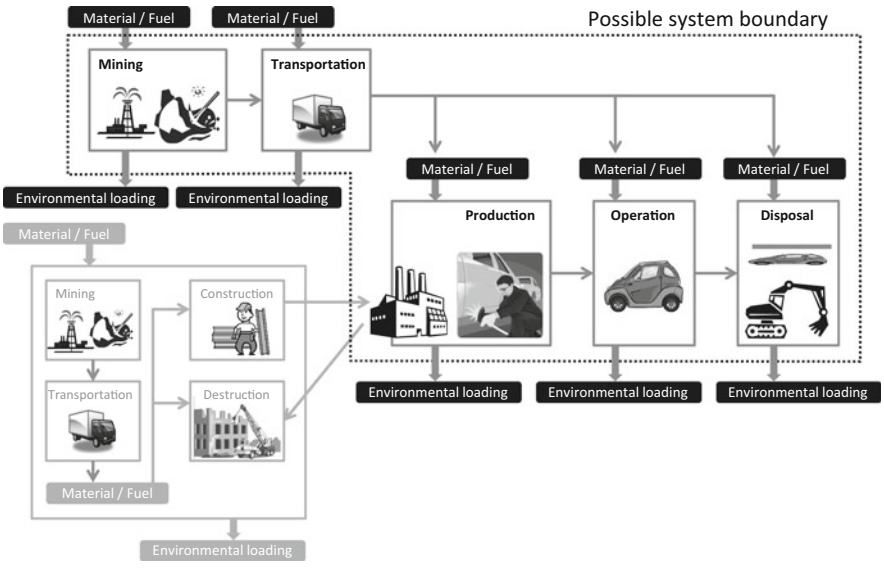


Fig. 5.5 Example of system boundary setting

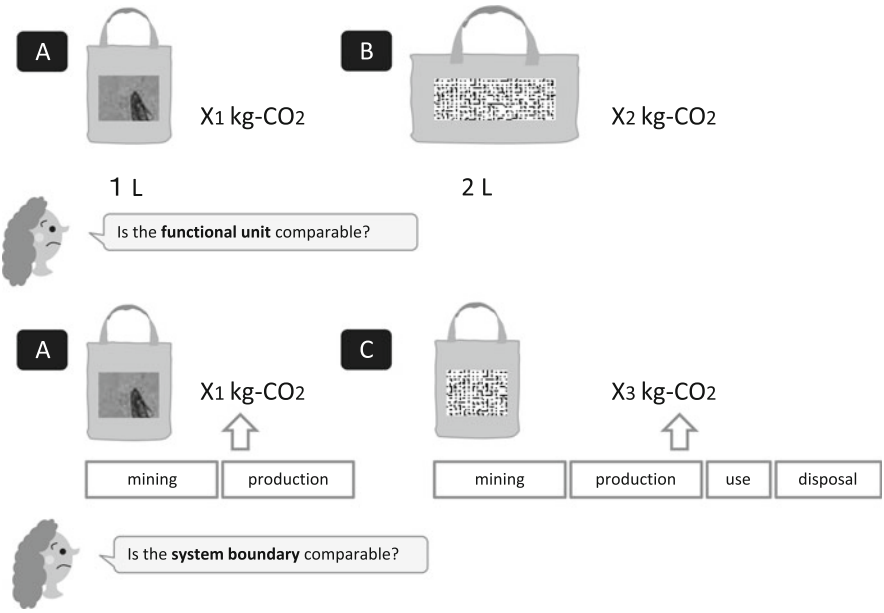
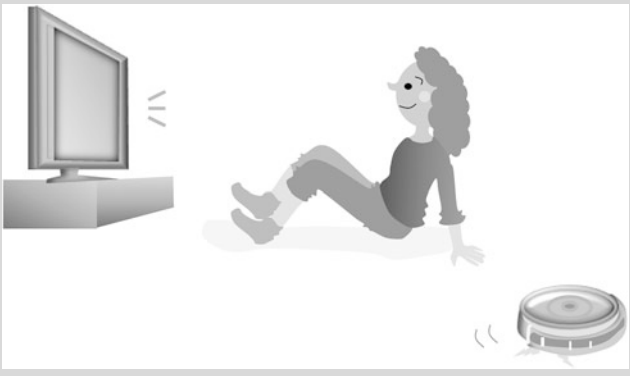


Fig. 5.6 Examining equality in comparisons

Column 5.1: Rebound Effect

For evaluating the environmental loading changes induced by behavioral changes, the rebound effect should be kept in our minds. For example, a person may save time and energy consumption by introducing a high-efficiency vacuum robot. However, if the person spends the saved time by conducting other more energy-consuming activities, the total energy consumption cannot be decreased. Although it is difficult to predict the induced behaviors by saved time or money, we must be aware of how the rebound effect could actually lead to an increase in environmental burdens.



5.3 Life Cycle Inventory Analysis (LCI)

The purpose of LCI is making an input and output table as shown in Fig. 5.7. Materials and energies required for the target product or service are listed. Once collected, the environmental loadings derived from each material or energy can be evaluated. The data of environmental loadings can be evaluated by **process-based analysis, by input–output (I–O) table analysis**, or as a hybrid of the two analyses. In this section, the process-based analysis where the inputs and outputs are accumulated by process is explained. The I–O table analysis is explained in Sect. 5.3.4.

5.3.1 Data Collection

The data directly related to the target processes is called **foreground data**. Collected by an analyzer, this data consists of the quantity of material and fuel input

One car
1,040 kg
production

	Process		Input material	Amount	Unit
Input	Production	Energy	Electricity	675	kWh
			Coal	25	kg
			Gasoline	2	L
			LPG	18	kg
			⋮	⋮	
		Raw material	Water	9	m^3
		Material	Iron	40	kg
			Aluminum	49	kg
			Propylene	7	kg
			⋮	⋮	
	Process		**Output material**	**Amount**	**Unit**
Output	Production	Co-products	Big steel	208	kg
			Resin	0.2	kg
		Environmental burden (to air)	CO_2	270	kg
			HCl	5	g
			NOx (as NO_2)	437	g
			SOx (as SO_2)	300	g
			VOC	3700	g
		Environmental burden (to water)	Water discharge	7	m^3
			BOD	27	g
			COD	80	g
			TN	26	g
			TP	14	g
			Suspended solids	36	g
			⋮	⋮	

Fig. 5.7 Input and output table for LCI

Table 5.1 Examples of LCI databases

Database	Founders		Covered area	URL
Ecoinvent	Switzerland	ETHZ, EPFL, PSI, Empa, Agroscope[a]	Switzerland, Europe, World	http://www.ecoinvent.org/
Gabi database	Germany	Pe International GmbH	Germany, Europe, World	http://www.gabi-software.com/databases/
ELCD	Europe	JRC-IES, EPLCA[b]	EU	http://eplca.jrc.ec.europa.eu/ELCD3/
US Life Cycle Inventory Database	USA	NREL[c]	USA	https://www.lcacommons.gov/nrel/search
JLCA database	Japan	METI[d]	Japan	http://lca-forum.org/english/
Korea National LCI Database	Korea	KEITI[e]	Korea	http://www.edp.or.kr/lci/lci_intro.asp

[a]ETHZ: ETH-Zürich, EPFL, École Polytechnique Fédérale de Lausanne; PSI, Paul Scherrer Institut; Empa, Swiss Federal Laboratories for Materials Science and Technology; Agroscope, Swiss Federal government agriculture, food, and environmental research organization
[b]JRC-IES, Institute for Environment and Sustainability (IES) of the European Commission's Joint Research Centre (JRC); EPLCA, European Platform on Life Cycle Assessment
[c]NREL, National Renewable Energy Laboratory
[d]METI, Ministry of Economy, Trade, and Industry, Japan
[e]KEITI, Korea Environment Industry and Technology Institute

used in the creation of the target product. The analyzer can collect this data by direct measurement or interviews with process managers.

Data indirectly related to processes that occur in the creation of the target product is called **background data**. The data that includes the material and fuel inputs and environmental loadings behind the target processes, such as mining, electricity generation, transportation, etc., can be collected from existing databases and literature.

LCA databases, as shown in Table 5.1, have been prepared in many countries. These data can be used as background data.

5.3.2 Cutoff Criteria

When conducting LCI, it is impossible to include every single material used in the product or the service, especially those materials present in minute quantity; that is why we set cutoff criteria. For example, a weight-based cutoff criterion at 98 % of the product's total weight would include materials contributing to 98 % of the product's total weight. Cutoff criteria can be set based on weight, energy, price, and so on. The environmental perspective, however, should be kept when setting the cutoff criteria. If a substance is omitted from being counted based on the weight-based cutoff criteria, the said substance should be included if the environmental

impact is significant. For example, aluminum is light but its production requires high-energy consumption; therefore, some aluminum may need to be included in the inventory for assessment. Another example would be if a highly toxic substance, such as mercury, were present in the creation of the product, in which case even a small amount would have a large impact and therefore must be included.

5.3.3 *Allocation*

When a target system or product is accompanied by coproducts, the environmental burden should be carefully considered. Figure 5.8 shows an example of this situation. In this case, E, the environmental burden, is generated by production of a_1 kg (b_1 J, c_1 \$) bioethanol as a main product and of a_2 kg (b_2 J, c_2 \$) glycerin as a coproduct. When estimating the environmental burden generated solely from the bioethanol, **allocation** is one possible method. Allocation can be done by weight, energy, monetary value, and so on. If weight allocation is selected, the environmental burden for the bioethanol is estimated as $E*a_1/(a_1 + a_2)$. Similarly, when the energy allocation and monetary allocation are applied, the environmental burden for the bioethanol is estimated as $E*b_1/(b_1 + b_2)$ and $E*c_1/(c_1 + c_2)$, respectively. Another case is also shown in Fig. 5.9. If cooling energy (X kWh) is used, not only for the target product (A kg) but also for the other products (B kg), the cooling energy used for the target product is estimated as $X*A/(A + B)$ kWh.

Allocation can be used for the system generating, not only the target product/service, but also the coproduct/service. However, allocation can increase the uncertainty of the LCA results; therefore, ISO recommends avoiding allocation and instead using alternative methods.

> "Wherever possible, allocation shall be avoided by:
>
> 1) Dividing the unit process to be allocated into two or more sub-processes and collecting the input and output data related to these sub-processes.
> 2) Expanding the product system to include the additional functions related to the co-products."
>
> (ISO 14041: 1998)

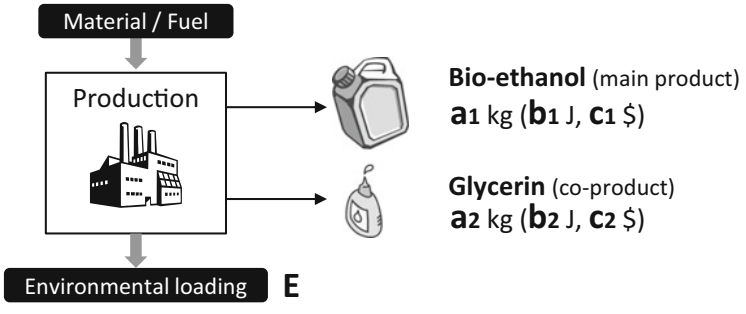


Fig. 5.8 Example of allocation case I

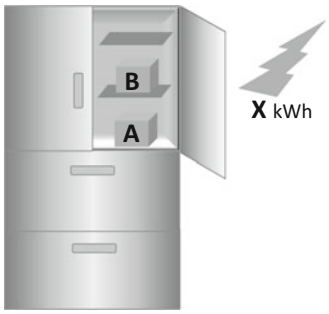


Fig. 5.9 Example of allocation case II

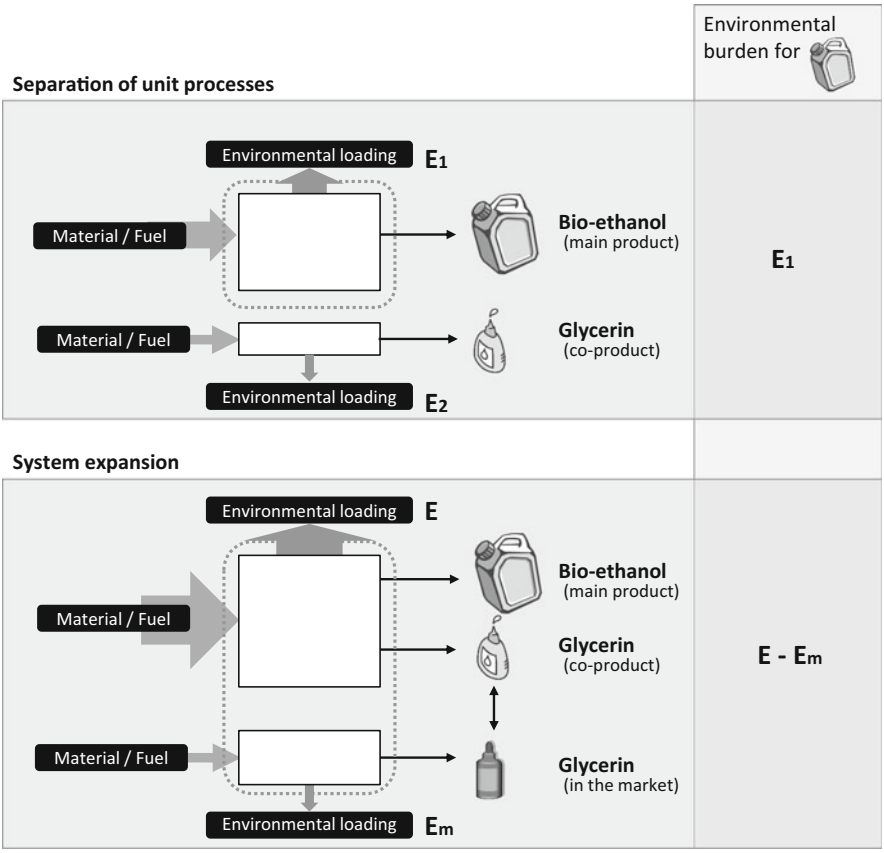


Fig. 5.10 Avoidance of allocation: separation of unit processes and system expansion

As shown in Fig. 5.10, dividing the whole process into subsystems is one possible way of tackling this challenge. In this example, production processes are

divided into two subsystem processes, for the bioethanol production and the glycerin production. Then, the environmental loading just from the target processes (E_1) can be counted as the environmental burden for the target product. However, the production processes are usually intricately combined and separation is often difficult.

The alternative method is **system expansion**. When the coproduct is produced, it can replace the same product in the market. From this concept, the system in question can be expanded to involve the production processes of the replacement product. As shown in Fig. 5.10, when glycerin is produced as a coproduct of bioethanol, it can replace glycerin on the market, and the environmental burden needed for market glycerin (E_m) can be subtracted from the whole environmental loadings (E) of the bioethanol and glycerin production system. Then, the environmental burden solely for bioethanol production is estimated as $E-E_m$.

5.3.4 I–O Table Analysis

For calculating environmental burdens, one promising method is accumulation of environmental burdens from unit processes. Using the I–O table method for this approach, the whole environmental burden related to the target product can be calculated based on the I–O table at one time.

The I–O table is the economic datasheet where the transaction values of production and sales between various sectors are shown in a matrix format. The inventory derived by I–O analysis can cover not only the environmental burden from the direct transaction but also the burden indirectly generated by other sectors. The total environmental burden for a product in question is estimated by the following equation:

$$E = \mathrm{e}(I - A)^{-1}\mathrm{X}$$

Here, E is the total environmental burden resulting from the target product, e is the emission factor (environmental burden/production value), I is the unit matrix, A is the input matrix (amount of materials and fuels consumed for unit of production), and X is the final demand in monetary costs.

Based on this I–O analysis, several countries have developed environmental emission factor books. In Japan, the National Institute of Environmental Studies (NIES) has developed 3EID (Embodied Energy and Emission Intensity Data for Japan Using Input-Output Tables), which shows the total environmental burden involving indirect and direct impacts generated by one unit production activity (in million JPY) for each sector. When you want to estimate the environmental burden for a product, you can multiply the production value (e.g., million JPY) with the 3EID value for the product (e.g., t-CO_2/million JPY).

The advantage of this I–O table method is coverage of whole sectors relating to the target product, whereas in process-based analysis, some omissions can happen.

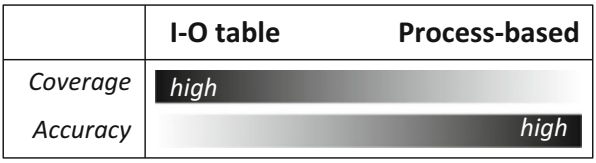


Fig. 5.11 Characteristics of I–O table analysis and process-based analysis

A possible disadvantage, however, is that the uncertainty of the data would be larger in the I–O method, whereas more accuracy can be gained by the process-based analysis as shown in Fig. 5.11.

5.3.5 Indexes Used In LCI

To evaluate environmental burdens, the data for various compounds are collected during the LCI process. Some common substances are shown here, explaining how they contribute to environmental problems.

5.3.5.1 Greenhouse Gases (GHGs)

Emissions contributing to global warming are called greenhouse gases (GHGs). The global warming process is shown in Fig. 5.12. Most of the sun's radiation is absorbed by the ground and warms the earth, while some part of solar radiation is reflected by the surface. Where GHGs exist, they can absorb reflected radiation and reradiate it in the atmosphere, increasing surface temperatures. Six of the most common GHGs and their sources are listed in Table 5.2. In LCI, long-life GHGs, such as CO_2, CH_4, and N_2O, are often counted.

5.3.5.2 Air Pollutants

The air pollutants often included in LCI are nitrogen oxides (NOx), sulfur oxides (SOx), and particulate matter (PM). These pollutants are produced mainly through combustion from **mobile sources** (mainly from vehicles) and **point sources** (mainly from factories). The main impacts caused by these pollutants include acidification of water and soil and human health impacts such as respiratory diseases.

In the case of NOx, nitric oxide (NO) is first emitted into the air and quickly oxidized creating nitrogen dioxide (NO_2); therefore, the environmental standard is usually set for NO_2. NOx is categorized into **thermal NOx**, which is produced by the combustion of nitrogen in the air, and **fuel NOx**, which is generated by the combustion of nitrogen contained in fuel. Nowadays, it is encouraged to remove nitrogen and sulfur from fuel, and with their contents being regulated, fuel-origin

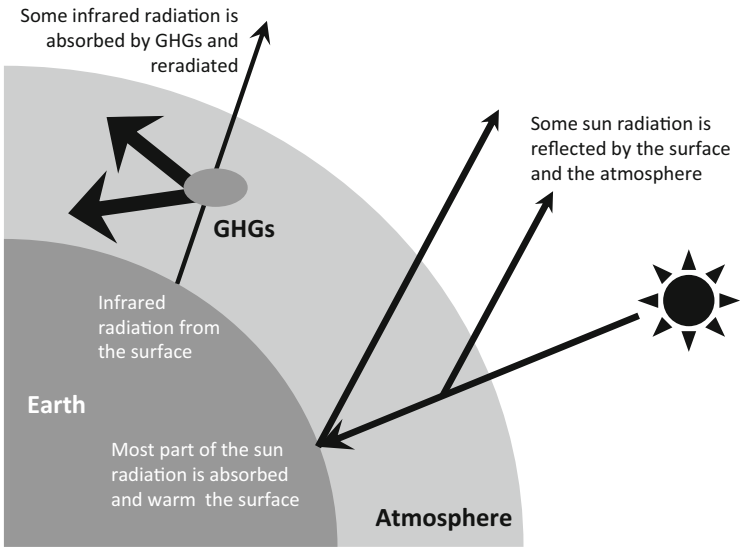


Fig. 5.12 Mechanism of global warming

Table 5.2 Common GHGs

GHGs		Main sources
Carbon dioxide	CO_2	Fossil fuel combustion
Methane	CH_4	Wetlands, ruminant animals' flatulence
Nitrous oxide	N_2O	Combustion, nitrogen fertilizer
Hydrofluorocarbons	HFCs	Alternative for chlorofluorocarbon
Perfluorocompounds	PFCs	Industrial materials
Sulfur hexafluoride	SF_6	Insulating materials

NOx and SOx are decreasing. On the other hand, the air has an abundance of nitrogen and is sometimes difficult to control; therefore, the reduction of thermal NOx is more difficult than that of fuel NOx. The main source of NO_2 in the urban area can often be vehicles. Regarding SOx, sulfur dioxide (SO_2) is the main compound, which is mostly produced during the combustion of fuel containing sulfur. The main sources of SO_2 are point sources, such as factories, where emission control measures can be easily applied, such as the installation of flue-gas desulfurization equipment. When NOx and SOx are deposited into water and soil, they cause acidification.

PM is microlevel particulate matter. Suspended particulate matter (SPM) and PM_{10} are particulate matters under 10 μm in diameter, and $PM_{2.5}$ represents particulate matter under 2.5 μm in diameter. These small particles can be inhaled deeply into the lungs and cause respiratory diseases. PM is directly emitted during combustion and also secondarily produced when SOx and NOx first react when released as gases.

When evaluating the impact of air pollution, it is critical that estimated air pollutants are discussed as being emitted at several sites in the lifetime of the target product. Unlike GHGs, the impact of air pollutants is not globalized but localized. Therefore, local emissions, especially during the operational stage, should be evaluated and discussed separately from other life cycle emissions.

5.3.5.3 Water Pollutants

When organic pollutants are discharged into water bodies, dissolved oxygen (DO) in the water is consumed, which oxidizes the organic matter creating carbon dioxide. The oxygen consumption means there is a depletion of oxygen in the water, which has an impact on aquatic organisms. The amount of organic pollutants discharged into water, therefore, is an important index. The popular indexes used to represent organic matters in the water are BOD (biochemical oxygen demand) and COD (chemical oxygen demand). The concepts of BOD and COD are shown in Figs. 5.13 and 5.14, respectively. When water is left for 5 days, degraders (mainly bacteria) oxidize the organic matter found in the original water and the dissolved oxygen is consumed. The amount of consumed oxygen (DO_5–DO_0) can therefore reflect the amount of organic matter existing in the original water. In the case of COD, chemical oxidants such as potassium permanganate ($KMnO_4$) and potassium dichromate ($K_2Cr_2O_7$) are added into the water to oxidize the organic matter. In this case, the consumed oxidant ($Oxidant_b - Oxidant_a$) represents the organic matter that existed in the original water as shown in Fig. 5.13. The COD measured using potassium dichromate is called COD_{Cr}, which is used worldwide, whereas the COD

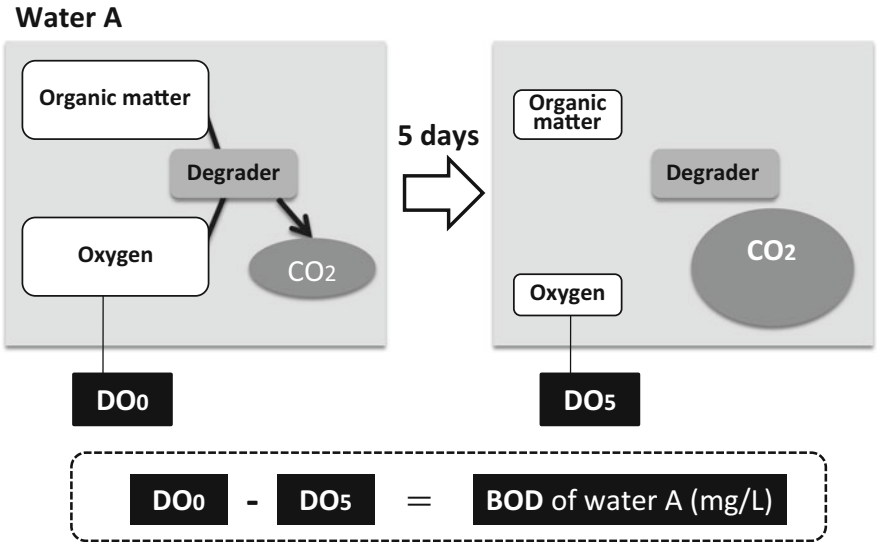


Fig. 5.13 Concept of BOD

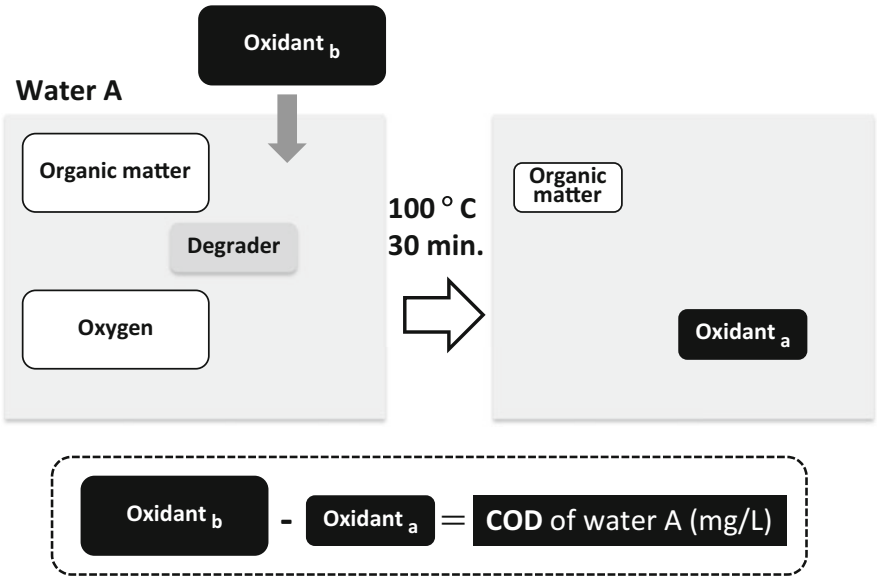


Fig. 5.14 Concept of COD

measured by using potassium permanganate is called COD_{Mn}, which is used in limited countries, such as Japan.

Nitrogen and phosphorus are limiting factors to algal growth; therefore, they can be indexes for representing water pollution. When algal blooms occur, it causes serious water use problems, suffocating fish, and DO decline due to an increase in decomposing organic matter. This can result in **eutrophication,** a condition characterized by rich nutrients such as nitrogen and phosphorus and severe algal blooms.

Like air pollution, water pollution is also a localized problem. Therefore, any discharges to local water bodies, especially during the operational stage, should be evaluated and discussed separately from other life cycle discharges.

5.3.5.4 Toxic Compounds

Inorganic and organic toxic compounds, which have acute or chronic toxic effects on humans and other organisms, are included in the LCI framework. Table 5.3 shows only a fraction of example compounds. When discharge of these compounds is investigated, the area of discharge, such as air, water, and soil, should be also clearly identified, as the impact estimated by LCIA can be different depending on the discharge area.

Other compounds should also be counted in LCI depending on their impact and safeguard categories such as resource consumption, ozone depletion, land use, waste disposal, and so on. However, using LCI to cover all compounds is usually difficult. Therefore, you can focus on limited compounds based on your objective.

Table 5.3 Examples of toxic compounds

Inorganic	Metal	Mercury	Hg
		Copper	Cu
		Cadmium	Cd
		Chrome	Cr
	Metalloid	Arsenic	As
		Selenium	Se
	Other inorganic compounds	Hydrogen chloride	HCl
		Sodium cyanide	NaCN
Organic	Aromatic compounds	Benzene	C_6H_6
		Toluene	C_7H_9
		Phenol	C_6H_5OH
		Pyrene	C_6H_{10}
	Organohalogen compounds	Chloroform	$CHCl_3$
		Tetrachloroethylene	C_2Cl_4
		Perfluorooctanesulfonic acid	PFOS
		Polychlorinated biphenyl	PCBs
	Dioxins and dioxin-like compounds	2,3,7,8-Tetrachlor-odibenzo-p-dioxin	$C_{12}H_4Cl_4O_2$ (TCDD)
		2,3,4,7,8-Pentachloro-dibenzofuran	$C_{12}H_3Cl_5O$ (2,3,4,7,8-PeCDF)

If you want to specifically learn about global warming effects, then you can focus on GHGs; if you want to view the resource consumption, you can focus on mineral resources and fossil fuels.

5.4 Lifecycle Impact Assessment (LCIA)

During the LCIA, the values estimated in LCI are compiled based on their impacts. As explained in Sect. 5.1.2, there are two approaches: midpoint and endpoint approaches. Various LCIA methods have been developed in several countries, such as Eco-indicator (Netherland), EPS (Sweden), LIME (Japan), and Impact 2002^+ (Switzerland).

5.4.1 Midpoint Approach

In the midpoint approach, the LCI values are compiled into several impact categories as shown in Tables 5.4 and 5.5.

Table 5.4 Impact categories and characterization factors in Heijungs (1992) (Table 3.2)

Impact category	Characterization factor		Unit after characterization
Abiotic depletion	1/reserves		kg/kg (reserves)
Biotic depletion	BDF	Biotic depletion factor	$year^{-1}$
Greenhouse effect	GWP	Global warming potential	kg-CO_2
Ozone depletion	ODP	Ozone depletion potential	kg-CFC11
Human toxicity (air)	HCA	Human toxicological classification factors	kg (the part of the body weight exposed to the toxicologically acceptable limit)
Human toxicity (water)	HCW		
Human toxicity (soil)	HCS		
Aquatic ecotoxicity	ECA	Ecotoxicological classification factors	m^3 (contaminated water)
Terrestrial ecotoxicity	ECT		kg (contaminated soil)
Oxidant formation	POCP	Photochemical ozone creation potential	kg-ethylene
Acidification	AP	Acidification potential	kg-SO_2
Nutrification	NP	Nutrification potential	kg-PO_4^{3-}
Aquatic heat	1		MJ
Malodorous air	1/OTV	1/odor threshold values	m^3 (air amount exceeding OTV)
Noise	1		$Pa^2 \cdot s$
Damage to ecosystems and landscapes	1		$m^2 \cdot s$
Victims	1		Persons

5.4.1.1 Global Warming

The impact on global warming derived from greenhouse gases emission is evaluated using GWP (global warming potential), which shows the impact of each greenhouse gas on global warming relative to CO_2. The time scales of GWP are 20, 100, and 500 years, among which 100 years (GWP_{100}) is most commonly used. The total global warming impact is evaluated using the following equation:

$$\text{Global warming impact} = \sum\nolimits_i GWP_i E_i \tag{5.1}$$

Here, i is the substance contributing to global warming, GWP_i is the global warming potential of i, and E_i is the emitted amount of i. The recent GWP values reported by

Table 5.5 Impact categories and characterization factors in LIME2

Impact category	Characterization factor		Unit after characterization
Resource depletion	1/R		1/kg
		Consumed energy	MJ
Greenhouse effect	GWP	Global warming potential	kg-CO_2
Ozone depletion	ODP	Ozone depletion potential	kg-CFC11
Human toxicity (cancer)	HTP_{cancer}	Human toxicity potential	kg-C_6H_6 air
Human toxicity (chronic disease)	$HTP_{chronic\ disease}$		kg-C_6H_6 air
Aquatic ecotoxicity	AETP	Ecological toxicity potential	kg-C_6H_6 water
Terrestrial ecotoxicity	TETP		kg-C_6H_6 soil
Photochemical oxidant formation	OCEF	Ozone creation equivalent factor	kg-ethylene
Acidification	DAP	Deposition-oriented acidification potential	kg-SO_2
Urban air pollution	UAF	Urban air pollution factor	kg-SO_2
Indoor air pollution	TVOC	Total VOC	kg (no weighting)
Eutrophication	EPMC	Eutrophication potential considered marine material circulation	kg-PO_4^{3-}
Noise	NPF	Noise potential factor	J/vehicle·km
Land use	LOF	Land occupation factor	1/m^2/year
	LTF	Land transformation factor	1/m^2
Waste	WPF	Waste potential factor	m^3/kg

Table 5.6 Global warming potential of three main greenhouse gases

		GWP_{100}		
		SAR	AR4	AR5
Carbon dioxide	CO_2	1	1	1
Methane	CH_4	21	25	28
Nitrous oxide	N_2O	310	298	265

SAR, IPCC 2nd report; AR4, IPCC 4th report (2007); AR5, IPCC 5th report

the Intergovernmental Panel on Climate Change (IPCC) are shown in Table 5.6. For example, when your target process emits E_1 kg of CO_2, E_2 kg of CH_4, and E_3 kg of N_2O, the total global warming impact by the three gases is calculated as $E_1 + 28E_2 + 265E_3$ [kg CO_2 eq.] using the GWP_{100} in AR5.

5.4.1.2 Other Impacts

To evaluate other impacts, the same methodology with Eq. 5.1 is used as shown in Eq. 5.2.

$$\text{M impact} = \sum_i C_i E_i \tag{5.2}$$

Here, i is the substance contributing to M effect, C_i is the characterization factor of i, and E_i is the emitted amount of i. For C_i, the factors shown in various LCIAs can be used. The factors shown in Tables 5.4 and 5.5 are possible examples.

As you can see, the acidification impact derived from the E_1 kg of NO_2 and E_2 kg of SO_2 is estimated as $AP_{NO2}E_1 + AP_{SO2}E_2$, where APi is the acidification potential of i.

5.4.2 *Endpoint Approach*

In the endpoint approach, impacts are compiled into safeguard categories. Like Eq. 5.2, the damage is commonly calculated as shown in Eq. 5.3.

$$\text{N damage} = \sum_i D_i E_i \tag{5.3}$$

Here, *i* is the substance giving N damage, D_i is the damage factor of *i*, and E_i is the emitted amount of *i*. For D_i, the factors shown in various LCIAs can be used.

Table 5.7 shows the endpoints used in various approaches. In this section, the index used in each safeguard category is explained.

Table 5.7 Safeguard categories used in various LCIAs

Name of tool		Eco-indicator 99	EPS	LIME	Impact 2002^+
Founder/covered area		Netherlands/ Europe	Sweden	Japan	Switzerland/ Europe
Safeguard category	Human health	DALY	YOLL, severe morbidity, morbidity, severe nuisance, nuisance	DALY	DALY
	Biodiversity	PAF, PDF	NEX	EINES	PAF, PDF
	Resource consumption	Surplus energy (MJ)	Depletion of reserves (kg)	User cost (yen)	MJ
	Social asset	–	Production capacity (kg)	Damage cost (yen)	–
	Primary production	–	–	NPP	–
	Global warming	–	–	–	(kg CO_2eq.)

DALY disability adjusted life years, *YOLL* years of life lost, *PAF* potentially affected fraction, *PDF* potentially disappeared fraction, *NEX* normalized extinction of species, *EINES* expected increase in number of extinct species, *NPP* net primary productivity

5.4.2.1 Human Health

The human health impact category is commonly involved in various endpoint approaches. **DALY (disability adjusted life years)** is usually used as an indicator of human health impact within the LCIA framework. The concept of this index is counting health impacts as time lost to disease. The original concept can be found in the index of **YOLL (years of life lost)**, which is used in EPS. For example, when a person dies 2 years earlier than his lifetime expectancy due to a cancer caused by substance X, the cancer risk of substance X is estimated as 2 years. However, YOLL can evaluate only the disease causing death and cannot evaluate other diseases causing daily disability. DALY is explained as DALY = YOLL + YLD, where YLD is years lived with disability. For example, if a person dies from respiratory disease 2 years earlier than his lifetime expectancy and he was suffering from asthma 10 years prior to this caused by substance X, the health risk of substance X is estimated as $2 + 10\alpha$. This α is the disability coefficient, which represents the lost proportion of the quality of life (QoL). For example, if the person loses 30 % of QoL by asthma, the DALY of substance X is estimated as 2 + 0.3*10 = 5 years.

In addition to the above disability coefficient, the original DALY developed by WHO (World Health Organization) involves the age weighting and time discounting. The original DALY gives the highest life value for 25-year-olds and takes 3 % time discounting. However, there are many criticisms on the age weighting and time discounting. Therefore, LIME does not accept the age weighting and time discounting in DALY factors as shown in Table 5.8. Eco-indicator 99 also does not involve time discounting, but it uses different damage factors for different personalities based on the cultural theory (see Sect. 4.2.4.1) involving the age weighting just for individualists.

5.4.2.2 Biodiversity

Eco-indicator 99 and Impact 2002^{+} use PAF (potentially affected fraction) and PDF (potentially disappeared fraction) as damage indicators for biodiversity. The damage factor (PDF/emission) is estimated based on the Netherlands situation and expanded to Europe. In Eco-indicator 99, the PAF is estimated at a tenth of the PDF and combined with the PDF. This assumption involves large uncertainty and the adequacy is controversial. EPS uses NEX (normalized extinction species);

Table 5.8 Concepts involved in DALY

			Eco-indicator 99		
	WHO	LIME	Egalitarian	Hierarchist	Individualist
Disability weighting	X	X	X	X	X
Age weighting	X	–	–	–	X
Time discounting	X	–	–	–	–

1 NEX is defined as annual whole damage to the ecosystem, which is allocated to each damage cause and finally divided by the substance emission contributing to the damage (e.g., kg-SO_2) to give the damage factor. This concept is simple and easily understood; however, the mechanisms from emission substance to damage occurrence are not evaluated and the ecosystem damage in Sweden is just used and expanded to apply to the whole world; therefore, the local characteristics of each country are not accurately reflected. EINES (expected increase in number of extinct species) is used in LIME, developed in Japan. It defines extinction risk as the reciprocal of expected lifetime before extinction. The remaining lifetime before extinction is calculated based on the red data book using the Monte Carlo simulation. The advantage of EINES is that the damage to ecosystems derived from land use change can be also estimated using EINES. However, the damage factors are prepared based on Japanese conditions. Therefore, an analyzer should carefully select the damage factors considering the characteristics of each methodology and reflecting their target region.

5.4.2.3 Resource and Social Asset

Damages to resources are categorized into "input," which represents the damage derived from resource extraction, and "output," which represents the damage to resources caused by emitted pollutants, as shown in Fig. 5.15.

Table 5.9 shows the methodologies used in several LCIAs. Eco-indicator 99 only involves "input," which uses the **surplus energy** for evaluating environmental damage derived from resource consumption. The concept is shown in Fig. 5.16. When a mineral resource is extracted, the quality of the same remaining

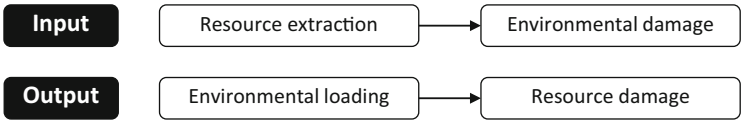


Fig. 5.15 Two concepts relating to resources

Table 5.9 Indicators for resource damage

	Eco-indicator 99	EPS	LIME
Input	Surplus energy for spoiled/alternative resource purification	Internal and external costs for alternative resource production	User cost
Output	–	[annual damage/annual emission] *[monetary value/damage] = [monetary value/emission]	[concentration/emission] * [damaged production/concentration] * [production value/production] = [production value/emission]

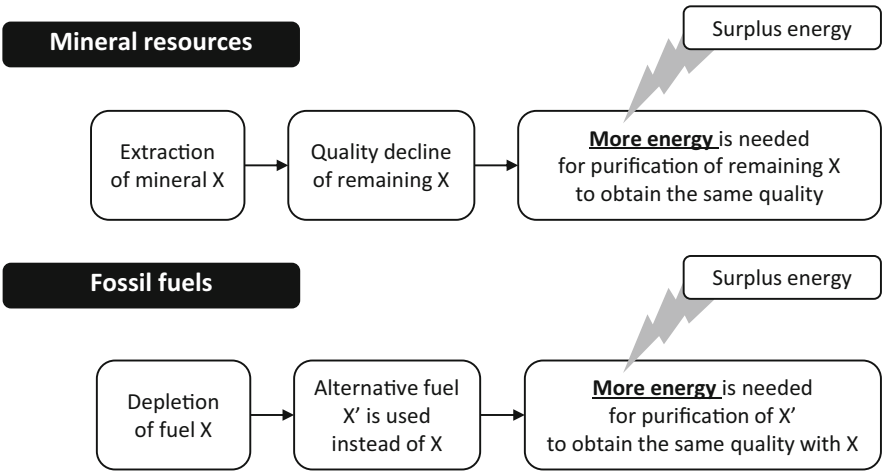


Fig. 5.16 Concept of surplus energy used in Eco-indicator 99

substance becomes lower and more energy for purification is needed in future processes to obtain the same quality as today's product. The additional energy for the purification is called surplus energy, which is used as an indicator of mineral resource consumption damage. Similarly, in the case of fossil fuels, Eco-indicator 99 determines alternative fuels; extra energy for obtaining the same quality as today in future fuel is counted as surplus energy. The damage factors are prepared as xx MJ surplus energy/t resource consumption. This method is easily understood; however, the uncertainties of quality depletion of mineral resources and alternative fuel settings for fossil fuels are involved. EPS also sets alternatives and evaluates the internal cost and external cost of the damage derived by resource consumption.

In LIME, the "input" uses the **user cost** method originally proposed by El Serafy (1989). The concept is shown in Fig. 5.17. The user cost method involves the discount rate; however, this figure shows a simple picture without the discount rate in order to easily explain the concept. Here, Y is the annual benefit gained from the target resource extraction. When the extraction is stopped after n years, the future generation cannot gain any benefits from the target resource. Therefore, Ys is annually stocked and the same benefit, the remaining benefit Yi, will be gained by future generations as annual interest of the investment of the stock with r interest rate. In this case, Ys (user cost) represents the damage from consumption of the target resource. If the target resource is very rare and n is quite short, a larger amount of Ys must be stocked. Hence, scarcity of the target resource can be evaluated by the user cost.

EPS and LIME also deal with "output." EPS first estimated the damage per emissions by dividing the annual damage by the annual emissions. Then, using the relationship between the monetary value loss and damage, the monetary value loss of the target resource per emissions is estimated as a damage factor. In the case of LIME, concentration is calculated from the emitted amount of a pollutant, and

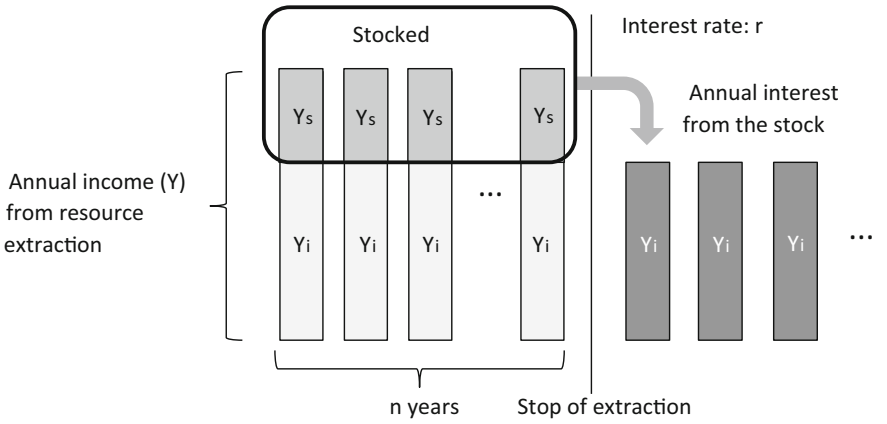


Fig. 5.17 Concept of user cost used in LIME (without discount rate consideration)

damaged production is estimated using the relationship between the concentration and damaged production. Then, loss of production value per emissions is calculated as a damage factor using the production value per unit product.

5.4.2.4 Primary Productivity

Primary production is the starting point of the food chain and supports all organisms by supplying oxygen via photosynthesis. Therefore, primary production can be one of the environmental damage indexes. For considering sustainable conservation, the rate of primary production should be considered instead of the current stock. Net primary productivity (NPP); t/ha/year), which is the primary productivity by subtracting the consumption by respiration from gross primary productivity (GPP), is used as a damage factor for primary production in LIME.

5.4.3 Midpoint vs. Endpoint

The advantages and disadvantages of the two approaches are shown in Table 5.10. The advantage of using the midpoint approach is that it is highly credible. Impact factors proposed for the midpoint approach, such as GWP and AP, are science based. On the other hand, results shown using the midpoint approach, such as xx $kgCO_2$-eq. and xx kg SO_2-eq., are difficult for people to imagine as actual impacts on the environment. In addition, there are a number of impact categories, making it quite difficult to evaluate all the different impacts together. When employing the endpoint approach, the number of safeguard categories is limited and the expressed impacts, such as human health and biodiversity, are easily understood. The

Table 5.10 Advantages and disadvantages of midpoint and endpoint approaches

Approach	Impacts are presented by	Advantage	Disadvantage
Midpoint	Impact category	High data credibility based on scientific mechanisms	More difficulty to understand actual impacts
Endpoint	Safeguard category	Easier-to-understand actual impacts	High uncertainty based on more assumptions made throughout the impact processes

disadvantage, however, is that many assumptions need to be made regarding damage factors, making it more uncertain than the midpoint approach.

5.5 Example of LCA Procedure

For helping readers understand the practical procedure of LCA, one example is shown in this section. Figure 5.18 outlines the LCA application.

For the first step, based on an analyzer's interest, the target behavior is decided; in this case, a reusable tumbler is selected for the target behavior. The second step is to decide the functional unit; here, the one-time use of a 350-mL tumbler is selected as the functional unit. At this step, each product's lifetime should be decided – the environmental loads from the production and disposal stages are allocated to a one-time use. In our example, the tumbler is to be used 50 times before disposal: this means that in order to render a one-time use calculation, we need to divide the environmental loadings from the production and disposal stages by 50 (the number of proposed uses).

Next, the process diagram should be drawn and the system boundary should be decided. Here, the system starts with mining raw materials, ends with the tumbler's disposal, and includes all in-between stages. Not all processes, except for construction/production and destruction/disposal stages of the factories and machines involved, are included in the calculation.

The fourth step is the collection of foreground data (X). Here, the original data relating to the target product or behavior should be collected. In this case, for example, we include the amount of materials and fuels needed for the production of the tumbler as well as water used during the washing stage. This information can be collected through direct measurements, interviews, or literature surveys.

At the fifth step, the background data (Y) relating to each foreground datum are collected. For example, the previous step reveals that polypropylene (PP) is used for the tumbler's production; for this step, data about the materials and fuels needed for one unit of PP production is collected from LCA databases and other literatures.

Then, emission factors (e) for each background datum are prepared. In this case, for production of PP, light diesel oil is inputted; therefore, the environmental

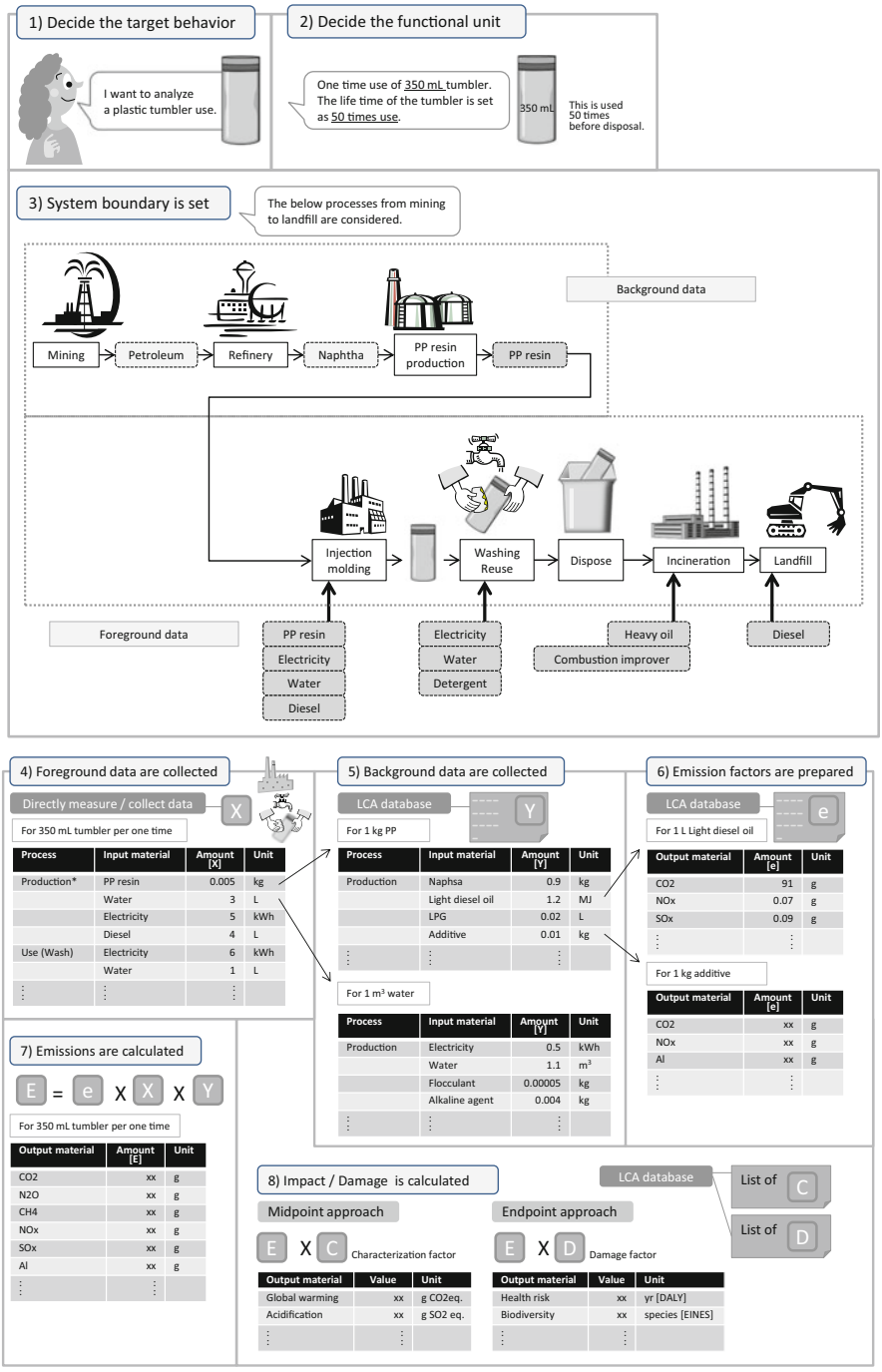


Fig. 5.18 Outline of the LCA procedure

loadings relating to one unit of light diesel oil production are prepared using LCA databases and other literatures.

In the final stage of LCI, the emissions (E) are calculated using the foreground data (X), the background data (Y), and the emission factors (e). For the LCIA stage, by multiplying the emissions (E) by characteristic factors (C) and damage factors (D), the impacts and damages caused by the target product/behavior are estimated.

5.6 Interpretation

Interpretation of the results is the important final step of LCA. An analyzer should interpret **which processes have a significant impact on the target product or behavior** in addition to focusing on the total impact.

If possible, it is recommended that **sensitivity and uncertainty analyses** should be carried out in addition to interpretation. The data used in LCA involves some uncertainties; none of the variables has a unique value, each has some distribution. Therefore, an analyzer should check the results by changing the values at a constant rate (such as +10 % to −10 %) or by using Monte Carlo simulation. Using sensitivity analysis, an analyzer can determine which variable gives a larger uncertainty on the final result.

5.7 Case Studies

There have been some trials using LCA to evaluate environmental loadings derived from PEBs. Some of these trials are described here.

We compared five daily behaviors, such as detergent use, rice storage, shopping bag use, dish use, and drinking cup use. For each case, several scenarios, including alternative PEB scenarios, were prepared. In the case of drinking cup use, four scenarios (Fig. 5.19) were prepared (Shimpo et al. 2012). Here, disposable paper

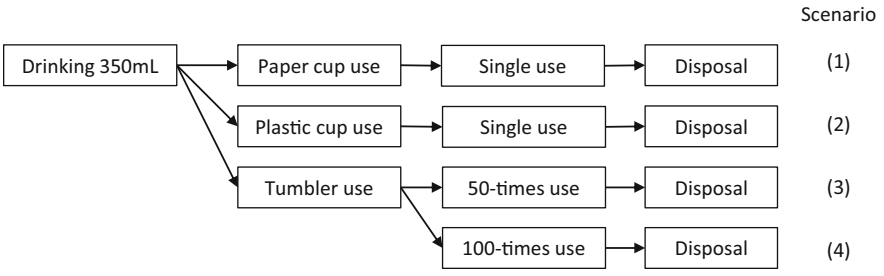


Fig. 5.19 Example of behavior evaluation by LCA: drinking behavior scenarios (Shimpo et al. 2012; reused by permission from Environmental Science © Society of Environmental Science, Japan)

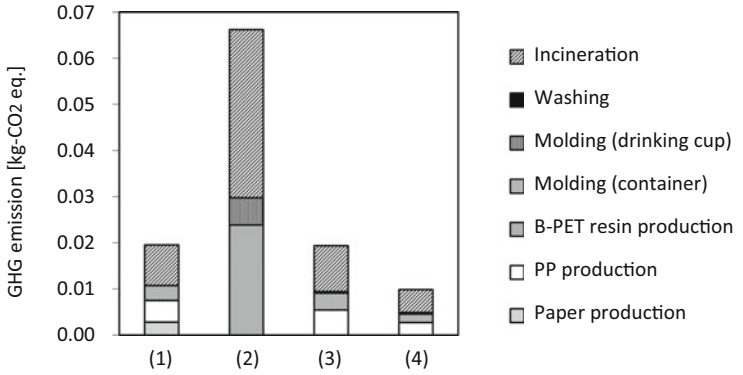


Fig. 5.20 Global warming impacts for the drinking scenarios (Shimpo et al. 2012; reused by permission from Environmental Science © Society of Environmental Science, Japan)

Table 5.11 Impacts by drinking behaviors (Shimpo et al. 2012; reused with permission from Environmental Science © Society of Environmental Science, Japan)

	Global warming	Acidification	Fossil resource consumption	Final waste generation	Household-waste generation
	[kg-CO_2 eq.]	[g-SO_2 eq.]	[MJ]	[g]	[g]
(1)	0.020	0.046	0.39	0.91	15.0
(2)	0.066	0.085	0.45	1.40	14.0
(3)	0.019	0.025	0.30	0.26	3.7
(4)	0.010	0.012	0.15	0.13	1.8

and disposable plastic-cup use are considered as baseline scenarios, and tumbler use is considered as PEB. We evaluated global warming, acidification, fossil resource consumption, and final waste disposal by LCA and compared those results with household-waste generation. As seen in Fig. 5.20, the plastic-cup use scenario gives the highest global warming impact out of the four scenarios. In addition, it is also implied that the incineration of disposed cups/tumblers has a significant impact on global warming. Table 5.11 shows the other estimated impacts in addition to global warming. From the LCA results seen here, it is concluded that plastic-cup use gives the highest environmental loadings and tumbler use gives a significant decrease in environmental loadings. The study also noted that while environmental impacts are usually judged using the more apparent impacts, such as household-waste generation, this is sometimes inconsistent with life cycle impacts. For example, the paper-cup use scenario gives a higher household-waste generation than the plastic-cup use scenario; however, from the viewpoint of life cycle environmental impacts, paper-cup use is more environment friendly than plastic-cup use.

Yamaguchi et al. (2007) compared old-model and new-model dishwashers by LCA. They showed that the new model had slightly decreased total CO_2 emissions compared to the old one. However, detergent use is greater in the new type;

therefore, the CO_2 decrease remained small. They also compared the use of the new dishwasher with washing up by hand. The total CO_2 emission from washing up by hand using warm water at 40 °C was much higher than from using the dishwasher, while washing by hand using water at 25 °C gave a much lower CO_2 emission than from using the dishwasher.

Chaffee and Yaros (2007) at Boustead Consulting & Associated Ltd. reported detailed LCA results of a comparison between three types of grocery bags: (1) recyclable plastic, (2) compostable or biodegradable plastic, and (3) recycled or recyclable paper bags. They also compared the final disposal options, such as recycling, combustion with energy recovery, landfill, and composting. Dewaele et al. (2006) compared Ariel® (Procter & Gamble) laundry detergents by LCA: major products in 1998 and 2001, and "Actif à froid" (coolclean) detergent, which allows consumers to wash at lower temperatures. These trials can give scientific evidence for consumers to select environment-friendly products and for producers to enhance their design for environment (DfE).

5.8 Other Concepts Relating to LCA

In addition to the various environmental loadings shown in previous sections, other concepts and indicators that focus on new issues have emerged. In this section, those concepts are explained.

5.8.1 Water Use

First introduced by Anthony Allan from the University of London (Allan 1998), **virtual water** focuses on water used in the production of goods or services, such as agricultural products. Virtual water evaluates the amount of water required for the production of food if the food-importing country produces that same food within their country. This concept is sometimes useful, but it does not follow the LCA framework.

Within LCA research, interests on water use evaluation have increased. Kohller (2008) advocates the importance of measuring the **water footprint** in addition to the carbon footprint. The water footprint follows the exact same framework of regular LCA, estimating total water use during the whole life cycle. A new approach to assessing water use, the details for the water footprint procedure have yet to be established. The latest trends are summarized in Kounina et al. (2013).

5.8.2 Life Cycle Cost Analysis and Social LCA

Using the same framework as with environmental LCA (E-LCA), other aspects can be also counted. The analysis for the total cost needed in all processes for the target product/behavior is called **life cycle cost analysis (LCCA)**. Similarly, using the same framework of E-LCA, social aspects, such as labor, privacy, safety, and so on, can be also collected, which is called **social LCA (S-LCA)**. S-LCA originated from a proposal to include a "social welfare" impact category within the LCA framework by Fava et al. in 1993 (Benoît et al. 2010). The United Nations Environment Programme (UNEP) provides the guideline of S-LCA (UNEP 2009); however, S-LCA developers are still on a learning curve.

Evaluation of these three aspects (environment, economic, and social) makes up a triple bottom line for sustainability and informs holistic viewpoint regarding target product/behavior.

5.8.3 Food Mile/Food Mileage

Food miles and food mileage calculate the distance the food is transported between production and consumption. The concept is simple and easily understood making it a widespread classroom favorite. This index is very useful in evaluating food self-sufficiency. However, if the analyst wishes to calculate the environmental burdens derived from food product, this index may lead to misunderstandings. The food mile/mileage only covers transportation, and in the life cycle of a product, the environmental loadings derived from the transportation part are often small compared to the loadings accrued during production stage (of course, there can be exceptions). Therefore, the use of food miles/mileage should be carefully considered based on the analyst's purposes. If the discussion about environmental burden is a central issue, LCA should be applied instead of food miles/mileage.

References

Allan JA (1998) Virtual water: a strategic resource global solutions to regional deficits. Groundwater 36(4):545–546

Benoît C, Norris GA, Valdivia S, Ciroth A, Moberg A, Bos U, Prakash S, Ugaya C, Beck T (2010) The guidelines for social life cycle assessment of products: just in time! Int J LCA 15:156–163

Chaffee C, Yaros BR (2007) Life cycle assessment for three types of grocery bags – recyclable plastic; compostable, biodegradable plastic; and recycled, recyclable paper. Boustead Consulting & Associated Ltd., 63 p. http://heartland.org/sites/default/files/threetypeofgrocerybags.pdf

Dewaele J, Pant R, Schowanek D (2006) Comparing the environmental burdens of home laundry detergent products and laundry habits in France 1998–2006. Procter & Gamble, Brussels Innovation Center, Central Product Safety –Environmental, 57 pp. http://www.avnir.org/documentation/bdd/sg/Ariel%20Actif%20a%20Froid%20LCA%20report%20Nov%202006_0.pdf

El Serafy S (1989), The proper calculation of income from depletable natural nesource. In: Ahmad YJ, El Serafy S, Lutz E (eds) Environmental accounting for sustainable development: a UNDP – World Bank symposium. The World Bank, Washington, DC, pp 10–18

Fava J, Consoli F, Denson R, Dickson K, Mohin T, Vigon B (1993) A conceptual framework for life-cycle impact assessment. Workshop Report, Society for Environmental Toxicology and Chemistry and SETAC. Foundation for Environmental Education, Inc, Pensacola

Heijungs R (1992) Environmental life cycle assessment of products-guide 1992. CML, Leiden. https://openaccess.leidenuniv.nl/handle/1887/8061

Hunt RG, Franklin WE (1996) LCA history: LCA-how it came about- personal reflections on the origin and development of LCA in the USA. Int J LCA 1(1):4–7

Hunt RG, Sellers JD, Franklin WE (1992) Resource and environmental profile analysis: a life cycle environmental assessment for products and procedures. Environ Impact Assess Rev 12 (3):245–269

ISO 14041 (1998) Environmental management – life cycle assessment – goal and scope definition and inventory analysis

ISO 14040 (2006) Environmental management – life cycle assessment – principles and framework, 20 p

Kohller A (2008) Water use in LCA: managing the planet's freshwater resources. Int J Life Cycle Assess 13(6):451–455

Kounina A, Margni M, Bayart JB, Boulay AM, Berger M, Bulle C, Frischknecht R, Koehler A, Canals LM, Motoshita M, Núñez M, Peters G, Pfister S, Ridoutt B, Zelm R, Verones F, Humbert S (2013) Review of methods addressing freshwater use in life cycle inventory and impact assessment. Int J Life Cycle Assess 18:707–721

Shimpo Y, Nakatani J, Kurisu K, Hanaki K (2012) Life-cycle assessment of household waste prevention behaviors. Environ Sci 25(2):95–105 (in Japanese). https://www.jstage.jst.go.jp/article/sesj/25/2/25_95/_pdf

UNEP (2009) Guidelines for social life cycle assessment of products, 104 p

Yamaguchi Y, Tsuchiya M, Tsuda T (2007) Evaluation of the dishwashing towards the reducing environmental load. J Home Econ Japan 58(7):397–406 (in Japanese; Tables and figures are provided in English). https://www.jstage.jst.go.jp/article/jhej/58/7/58_7_397/_pdf

Chapter 6
Trials to Foster PEBs

Abstract Various interventions to foster PEBs have been proposed by many researchers. In this chapter, those strategies are explained. In Sect. 6.1, the intervention methods, such as commitment, goal setting, introduction of leaders, foot-in-the-door technique, feedback, and incentive/reward, are explained. Other methods enhancing psychological factors (especially norm activation) are explained in Sect. 6.2. In Sect. 6.3, the methods using "information" are explained. Examples of information for enhancing "norms" such as descriptive norm, injunctive norm, and personal norm and for providing "knowledge" such as declarative knowledge, procedural knowledge, and effectiveness can help readers catch the outline. Each intervention method is based on some psychological factors. The relationships are shown in a diagram in Sect. 6.4. Labeling is one of the information provision methodologies and can have some impact on consumers to select products. The details are explained in Sect. 6.5. In Sect. 6.6, the trials using life cycle assessment (LCA) results and life cycle thinking (LCT) concepts are shown. Other programs or campaigns are explained in Sect. 6.7. In the final section (6.8), some ideas and new trials for achieving widespread and lasting influence of fostering PEBs are shown.

Keywords Intervention • Commitment • Feedback • Information • Eco Mark • Carbon footprint • Life cycle thinking (LCT)

6.1 What Kind of Strategy Is Effective?

Abrahamse et al. (2005) reviewed 38 studies and evaluated the effectiveness of interventions for encouraging reduction of household energy consumption. They separated the interventions into **antecedent interventions** and **consequence interventions** (this categorization is seen in many studies, e.g., Lehman and Geller 2004): that is the measures prepared before the PEB program and the measures applied during/after the program. Dwyer et al. (1993) reviewed intervention studies conducted from 1980 to 1990 and categorized them into several antecedent strategies, such as "commitment," "oral activator or demonstration," "written activator," "assigned individual goal," and "environmental alteration," and other consequence categories, such as "feedback signaling consequences," "feedback not signaling consequences," "rewards to individuals," "rewards to groups," and

K. Kurisu, *Pro-environmental Behaviors*, DOI 10.1007/978-4-431-55834-7_6

Table 6.1 Interventions for PEBs

Antecedent	Consequence
Commitment Goal setting Information provision Product/service provision Incentive Leader introduction Competition framework Modeling	Feedback Reward Penalty

Table 6.2 Evaluation aspects for interventions

Evaluation aspect (De Young 1993)	Key question
Reliability	Is the effectiveness reliable or not?
Speed of change	How rapidly can the behavior be changed?
Particularism	Is the intervention universal or site/situation specific?
Generality	Is there a spillover effect onto other, similar behaviors?
Durability	Is the changed behavior repeated?

"penalty." Steg and Vlek (2009) categorized the strategies into **informational** and **structural**: that is the measures providing information and the measures providing products or services. Based on these studies, the possible interventions for PEBs are summarized in Table 6.1.

The intervention strategies can be decided considering several aspects. De Young (1993) showed five aspects to evaluate the intervention program, "reliability," "speed of change," "particularism," "generality," and "durability," as shown in Table 6.2.

6.1.1 Commitment

The commitment strategy is that participants are asked to make a formal commitment (promise) to conduct the target behavior before the program starts. Often, this commitment involves not only the behavior itself but also the goal of the behavior, such as an amount of energy reduction. Many studies show that the people who make commitments are more likely to conduct the target behavior (Bachman and Katzev 1982; Katzev and Johnson 1984). Cobern et al. (1995) tested three conditions to promote grass recycling: (1) control, (2) written commitment to change their own behavior, and (3) written commitment to change their own behavior and verbal commitment to promote their neighbors' behaviors. Their results showed that grass recycling was significantly increased by commitment intervention during the 4-week program period and 4-week follow-up stage. After 1 year, a decrease of recycling (rebound) was observed; however, the commitment conditions showed a

higher recycling rate than the control condition. The intervention using the combination of commitment for their own behaviors and verbal commitment to promote neighbors' behavior showed the highest effect on enhancing grass recycling.

Conversely, insignificant results of commitment strategy have also been shown. De Leon and Fuqua (1995) compared three intervention strategies for recycling behavior: (1) commitment only, (2) feedback only, and (3) combined commitment and feedback. They asked the subjects, who live in an apartment complex affiliated with a Midwestern university, to sign a letter making a commitment to recycle and to accept the publication of the letters in a campus newspaper. The results showed that the commitment-only group did not show any significant change of recycling behavior (about the results of feedback strategy, see Sect. 6.1.5).

Although negative results exist, commitment is viewed as a normative motivational approach (Wiener 1982); therefore, when norms are properly activated through commitment interventions, the strategy can work well for fostering PEBs for a long time.

6.1.2 Goal Setting

Setting specific goals, such as the amount of saved energy and the frequency of car use, can support people's efforts for PEBs. As observed by McCalley and Midden (2002), **to make goal setting effective, feedback of goal attainment should be accompanied**. Loock et al. (2013) showed the effectiveness of goal setting with feedback on household energy-saving behavior. They listed three effects by goal setting as follows:

> a goal directs a person's attention and effort toward the activities relevant to the goal, . . . a goal affects one's persistence, . . . [and] goals also indirectly affect action by leading individuals to seek, discover, and/or use knowledge and strategies related to the task at hand.

They compared three groups: no-goal subjects ($G^{-}D^{-}$), goal and no-default subjects ($G^{+}D^{-}$), and goal and default subjects ($G^{+}D^{+}$). The goal setting enhanced energy savings and the default goals also led to significant energy savings. They also reported that too low and too high default goals with respect to the self-set goals had negative impacts on energy saving. McCalley and Midden (2002) also tested the goal setting with feedback for energy saving of washing machines. They tested four groups: no goal with feedback, self-set goal with feedback, assigned goal with feedback, and no goal with no feedback. Their results showed no difference between the no-goal with feedback group and the no-goal with no-feedback group. However, the two groups where goals were set showed a significant decrease of energy consumption for washing machine use. In addition, they tested the personality influence and reported that pro-self individuals saved more energy when goals were set by themselves, while pro-social individuals saved more energy when goals were assigned.

The possible strategies for goal setting are summarized in Fig. 6.1.

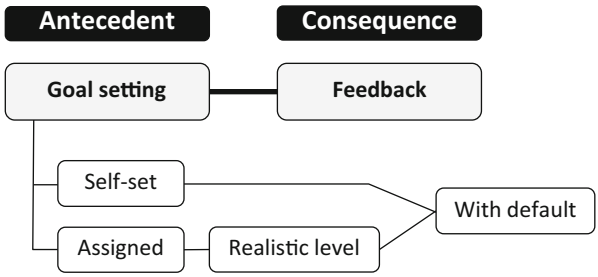


Fig. 6.1 Possible strategies for goal-setting interventions

6.1.3 Introduction of Leaders

Hopper and Nielsen (1991) analyzed the block-leader approach to recycling behavior. The purpose of block leaders is to enhance interpersonal communication in the neighborhood and encourage people's behaviors. They showed that the block-leader program would enhance altruistic norms and increase recycling behavior. Burn (1991) also introduced block leaders who gave approximately 10 non-recycling neighbors a persuasive communication advocating recycling and special recycling bags. The results showed a higher recycling rate in the case of block-leader introduction. Meneses and Palacio (2007) tested the effect of commitment by block-leader encouragement on recycling behavior. They concluded that the technique of commitment by group-leader encouragement was not characterized by immediate attitudinal change but showed high levels of effectiveness in the long term.

Carrico and Riemer (2011) introduced the leader for energy saving at offices in a university. They briefed peer educators on energy saving and investigated the influence. They demonstrated the effectiveness of the introduction of peer education and concluded that "when information is disseminated by someone within an individual's social group, it tends to be more effective than information that is provided from an outside source or unknown third party."

Although the effect of group-leader introduction on social norms has not been clearly demonstrated (Carrico and Riemer 2011), **the introduction of leaders would be more effective for behaviors** such as curbside recycling and PEBs at workplaces, which are **conducted in the sight of others inside a community or a group**.

6.1.4 Foot-in-the-Door Technique

When asking people to conduct a PEB with regard to a large task, it can be more effective to ask them to perform an easier PEB ahead of it. This seems to make people more accepting of the following larger task. This is well known as the **foot-in-the-door (FITD) technique**, which was first proposed by Freedman and Fraser

(1966) and uses a similar concept to the self-perception theory proposed by Bem (1972). FITD is defined as follows:

> A technique for eliciting compliance by preceding a request for a large commitment with a request for a small one, the initial small request serving the function of softening up the target person.
>
> (Oxford Dictionary of Psychology 3rd ed.)

The opposite technique is called **door-in-the-face (DITF) technique**, which requests larger task before the smaller task (Cialdini et al. 1975).

Arbuthnot et al. (1976–1977) introduced the FITD technique to foster recycling behaviors. They prepared three manipulations, such as "survey on recycling related knowledge (survey: S)," "one week recycling of cans (appeal: A)," and "receiving a letter describing recycling importance and sending back a postcard to the city council supporting expanded recycling (letter: L)." They reported that the combination of some manipulations such as A + L and S + A + L showed effectiveness in fostering recycling behavior. Katzev and Johnson (1983) revealed that the FITD technique had a significant effect on energy conservation behaviors. They compared again the effects of a small task (FITD technique), commitment, and monetary incentive for electricity conservation behaviors (Katzev and Johnson 1984). They prepared six groups: (1) control, (2) small questionnaire (FITD), (3) commitment, (4) questionnaire + commitment, (5) monetary incentive, and (6) questionnaire + commitment + incentive. They reported that the groups treated by "commitment" and "FITD + commitment + incentive" showed more electricity conservation than other groups during the conservation period. These studies showed the effectiveness of FITD when used in combination with other techniques.

Dejong (1979) discussed that a significant FITD effect was not always found. He pointed two requirements to bring FITD to a successful conclusion: the first one is that "the initial request must be large enough to cause people to think about the implications of their own behavior; if the request is too small, the effect will probably not be obtained." The second is that "people must feel that their initial compliance resulted from the exercise of free choice, not because of pressure to comply."

6.1.5 Feedback

As shown in Sect. 6.1.1, De Leon and Fuqua (1995) compared three intervention strategies, where they gave weekly information about the amount of recycled papers to the participants as feedback intervention. Unlike the commitment-only intervention, the feedback-only and combination groups showed a significant increase in recycled papers during the program. Midden et al. (1983) showed that general information provision did not work for enhancement of energy saving at home, while weekly feedback about saved energy and money showed significant effects on energy savings.

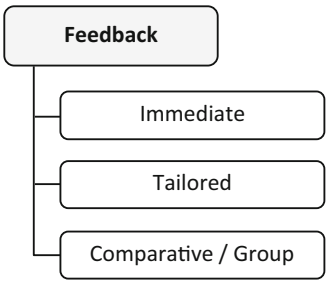


Fig. 6.2 Requirements for effective feedback

In the case of feedback, instead of general information feedback, the **tailored feedback** for each participant is more effective. Abrahamse et al. (2007) showed the effectiveness of tailored feedback, which gives information relevant for each participant.

Loock et al. (2013) summarized nine studies using the feedback interventions by web portal and software. They mentioned that information systems (IS) can make the feedback cost efficient and easier. IS can also easily measure the actual consumed energy; therefore, it can be an effective tool for interventions to enhance energy savings at home and at the workplace.

According to Geller (2002), the **immediate feedback** after each behavior is more effective. In addition, group feedback is more effective than individual feedback. Siero et al. (1996) tried to compare the individual feedback and **comparative feedback** at a company. They concluded that employees in the comparative feedback group saved more energy than employees who only received information about their own performance.

These three elements making feedback interventions effective are summarized in Fig. 6.2.

6.1.6 Incentive/Reward

Interventions showing monetary (or other) benefits before and after the program have been called incentive and reward interventions, respectively. Geller (2002) recommended incentive/reward interventions instead of disincentive/penalty ones because penalty interventions generate negative affections and attitudes in people.

Katzev and Johnson (1984) demonstrated the limited impact of monetary incentives on energy savings. Bolderdijk et al. (2012) compared the economic interventions with biospheric and natural appeals for tire-check behavior. They also concluded that just raising economic self-interest cannot be the best way to promote PEBs. In another study, Kerr et al. (2012) showed that group payment through leaders cannot work when the participants do not trust the leaders. Stern (1999) defined the incentive and information interventions as contextual and personal domains, respectively, and proposed the effectiveness of combining these two interventions. The study showed that the effectiveness of the incentive could

depend on how it is explained to people. In addition to monetary incentives, other incentives, such as an increase in convenience, could also be used as interventions (Stern 1999).

Foxx and Schaeffer (1981) demonstrated the effectiveness of monetary reward for energy conservation; however, they also showed that the effects were immediately lost when the reward was stopped. Instead of monetary rewards, Luyben (1984) used the thanking message as a reward for energy conservation through nighttime use of venetian blinds in a college. The group receiving the thanking message from the cleaning staff showed more use of blinds than the groups just receiving the written request from the college president.

Budget limitations make it impossible to continue the monetary incentives and rewards. Thus, if these interventions can change people's habits or attitudes fundamentally, some impacts on PEBs can be expected. However, as shown in Foxx and Schaeffer (1981), people maintain their motivations only during the benefit period, and they usually stop their behaviors after the benefit period ends. Therefore, these interventions can be used only for rising first awareness of PEBs; for long-term behavioral change, combination with other interventions working on normative domains, as explained in the following section, should be considered.

6.2 Psychological Factor Enhancement

6.2.1 Attitude Change

Changing attitudes is one of the possible means to enhance PEBs. However, many studies have shown that the effect of attitudinal change on actual behaviors is quite low.

Jordan et al. (1986) conducted 6-day workshops for high school students to develop their environmental concerns. After 2 months, simply enhancing awareness without action strategies brought no behavioral changes, while awareness enhancement accompanied by action strategies showed significantly positive effects on PEBs.

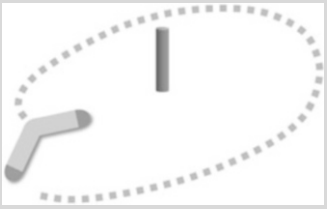
As already explained in Sect. 2.2.2, gaps between attitudes and behaviors have been pointed out by many studies and just targeting attitudinal change cannot be an effective measure to foster an actual behavior; it should be combined with other strategies.

6.2.2 Norm Activation

As seen in Chaps. 2 and 3, social norms and personal norms are important driving forces to enhance people's PEBs.

Bolderdijk et al. (2012) mentioned that interventions to maintain a positive self-concept can motivate people to act morally. They compared the information offering biospheric benefits and economic benefits such as "Care about the environment? Get a free tire check" and "Do you care about your finances? Get a free tire check." Their results showed that people felt much better when they received the biospheric appeal than the economic one; the biospheric appeal can persuade more people than the economic appeal. Their results indicated that moral activation would be a better intervention than monetary incentives.

Schultz et al. (2007) gave descriptive and injunctive normative messages and investigated their effects on people's energy-saving behaviors in San Marcos, CA. They gave feedback of actual energy consumption of the average household in the participants' neighborhood as descriptive normative information. In addition, the group who received the combination of descriptive and injunctive normative information was also given happy face or sad face marks depending on their energy consumption, representing approval or disapproval for energy consumption working on the injunctive norms. Their results showed that in the descriptive normative information-only provision, the boomerang effect occurred (see Column 6.1) and some increases in energy consumption were observed. On the other hand, the injunctive normative intervention showed a significant decrease in energy consumption and also offset the boomerang effect.



Column 6.1: Descriptive Norm vs. Boomerang Effect

Although information provision about others' behaviors is considered to be one of the effective ways to foster PEBs, ***negative effect*** *has been also reported, namely, the "boomerang effect." When people are provided with information about the average energy consumption in their community and are shown that their energy consumption is above the average, they can try to reduce their energy consumption. On the other hand, if their energy consumption is below the average, they start to think that they can consume more energy than before (Schultz et al. 2007). In this case, the information provision negatively affects the fostering of PEBs.*

The "boomerang effect" is defined as an opposite reaction to the persuasive treatment. In other words, it can be the ***opposite behavioral reaction to what is expected****. The boomerang effect for altruistic behavior was also reported by Schwartz. When the seriousness of need is high, it is expected that the personal norm is activated and helping behavior can occur. However, an opposite phenomenon was observed (Schwartz 1970; Schwartz 1977) in this regard. Schwartz and Howard (1982) described that the* ***intention*** *for helping others* ***can be lost*** *when the seriousness of need is too high.*

6.3 Information Provision

In the case of information provision, two factors should be considered: "**contents**" and "**methods**." As shown in Table 6.3, the contents can be divided into psychological enhancement and knowledge provision.

The psychological factor enhancement (see Sect. 6.2) involves **norm activation** and attitude change. Figure 6.3 shows examples of norm activation using posters. In the case when the descriptive norm is the target, information about other people's behaviors can be provided. In Fig. 6.3, the percentage of own shopping bag use is provided as information for descriptive norm activation. When the injunctive norm

Table 6.3 Information provision strategies

Contents			**Methods**
Purpose	**Data type**		
Psychological enhancement Descriptive norm Subjective/injunctive norm Personal norm Attitude change Knowledge provision Declarative Procedural Effectiveness	Quantitative Qualitative	X	Mass media Newspaper TV/radio Internet Local media Free paper Social network Workshop Poster Leaflet

Fig. 6.3 Examples of norm enhancement strategies by posters

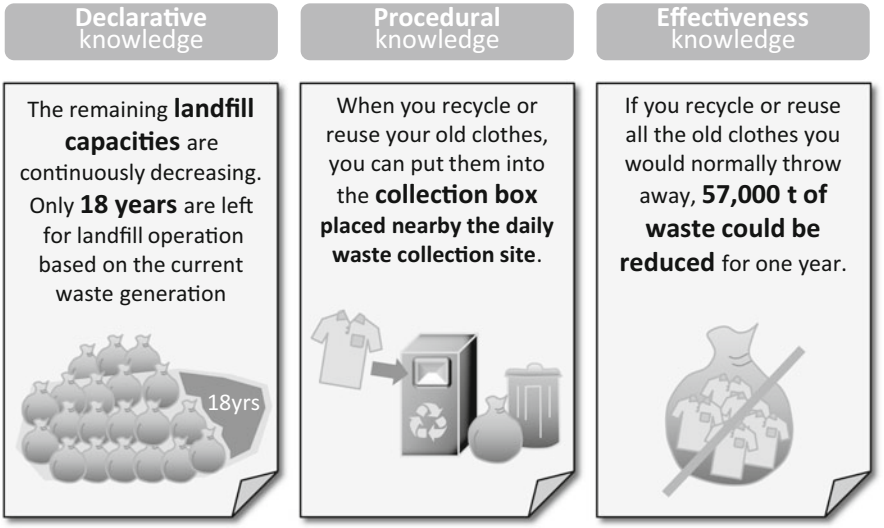


Fig. 6.4 Examples of knowledge provision by posters

is to be enhanced, an injunctive message can be provided. In this example, a request from the supermarket is provided in the imperative form. For personal norm activation, following Schwartz's norm-activation model (see 3.1.1 and Fig. 3.1), approach to "awareness" or "responsibility" can activate the personal norm. In the case of Fig. 6.3, the message to enhance the ascription of responsibility (AR) is provided.

Another strategy is **knowledge provision**. As explained in Chap. 2 (2.4), three types of knowledge can be considered: **declarative**, **procedural**, and **effectiveness**. Examples are shown in Fig. 6.4. In this case, the current fact of landfill capacity is provided as declarative knowledge. Information about how to conduct the target behavior is provided as procedural knowledge – in the example case, the location of the collection box for old clothes. For effectiveness, the amounts of saved wastes are shown.

Consideration should also be given with regard to "media" providing information. Media can be divided into two levels: mass media and local media. Several environment-related campaigns have been found in the **mass media** such as television and newspapers. Chan (1998) applied the TPB theory to the use of recycling receptacle behavior in Hong Kong. She investigated how people perceived the information from mass media as a subjective norm. It was shown that heavy users perceived a higher influence from mass media than light users. She concluded that "more publicity messages should be put on the mass media to promote green behaviors." Sampei and Aoyagi-Usui (2009) demonstrated the significant relationships between the increase of newspaper coverage on global warming and increase of people's concern on the issue. Holbert et al. (2003) investigated several types of television viewing and their influences on PEBs.

They showed that highly environment-concerned people tended to watch the television news and nature documentaries and this contributed to PEBs, whereas entertainment television use had no relationship with environmental concern and PEBs. Shanahan et al. (1997) discussed the influence of television on environmental concern using the **cultivation theory**, which was proposed by George Gerbner (1919–2005) in the 1970s. The original concept was that long periods of television viewing gives people partial views of the real world. By extension of this concept, it has been proposed that television messages can have a strong impact on changes in people's perceptions.

On the other hand, many studies have showed insignificant relationships between mass media exposure and EA and PEBs (McLeod et al. 1987; Mikami et al. 1995; Allen and Weber 1983). Staats et al. (1996) evaluated the influence of a public information campaign by the mass media about the greenhouse effect, designed by the Dutch Ministry of the Environment. Although a slight increase of knowledge was observed, no campaign effects were found for problem awareness. They concluded that it was hard to change current cognitions and behaviors in the short term just by mass media campaigns.

Use of local media has been proposed in overcoming the shortcomings of mass media. Local media, such as local radio, free newspapers (Lee et al. 2015), and community magazines, can connect environmental awareness with people's daily lives. Thus, effective use of local media can be one of the possible measures to provide information on PEBs. In addition, the use of social networking service (SNS) can be also considered, which have some characteristics similar to local (community-based) media (see 6.8).

6.4 Relationships Between Interventions and Psychological Effects

Figure 6.5 describes the possible relationships between the interventions and psychological influences on the motivation of PEBs. As shown in previous sections, many studies have reported that combinations of several interventions can have stronger influences on people's behavior change. As described in Fig. 6.5, each intervention has a different effect on psychological factors; therefore, a combination of interventions, working on different psychological factors, would give more effective results in the fostering of PEBs. Stern (1999) stated:

> Use multiple intervention types to address the factors limiting behavior change
>
> a. Limiting factors are numerous (e.g., technology, attitudes, knowledge, money, *convenience, trust)*
> b. Limiting factors vary with actor and situation, and over time
> c. Limiting factors affect each other (interactive principle)
>
> (Table 1 in Stern, 1999)

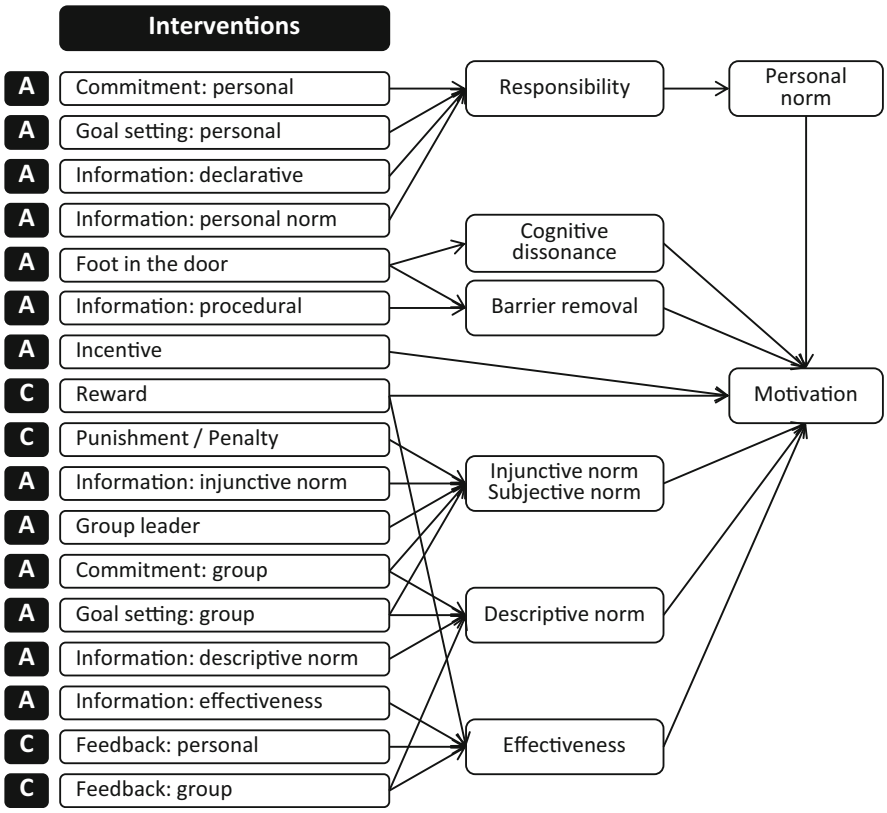


Fig. 6.5 Relationships of interventions and normative effects: *A* antecedent interventions, *C* consequence interventions

6.5 Eco-labeling

Labeling is an information provision methodology and can have some impact on consumers to select products. Eco-labels show information relating to the environment. Boström and Klintman (2011) use the term "green labeling" instead of eco-labeling and define it as follows:

> As a kind of eco-standardization, green labeling is based on the standardization of principles and perspective criteria. This type of eco-standard is market-based and consumer-oriented, and it relies on symbolic differentiation. (p. 28)

Eco-labeling is internationally standardized by the ISO 14020 family, where three types of labels are defined, as shown in Table 6.4.

Type I labels show that the product is certified by a third party as environment friendly. Some quantitative data, such as LCA data, are used during the certification process; however, the label itself shows no actual data, just the certification itself. A type I label in Germany, the so-called Blue Angel (Fig. 6.6a), is the oldest type I

Table 6.4 Eco-labeling categorization by ISO

Type	ISO	Characteristics	Example
Type I	14024	Eco-label with third-party certification	Eco-label in each country
Type II	14021	Self-declaration by a producer	Eco-labels by companies
Type III	14025	Quantitative display of environmental burdens	Carbon footprint

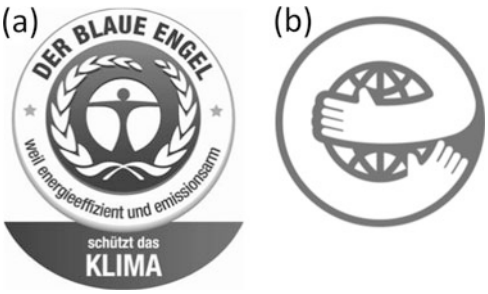


Fig. 6.6 Type I labels in Germany and Japan (used by permission from the Eco Mark offices). This is a label for "klima (climate)" category. Three more categories exist: "wasser (water)," "ressourcen (resources)," and "umwelt und gesundheit (environment and health)." (**a**) Germany, (**b**) Japan

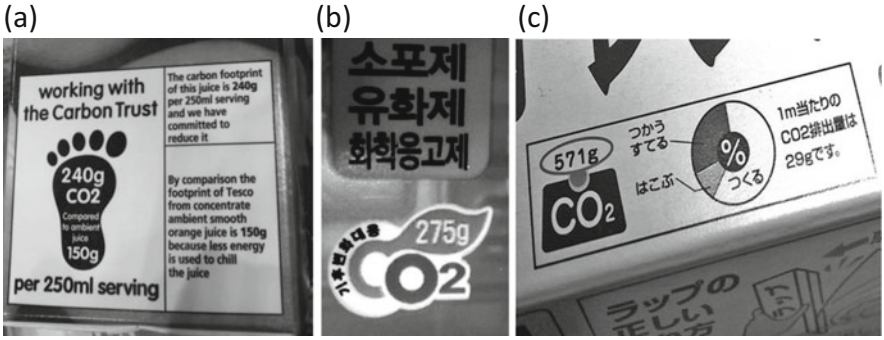


Fig. 6.7 CFPs in UK, Korea, and Japan. (**a**) UK, (**b**) Korea, (**c**) Japan

label in the world, instituted in 1978. Four protection goals, "environment and health," "climate," "water," and "resources," are prepared, which specify the target area mainly protected by the labeled product. Crnobrnja et al. (2009) summarize the type I labels and show 35 worldwide labels with their marks.

Type II labels are based on the producer's self-declaration. ISO (2012) shows three requirements for claims: "use symbols," "evaluation and claim verification," and "specific requirements for selected claims." The labels voluntary made by producers can help consumers to select their more environment-friendly products.

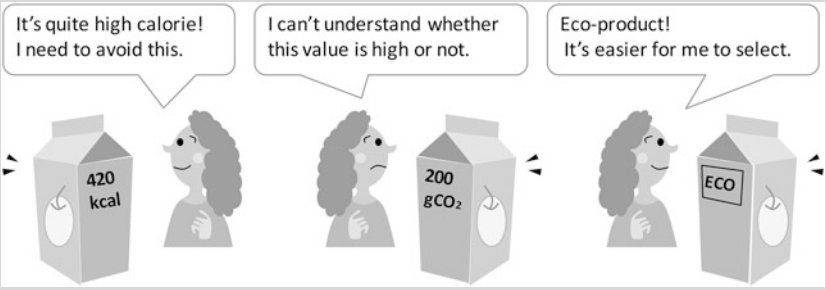
Type III labels display quantitative information about environmental burdens usually estimated by LCA. **Carbon footprint (CFP)** which shows the greenhouse

gas emission in CO_2 equivalence is one of the typical type III labels. Figure 6.7 shows the examples of CFP in several countries. The main purposes of CFP are (1) to foster consumers' choice of environment-friendly products and (2) to enhance the companies' efforts to develop environment-friendly products.

Some studies show the efficiency of carbon labeling. However, criticisms on the efficiency of carbon labeling have also been raised by many researchers and organizations (see Column 6.2). Upham et al. (2011) described the importance of carbon labeling as well as showing some of its limitations. Most of their respondents gave a low priority to carbon labeling for future purchasing decisions; they needed more information to understand the actual environmental impacts of CO_2 emission.

Column 6.2: It Is Still Doubtful Whether CFPs Can Support People's Behavior: Germany's Decision

Many countries support the CFP concept, such as the UK and Korea. However, Germany has incorporated it into their existing type I label (Blue Angel as shown in Fig. 6.1a) and has not introduced CFP. Discussions on this decision in Germany centered on whether or not type III labeling can really aid consumers' product choice. Unlike information on calorie value, for instance, that can help inform people who are health conscious or concerned about weight, it is questionable how you can check CO_2 values when you buy goods. Even if consumers check the CFP, they do not currently have sufficient criteria to compare products against. Thus, Germany concluded that type I labeling that shows environment friendliness is a better method of informing consumers. They therefore continue to use Blue Angel labeling instead of CFPs.



6.6 Education for Life Cycle Thinking

Education about life cycle thinking (LCT) has been widely proposed to enhance people's awareness of life cycle environmental burdens. Various tools to enhance people's LCT have been developed and tested. In this section, those trials are explained.

6.6.1 Card Game (Tahara et al. 2010)

Tahara et al. (2010) developed card games for LCT using CO_2 emissions from various daily behaviors. They assigned behaviors to the four card suits: transportation to spades, appliance use to hearts, commodity use to diamonds, and food to clubs, as shown in Fig. 6.8. The CO_2 values based on LCA were collected from the literature, CFP data, and company reports. They assigned the ace to the highest CO_2 emission in each category and 2 to the lowest. They proposed games such as poker, modifying the normal rules to make players aware of CO_2 emission from each behavior. The card numbers corresponding to the order of CO_2 emissions in the category can help players recognize which behaviors produce higher CO_2 emissions. In addition, the pie chart showing the contribution of production, usage, and disposal processes to the total CO_2 emission provides awareness of environmental burdens not only from the usage stage but also from other stages before and after usage – production and disposal.

6.6.2 LCA Educational Software (Hondo et al. 2008)

Hondo et al. (2008) developed the educational software using LCA shown in Fig. 6.9. They focused on products often found in a student's bag. When students input the number of products in the bag, such as pencils and notebooks, and the duration of use, the annual life cycle CO_2 ($LCCO_2$) for one bag is calculated. In addition, two types of bag as shown in upper and bottom of Fig. 6.9 are prepared, and students can compare the $LCCO_2$ depending on the different contents of the bags.

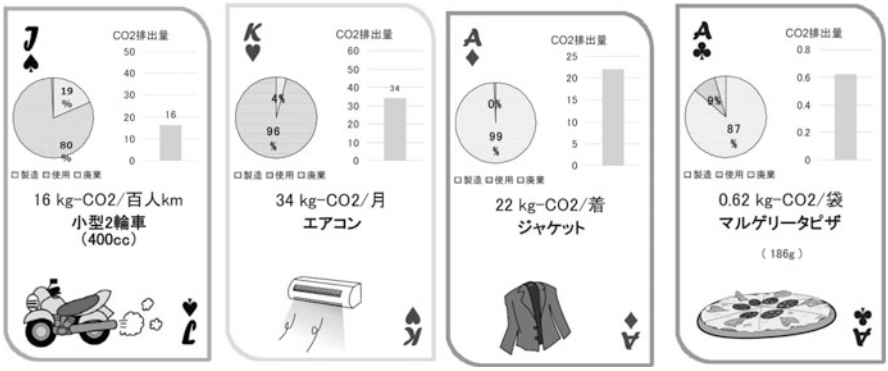


Fig. 6.8 Card game developed by Tahara et al. (2010).
These card images were kindly provided by the authors. ♠J, motorcycle (kg-CO_2/million people•km); ♥K, air conditioner (kg-CO_2/month); ♦A, jacket (kg-CO_2/one jacket); ♣A, Margherita pizza (kg-CO_2/one pack).
The pie chart shows the proportions of production, usage, and disposal

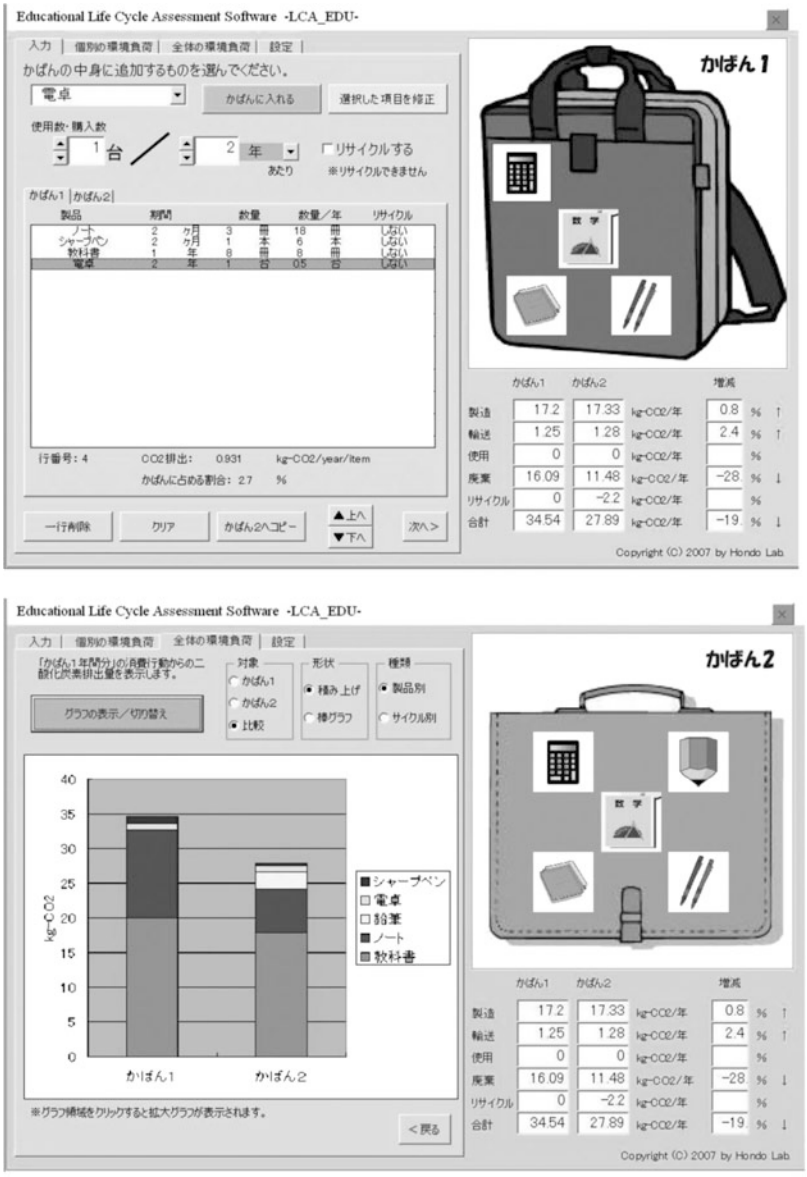


Fig. 6.9 LCA educational software developed by Hondo et al. (2008) (Reused by permission of *Journal of Life Cycle Assessment*, Japan © The Institute of Life Cycle Assessment, Japan)

The results can be displayed in bar graphs, as seen in the left bottom part of Fig. 6.9. Here, the CO_2 emissions from mechanical pencils, calculators, pencils, notebooks, and textbooks are separately shown in one bar. Students can also compare the total CO_2 emissions from two different bags. They also tried a 3-h educational program consisting of a 50-min lecture and two 50-min exercises using PCs for university students. They reported that the participants increased their sense of connection between their daily lives and $LCCO_2$ and their intentions regarding PEBs were also increased after the program.

Their research group tried and tested the original and modified programs (Hirayama et al. 2009; Nakajima et al. 2011; Amano et al. 2012). Hirayama et al. (2009) tried the program for junior high school and high school students. They concluded that the increase in the sense of connection between daily consumption behaviors and global warming through the program can increase the sense of responsibility for environmental problems and the effectiveness of behaviors. Nakajima et al. (2011) also tried the program for high school students and concluded that the sense of connection can increase the feeling of responsibility, which can in turn increase the environmental attitudes and behavioral intentions. Amano et al. (2012) tried to improve the original version of the software. They introduced the window showing the life cycle flow of each product to enhance the sense of connection. They also introduced a graphic user interface to increase the usability of the software, especially for teachers. They also tried to raise the accuracy of $LCCO_2$ data by using process-based analysis instead of the originally used I-O table analysis (for a detailed explanation about process-based and I-O table analyses, see Sect. 5.3.4). They tried the new version of the software in the educational program for high school students. The time for inputting data by students was reduced and the explanation for operation was also shortened; thus, it was able to increase the discussion time for LCT making the program more effective.

Hondo et al. (2008) first pointed out that there is a missing link between our daily behaviors and global environmental problems. Their educational program using their developed software can enhance the sense of connection between these two factors.

6.6.3 Life of a Product

Foods and commodities can be good study materials which students are familiar with in their daily lives. In this section, several trials and materials for LCT education are discussed.

6.6.3.1 Hamburger (CEEE, University of Northern Iowa; SPI: The Plastics Industry Trade Association)

The Center for Energy and Environmental Education (CEEE) of the University of Northern Iowa has developed the educational material "Life of a Hamburger," where one of the objectives being explained is that "students will demonstrate

awareness of the chain of environmental impacts caused by the creation of a product." They provide a 40-min lesson plan consisting of a 5-min introduction, 15–20-min activity, 5–10-min discussion, and finally a 2–5-min conclusion. In the introduction, the chain of production is briefly explained by the teacher. In the activity part, each student receives one card with an illustration of a component of the chain of production of a hamburger and is asked to locate the component group, according to the color of the card. Students are then asked to make a story of the hamburger's life cycle and each group gives presentation about the story. In the discussion that follows, the teacher explains that there are several different stages and it is important to see which part of each chain of production is what stage and what that means. The discussion about resource consumption is also included in this part. In addition to the summary and conclusion, they also recommend several extended activities, such as making life cycle posters and creating web connections or Venn diagrams showing resources used in various chains or stages.

Similarly, SPI also provides a lesson plan entitled "Life of a Hamburger," which consists of two parts, 45 min each. They explain that the "program is based on the concept of life cycle analysis, which involves looking at the 'big picture' from resource extraction and production; through transportation, warehousing and retailing; to consumption and disposal." In the program, seven stages for the burger, five stages for bun and condiments, and four stages for packaging in the hamburger life cycle are explained: (1–1) growing grain; (1–2) feeding grain to cattle; (1–3) shipping cattle; (1–4) processing cattle; (1–5) shipping beef and forming patties; (1–6) cooking and storage until served; (1–7) disposal of uneaten part; (2–1) growing grain and vegetables; (2–2) flour production and shipping vegetables; (2–3) processing vegetables; (2–4) baking buns and shipping condiments; (2–5) making a hamburger and disposal of leftover bread; (3–1) cutting trees and extraction of oil; (3–2) pulping and making papers, production of polyethylene, and production of glass bottles; (3–3) making boxes and bags by papers and plastics and shipping glass bottles to the ketchup and relish plants; and (3–4) shipping packaging. They prepare eight questions to students at the end of the program as follows:

1) What inputs and outputs resulted from manufacturing this product?
2) Are all the outputs equal in terms of environmental effects?
3) What were the environmental effects, and could any be minimized?
4) What other resources were consumed as a result of this product's manufacture and distribution?
5) Will you look at products differently now?
6) What considerations do you now have as consumers that you did not have before?
7) Do you see how using less has a huge impact throughout a product's life?
8) Where does the real waste occur in the production of hamburgers?

Through these programs, students can be made aware of the many latent life cycle processes that lie behind the production of a hamburger and know generation of various environmental burdens from each process. Besides, they can also extend this awareness to other foods and products in their daily lives.

6.6.3.2 Canned Mackerel (Ando et al. 2010; Ando 2010; Ando and Hasegawa 2011)

Ando and his colleagues conducted LCA for a fishery product, canned mackerel, which is the main fish landed in their local area in Japan. The total CO_2 emission from the life cycle of one canned mackerel was first estimated using LCA (Ando 2010; Ando and Hasegawa 2011). And then, they conducted an educational program for 20 junior high school students in their region (Ando et al. 2010). The program consisted of a lecture and group work. The lecture started with a 30-min introduction, followed by a 30-min explanation about canned mackerel's CFP and a 30-min explanation for boiled mackerel's CFP. In the following group work, students tried to compare canned mackerel and boiled mackerel from the viewpoints of convenience, preservative quality, and CFP and decide which food they supported. In addition, the students compared the taste by eating both of them and calculated the CO_2 emission from the final disposal of the wastes.

For canned mackerel's CFP, they explained the steps involved in the life cycle, such as catching the fish, cold storage, production, transportation, selling, and disposal. The students were asked to fill the value of the CO_2 emission from each step in a worksheet provided, calculate the total CO_2 emission as CFP, and paste a seal with the CFP value on the can as shown in Fig. 6.10.

Ando et al. (2010) reported that the students increased the feeling of attachment to their local area and also increased their intention to follow PEBs. In addition, the students gained a sense of CO_2 emissions from their daily lives through the program. The study indicated that using local foods for an LCT educational program can generate interest among students helping them easily connect their daily lives with environmental loadings.

6.6.3.3 CD and DVD, Soccer Ball, and Smartphone (US-EPA)

The "Make a Difference" campaign by the US-EPA provides teaching materials for middle school students. "Life Cycle of a CD or DVD" is two-page poster, where seven stages of the life cycle of a CD or DVD are colorfully illustrated and explained on the first page: (1) materials acquisition, (2) materials processing, (3) manufacturing, (4) packaging, (5) transportation/distribution, (6) useful life, and (7) reuse, recycling, or disposal. They mention that "by learning about product life cycles, you can find out how to reduce the environmental impacts and natural resource use associated with products you use every day. When you understand these connections, you can make better environmental choices about the products you use, and how you dispose of them." The second page provides the explanations about life cycles such as "why are product life cycles important?" and "what is a life cycle?" They also provide several exercises for students, such as listing end-of-life options and discussions, rough estimation of the lasting period of each component

Fig. 6.10 Canned mackerel used as an educational material by Ando et al. (2010) (This photo was kindly provided by Prof. Takao Ando)

in a landfill, and making a report by contacting local recyclers or manufacturers of CDs or DVDs.

Similarly, "The Life Cycle of a Soccer Ball" is also two-page poster, the first page of which shows six stages: (1) gathering the materials, (2) preparing the materials, (3) putting the pieces together, (4) getting the soccer ball to you, (5) using the ball, and (6) getting rid of the ball. In the second page, they provide an explanation about the life cycle and also give several exercise questions to students focusing on the environmental burdens generated by the transportation of soccer balls.

"The Secret Life of a Smartphone" is one-page poster, which provides information about materials used in a smartphone, environmental impacts derived from transportation and packaging, and the importance of long-time use. Finally, donation and recycling are strongly recommended from the viewpoints of recovery of rare metals, such as platinum, gold, silver, and copper.

These posters were prepared by the waste division of the US-EPA; therefore, the main aim is the increase of reuse and recycling. However, these materials can also enhance awareness of various processes involved in the product's life cycle where various environmental loadings are generated.

6.7 Examples of Programs

6.7.1 Database of Case Studies

Dr. Doug McKenzie-Mohr collects various articles and actual case studies for four categories of PEBs: "agriculture and conservation," "energy," "transportation,"

"waste and pollution," and "water." The title of the page is "Fostering Sustainable Behavior: Community-Based Social Marketing," which can be found at http://www.cbsm.com/public/world.lasso. As of November 2014, 90 case studies were available on this website which can help you with various programs to foster PEBs. McKenzie-Mohr (2000) showed the process of community-based social marketing, which consists of four steps: (1) uncovering barriers and selecting behaviors, (2) designing strategies, (3) piloting, and (4) evaluation.

6.7.2 EcoTeam Program (ETP)

The Global Action Plan for the Earth (GAP), an international environmental organization, has distributed the EcoTeam Program (ETP), where people's behavioral changes are encouraged through information, feedback, and social interaction, based on small-size groups, usually consisting of 6–10 people who know each other (Staats et al. 2004).

6.7.2.1 Trials in the Netherlands (Staats and Harland 1995; Staats et al. 2004)

The group members meet once a month and share their ideas, experiences, and achievements about six domains: garbage, gas, electricity, water, transport, and consumer behavior. EcoTeams focus on one of the domains for a consecutive 4 weeks and the overall period of the program is approximately 8 months. The participants are given a logbook, containing brief explanations for the six domains, goal of GAP, long list of PEBs, and progress check sheets. The achievements, such as saved energy and gas, are recorded in the logbook. In addition, the recorded data are sent to the national GAP office in Hague and the compiled data sent back to each EcoTeam as a feedback.

Staats and Harland (1995) and Staats et al. (2004) reported the study results targeting 60 EcoTeams consisting of 445 participants, who conducted the program in 1994. One hundred fifty participants were also surveyed again after 2 years of the program. They created a pro-environmental behavior index (PBI) based on eight PEBs and compared the scores between the ETP participants and control groups. The results showed that the ETP participants ($n = 150$) showed significantly higher PBI scores than the control even 2 years after the ETP completion. To understand the reason for the EcoTeam effectiveness, they picked up the transportation behaviors and investigated the impacts of intention, habit, and social influence on the behavior change. The results of their regression analysis showed that intention itself and a combination of three elements (intention $\times$ habit $\times$ social influence) brought significantly positive impacts on the behavior change, while habit itself and intention $\times$ habit had a negative impact.

6.7.2.2 Trials in the UK (EcoTeams, UK)

EcoTeams in the UK provide a colorful, user-friendly website covering four topics: rubbish and shopping, energy, water, and travel. The project period is set from 10 weeks to a maximum of 6 months. Through the website, a person can easily register and start the program. After getting a personal profile page, the person is able to set up a team or join an open EcoTeam.

They report that since 2000, more than 4000 UK households have taken part in EcoTeams and they have used 21 % less energy, lowered their carbon emissions by 17 %, cut waste by 20 %, and spent £170 less on yearly household bills (data from the webpage accessed in March 2015).

6.7.2.3 Trials in Issaquah, Washington

The effectiveness of ETP trials in Issaquah, Washington, conducted between 1992 and 1997 was evaluated through a mail survey in 1998 (Issaquah Sustainable Lifestyle Campaign). The post-1995 participants ($n = 20$) showed that they sustained or improved their behavior changes after the program in 85 % of the actions in five categories: garbage, water, energy, transportation, and consumption.

6.8 For Achieving Widespread and Lasting Influence

As seen in various trials, education programs are usually conducted in small communities. Therefore, the impact can be limited and the influence often lasts only a short period. Mass media can have a widespread impact; however, the impact on people's long-term behavioral change by a short-term mass media campaign is doubtful, as discussed in Sect. 6.3. To achieve a widespread and permanent impact on the promotion of PEBs, fundamental approaches should be considered.

It is more difficult to change the behavior of adults. Therefore, continuous education from childhood is necessary. As seen in various trials, one-shot educational programs have been tried in classrooms; however, a **consistent program from an early age to adolescence** should be designed and **incorporated into the school education curriculum**. Although the current curriculum covers various features of environmental problems, the consistency of the contents and **linking them with daily lives** should be further discussed and improved. Consideration of the linkage and consistency between subjects is also necessary.

In considering the widespread impacts especially for the behavioral change of adults, **use of social networking service** (SNS) is worthy of note. Unlike mass media, SNS has some community-like features; therefore, the advantages of a community-based program and widespread influence are expected. Mankoff et al. (2010) launched the StepGreen.org site to enhance people's energy-saving behaviors. Over 1000 people had used it until the site was closed at the end of June in

2013. StepGreen.org connected with SNS like Facebook, visualized the progress, and suggested actions that might save money or energy. StepGreen.org sent behavioral suggestions directly to a participant's SNS page, which corresponded to a tailored information provision. The program mainly consisted of participants' commitments to actions and reports on whether the commitments were actually fulfilled. They concluded that "motivating factors like public commitment and competition are effective, and better leveraging these factors will likely lead to even greater appeal and effectiveness." Foster et al. (2010) developed the Facebook application called "Wattsup" which displayed live data from a commercial off-the-shelf energy monitor and demonstrated it for eight households. Through the SNS, the participants were able to see other participants' energy data. They reported that energy consumption was significantly lower when the participant was able to see the other participants' energy consumption. These trials followed the previous educational programs using group feedback and commitment; however, by using SNS, the process became more sophisticated and attractive than before.

The development of attractive educational tools is important for effective and continuous education. The digital materials have been widely developed and started to be used in classrooms. The **development of information technologies enables the construction of novel and attractive digital educational tools**; therefore, an aggressive introduction of those materials should be considered. Huizenga et al. (2009) proposed the use of mobile games for learning the history of Amsterdam. Their results showed that the pupils who learned the history using the game gained significantly more knowledge than the pupils who received regular project-based instruction. Kamarainen et al. (2013) demonstrated an augmented reality (AR) system for environmental education. Students used smartphones and experienced the AR system on a field trip to a pond. The AR system gave information to the students, for instance, about organisms around the pond, the water quality they measured, visual overlays, 3D models, videos, and additional information related to consumers and decomposers. They reported that this program enhanced the student-centered education rather than a teacher-directed one. They concluded that there are multiple benefits to using this suite of technologies for teaching and for learning.

References

Abrahamse W, Steg L, Vlek C, Rothengatter T (2005) A review of intervention studies aimed at household energy conservation. J Environ Psychol 25:273–291

Abrahamse W, Steg L, Vlek C, Rothengatter T (2007) The effect of tailored information, goal setting, and tailored feedback on household energy use, energy-related behaviors, and behavioral antecedents. J Environ Psychol 27:265–276

Allen C, Weber J (1983) How presidential media use affects individuals' beliefs about conservation. Journal Q 60:98–104

Amano Y, Hirayama Y, Hondo H (2012) Development of educational LCA software "Global warming even in your bag?! Ver. 2". J Life Cycle Assess 8(1):55–65 (in Japanese; English abstract is available). http://www.hondo.ynu.ac.jp/hiroki/Amano_et_al_LCA%282012%29.pdf

Ando T (2010) The estimate of the carbon footprint of canned mackerel from Choshi area and the evaluation of the adaptive possibility for the environmental education tool. Bull Chiba Inst Sci 3:15–23 (in Japanese). https://cis.repo.nii.ac.jp/?action=pages_view_main&active_action=repository_view_main_item_detail&item_id=47&item_no=1&page_id=13&block_id=21

Ando T, Hasegawa K (2011) Estimating the "life cycle CO_2 ($LC\text{-}CO_2$)" of canned mackerel (*Scomber* spp.) and its potential as an environmental education tool -A case study (2008) at Choshi City, Chiba Prefecture. J Fish Technol 3(2):99–105 (in Japanese; English abstract is available). http://www.fra.affrc.go.jp/bulletin/fish_tech/3-2/03.pdf

Ando T, Kasukawa M, Karino T (2010) The effect of environmental education using the "Carbon Footprint" of canned mackerel from the Choshi area, Chiba prefecture. Bull Chiba Instit Sci 3:1–13 (in Japanese). https://cis.repo.nii.ac.jp/?action=pages_view_main&active_action=repository_view_main_item_detail&item_id=46&item_no=1&page_id=13&block_id=21

Arbuthnot J, Tedeschi R, Wayner M, Turner J, Kressel S, Rush R (1976–1977) The induction of sustained recycling behavior through the foot-in-the-door technique. J Environ Syst 6(4):355–368

Bachman W, Katzev R (1982) The effects of non-contingent free bus tickets and personal commitment on urban bus ridership. Transp Res A: General 16(2):103–108

Bem D (1972) Self-perception theory. In: Berkowitz L (ed) Advances in experimental social psychology. Academic, New York, pp 1–62

Bolderdijk JW, Steg L, Geller ES, Lehman PK, Postmes T (2012) Comparing the effectiveness of monetary versus moral motives in environmental campaigning. Nat Clim Chang 3:413–416

Boström M, Klintman M (2011) Eco-standards, product labeling and green consumerism. Palgrave Macmillan, Houndmills/Basingstoke/Hampshire, 247 p

Burn SM (1991) Social psychology and the stimulation of recycling behaviors: the block leader approach. J Appl Soc Psychol 21(8):611–629

Carrico AR, Riemer M (2011) Motivating energy conservation in the workplace: an evaluation of the use of group-level feedback and peer education. J Environ Psychol 31(1):1–13

Center for Energy & Environmental Education of University of Northern Iowa, Life of a hamburger. http://www.uni.edu/ceee/content/life-hamburger

Chan K (1998) Mass communication and proenvironmental behaviour: waste recycling in Hong Kong. J Environ Manag 52:317–325

Cialdini RB, Vincent JE, Lewis SK, Catalan J, Wheeler D, Darby BL (1975) Reciprocal concessions procedure for inducing compliance: the door-in-the-face technique. J Pers Soc Psychol 31 (2):206–215

Cobern MK, Porter BE, Leeming FC, Dwyer WO (1995) The effect of commitment on adoption and diffusion of grass cycling. Environ Behav 27(2):213–232

Crnobrnja B, Budak I, Ilić M, Hodolič J (2009) Environmental labelling of products with type I labels. RMZ – Mater Geoenviron 56(3):346–355

De Leon IG, Fuqua RW (1995) The effects of public commitment and group feedback on curbside recycling. Environ Behav 27(2):233–250

De Young R (1993) Changing behavior and making it stick: the conceptualization and management of conservation behavior. Environ Behav 25(4):485–505

Dejong W (1979) An examination of self-perception mediation of the foot-in-the-door effect. J Pers Soc Psychol 37(12):2221–2239

Dwyer WO, Leeming FC, Cobern MK, Porter BE, Jackson JM (1993) Critical review of behavioral interventions to preserve the environment: research since 1980. Environ Behav 25 (3):275–321

EcoTeams, UK. http://ecoteams.org.uk/

Foster D, Blythe M, Cairns B, Lawson S (2010) Competitive carbon counting: can social networking sites make saving energy more enjoyable? In: CHI '10 extended abstracts on human factors in computing systems, pp 4039–4044

Foxx RM, Schaeffer MH (1981) A company-based lottery to reduce the personal driving of employees. J Appl Behav Anal 14:273–285

Freedman JL, Fraser SC (1966) Compliance without pressure: the foot-in-the-door technique. J Pers Soc Psychol 4(2):195–202

Geller ES (2002) Chap. 34: The challenge of increasing proenvironmental behavior. In: Bechtel RB, Churchman A (eds) Handbook of environmental psychology. Wiley, New York, pp 525–540

Hirayama Y, Nakajima K, Hondo H (2009) Effects of environmental education program with LCA education software: a mechanism to induce pro-environmental behavior. J Life Cycle Assess 5 (3):367–381 (in Japanese; English abstract is available). http://www.hondo.ynu.ac.jp/hiroki/Hirayama_et_al_LCA5%283%29_2009.pdf

Holbert RL, Kwak N, Shah DV (2003) Environmental concern, patterns of television viewing, and pro-environmental behaviors: integrating models of media consumption and effects. J Broadcast Electron Media 47(2):177–196

Hondo H, Hirayama Y, Nakajima K, Yamada S, Fukuhara I (2008) Use of life cycle thinking in environmental education: visualization and recovery of the missing link towards sustainable consumption. J Life Cycle Assess 4(3):279–291 (in Japanese; English abstract is available). https://www.jstage.jst.go.jp/article/lca/4/3/4_279/_pdf

Hopper JR, Nielsen JM (1991) Recycling as altruistic behavior- Normative and behavioral strategies to expand participation in community recycling program. Environ Behav 23 (2):195–220

Huizenga J, Admiraal W, Akkerman S, ten Dam G (2009) Mobile game-based learning in secondary education: engagement, motivation and learning in a mobile city game. J Comput Assist Learn 25:332–344

ISO (2012) Environmental labels and declarations: how ISO standards help. http://www.iso.org/iso/environmental-labelling.pdf

Issaquah Sustainable Lifestyle Campaign, EcoTeam survey and program evaluation – results and analysis. http://www.empowermentinstitute.net/index.php/docman-default-enabler/behavior-change-research/38-evaluation-of-ecoteam-program-methodology-and-long-term-participant-benefits-issaquah-king-county-wa/file

Jordan JR, Hungerford HR, Tomera AN (1986) Effects of two residential environmental workshops on high school students. J Environ Educ 18(1):15–22

Kamarainen AM, Metcalf S, Grotzer T, Browne A, Mazzuca D, Tutwiler MS, Dede C (2013) EcoMOBILE: integrating augmented reality and probeware with environmental education field trips. Comput Educ 68:545–556

Katzev RD, Johnson TR (1983) A social–psychological analysis of residential electricity consumption: the impact of minimal justification techniques. J Econ Psychol 3:267–284

Katzev RD, Johnson TR (1984) Comparing the effects of monetary incentives and foot-in-the-door strategies in promoting residential electricity conservation. J Appl Soc Psychol 14(1):12–27

Kerr J, Vardhan M, Jondal R (2012) Prosocial behavior and incentives: evidence from field experiments in rural Mexico and Tanzania. Ecol Econ 73:220–227

Lee H, Kurisu K, Hanaki K (2015) Effect of information provision on pro-environmental behaviors. Low Carbon Econ 6:30–40

Lehman PK, Geller ES (2004) Behavioral analysis and environmental protection: accomplishments and potential for more. Behav Soc Issues 13(1):13–32

Loock C-M, Staake T, Thiesse F (2013) Motivating energy-efficient behavior with green IS: an investigation of goal setting and the role of defaults. MIS Q 37(4):1313–1332

Luyben PD (1984) Drop and tilt: a comparison of two procedures to increase the use of venetian blinds to conserve energy. J Commun Psychol 12:149–154

Mankoff J, Fussell SR, Dillahunt T, Glaves R, Grevet C, Johnson M, Matthews D, Matthews HS, McGuire R, Thompson R, Shick A, Setlock L (2010) StepGreen.org: increasing energy saving behaviors via social networks. In: Proceedings of the fourth international AAAI conference on Weblogs and Social Media, pp 106–113

McCalley LT, Midden CJH (2002) Energy conservation through product-integrated feedback: the roles of goal-setting and social orientation. J Econ Psychol 23:589–603

McKenzie-Mohr D (2000) Promoting sustainable behavior: an introduction to community-based social marketing. J Soc Issues 56(3):543–554

McLeod J, Glynn C, Griffin R (1987) Communication and energy conservation. J Environ Educ 18 (3):29–37
Meneses GD, Palacio AB (2007) The response to the commitment with block-leader recycling promotion technique: a longitudinal approach. J Nonprofit Public Sect Mark 17(1–2):83–102
Midden CJH, Meter JE, Weenig MH, Zieverink HJA (1983) Using feedback, reinforcement, and information to reduce energy consumption in households: a field-experiment. J Econ Psychol 3:65–86
Mikami S, Takeshita T, Nakada M, Kawabata M (1995) The media coverage and public awareness of environmental issues in Japan. Gazette 54:209–226
Nakajima K, Hirayama Y, Hondo H (2011) Influences of life cycle thinking-based environmental education program on pro-environmental behavior. J Life Cycle Assess 7(1):84–95 (in Japanese). https://www.jstage.jst.go.jp/article/lca/7/1/7_84/_pdf
Sampei Y, Aoyagi-Usui M (2009) Mass-media coverage, its influence on public awareness of climate-change issues, and implications for Japan's national campaign to reduce greenhouse gas emissions. Glob Environ Chang 19:203–212
Schultz PW, Nolan JM, Cialdini RB, Goldstein NJ, Griskevicius V (2007) The constructive, destructive, and reconstructive power of social norms. Psychol Sci 18(5):429–434
Schwartz SH (1970) Elicitation of moral obligation and self-sacrificing behavior. J Pers Soc Psychol 15(4):283–293
Schwartz SH (1977) IV. Boomerang effects on altruism, in "Normative influences on altruism". Adv Exp Soc Psychol 10:263–267
Schwartz SH, Howard J (1982) Chap. 14. Helping and cooperation: a self-based motivational model. In: Derlega VJ, Grzelak J (eds) Cooperation and helping behavior: theories and research. Academic, New York, pp 328–356
Shanahan J, Morgan M, Stenbjerre M (1997) Green or brown? Television and the cultivation of environmental concern. J Broadcast Electron Media 41(3):305–323
Siero FW, Bakker AB, Dekker GB, van den Burg MTC (1996) Changing organizational energy consumption behavior through comparative feedback. J Environ Psychol 16:235–246
SPI: The Plastic Industry and Trade Association, Lesson plan for life of a hamburger- an exercise in Life Cycle Analysis. http://www.plasticsindustry.org/files/outreach/school/lifeofahamburger.pdf
Staats H, Harland P (1995) The EcoTeam program in the Netherlands – Study 4: as longitudinal study on the effects of the Eco Team program on environmental behavior and its psychological backgrounds- Summary report, E&M Center for Energy and Environmental Research, Leiden University. http://www.globalactionplan.com/leiden
Staats HJ, Wit AP, Midden CYH (1996) Communicating the greenhouse effect to the public: evaluation of a mass media campaign from a social dilemma perspective. J Environ Manag 45:189–203
Staats H, Harland P, Wikle HM (2004) Effective durable change- A team approach to improve environmental behavior in the household. Environ Behav 36(3):341–367
Steg L, Vlek C (2009) Encouraging pro-environmental behaviour: an integrative review and research agenda. J Environ Psychol 29:309–317
Stern PC (1999) Information, incentives, and proenvironmental consumer behavior. J Consum Policy 22:461–478
Tahara K, Fujii C, Tsuda S, Mizuno T (2010) Development of a card game for an environmental education. In: The 5th meeting of the Institute of Life Cycle Assessment, Japan, pp 176–177 (in Japanese). https://www.jstage.jst.go.jp/article/ilcaj/2009/0/2009_0_90/_pdf.
Upham P, Dendler L, Bleda M (2011) Carbon labelling of grocery products: public perceptions and potential emissions reductions. J Clean Prod 19:348–355
US-EPA, Make A Difference Campaign for Middle School Students/Educational Materials/Wastes. http://www.epa.gov/epawaste/education/mad.htm
Wiener Y (1982) Commitment in organizations: a normative view. Acad Manag Rev 7(3):418–428

Recommended Books and Papers

Influential Factors on EA

- Van Liere, K.D. and R.E. Dunlap, 1980,
  "Social bases of environmental concern: A review of hypotheses, explanations and empirical evidence,"
  Public Opinion Quarterly, 44, 181–197.
  - This article reviews many previous studies and shows relationships between EA and various sociodemographics such as age, education, income, occupational prestige, residence, gender, political party, and political ideology.

Influential Factors on PEBs

- Kollmuss, A. and J. Agyeman, 2002,
  "Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior?,"
  Environmental Education Research, 8(3), 239–260.
  - This article reviews various PEB models (incl. TRA, TPB, Stern's model, etc.) and also explains for various influential external factors, such as demographic, institutional, economic, and social and cultural factors, as well as internal factors like motivation, environmental knowledge, values, attitudes, environmental awareness, emotional involvement, locus of control, and responsibility and priorities.

K. Kurisu, *Pro-environmental Behaviors*, DOI 10.1007/978-4-431-55834-7

- Davis, J., G.R. Foxall and J. Pallister, 2002,
  "Beyond the intention–behaviour mythology: An integrated model of recycling," *Marketing Theory*, 2(1), 29–113.

  – This article focuses on recycling behaviors, but the details about TRA, TPB, and Schwartz's models are explained. Besides, explanations about influential psychological factors, such as attitude, perceived behavioral control, intention, personal norms, affective evaluation, and so on, and sociodemographics and personality are also shown in detail.

Methodologies of Fostering PEBs

- Abrahamse, W., L. Steg, C. Vlek, and T. Rothengatter, 2005,
  "A review of intervention studies aimed at household energy conservation,"
  Journal of Environmental Psychology, 25, 273–291.

  – This article reviews 38 intervention studies and summarizes the methodologies to foster household energy conservation behavior. Their appendix shows details of each study, such as target behavior, period, sample size, intervention category, and so on.

- McKenzie-Mohr, D., 2011,
  Fostering Sustainable Behavior: An Introduction to Community-Based Social Marketing 3rd edition,
  New Society Publishers, 171p.

  – This book describes details how to foster people's PEBs and also involves many case studies. Nine icons help readers easily catch the points of the contents.

- **"Fostering Sustainable Behavior: Community-Based Social Marketing"**
  by Doug McKenzie-Mohr, http://www.cbsm.com/public/world.lasso

  – This site shows the contents of the book shown above.
  "This site consists of five resources for those working to foster sustainable behaviors, such as those involved in conservation, energy efficiency, transportation, waste reduction, and water efficiency. The site includes the complete contents of the book, *Fostering Sustainable Behavior*, as well as searchable databases of articles, case studies, and turnkey strategies. Further, it includes discussion forums for sharing information and asking questions of others." (from the website)

- Dwyer, W.O., F.C. Leeming, M.K. Cobern, B.E. Porter and J.M. Jackson, 1993,
  "Critical review of behavioral interventions to preserve the environment: Research since 1980,"
  Environment and Behavior, 25(3), 275–321.

– They reviewed intervention studies conducted from 1980 and 1990 and categorized them into several antecedent strategies, such as "commitment," "oral activator or demonstration," "written activator," "assigned individual goal," and "environmental alteration," and other consequence categories such as "feedback signaling consequences," "feedback not signaling consequences," "rewards to individuals," "rewards to groups," and "penalty." The tables showing which strategy each study uses can help readers to know the outline.

Statistics

- Hair Jr., H.F., W.C. Black, B.J. Babin, and R.E. Anderson, 2009, ***Multivariate Data Analysis*** 7th Edition, Prentice Hall, 816 p. ISBN-13: 978–0138132637

  – This book covers principles of all multivariate analyses, such as multiple regression analysis, MANOVA, cluster analysis, and structural equation modeling

- Brace, N., R. Kemp, and R. Snelger, 2012, ***SPSS for Psychologists*** 5th edition, Routledge, 488 p. ISBN-13: 978–1848726000

  – This book explains how to use SPSS to analyze data. The screenshots of SPSS can help you understand how to understand the outputs by SPSS.

- Dytham, C., 2011, ***Choosing and Using Statistics: A Biologist's Guide*** 3rd edition, Wiley-Blackwell, 320 p. ISBN-13: 978–1405198394

  – The title shows this book is for biologists; however, the contents can be also useful for people who handle questionnaire data. This book explains details how to use SPSS and understand the outputs of SPSS.

Life Cycle Assessment

- ***Handbook on Life Cycle Assessment: Operational Guide to the ISO Standards***, J.B. Guinée (ed.), Kluwer Academic Publishers, 692p., ISBN: 1-4020-0228-9

  – This book explains all important processes of LCA and shows scientific backgrounds for each process.

- Hfstetter, P., 1998,
  Perspectives in Life Cycle Impact Assessment: A Structured Approach to Combine Models of the Technosphere, Ecosphere and Valuesphere,
  Kluwer Academic Publishers, 484p., ISBN-13: 978–0792383772

  – From this book, readers can know the concepts and key issues of life cycle impact assessment.

- Hendrickson, C.T., L.B. Lave and H.S. Matthews, 2006,
  Environmental Life Cycle Assessment of Goods and Services: An Input–Output Approach,
  Resources for the Future, 262p., ISBN: 1-933115-24-6

  – I-O table analysis can be learned by this book. Several examples of calculation also help readers understand the procedure.

- Goedkoop, M. and R. Spriensma, 2001,
  The Eco-indicator 99: A Damage Oriented Method for Life Cycle Impact Assessment, Methodology Report, 3rd edition,
  Eco-indicator 99 Manuals, PRé Consultants,
  http://www.pre-sustainability.com/eco-indicator-99-manuals

  – The details of Eco-indicator 99 can be studied by this material. In addition to "Methodology," other reports, such as "Manual for Designers" and "Annex," are available at the above URL.

- Itsubo, N. and A. Inaba, 2012,
  "LIME2: Life-cycle impact assessment method based on endpoint modeling,"
  JLCA Newsletter, No. 12, Life-Cycle Assessment Society of Japan, http://lca-forum.org/english/pdf/No12_Summary.pdf

  – The outline of LIME2, which is endpoint LCIA in Japan, is compactly explained.

Abbreviations

AC	Awareness of consequences
ANOVA	Analysis of variance
AP	Acidification potential
AR	Ascription of responsibility
BOD	Biochemical oxygen demand
CFP	Carbon footprint
COD	Chemical oxygen demand
DALY	Disability-adjusted life years
DfE	Design for environment
DITF	Door in the face
DO	Dissolved oxygen
EA	Environmental attitude
EINES	Expected increase in number of extinction species
E-LCA	Environmental LCA
FA	Factor analysis
FITD	Foot in the door
GHGs	Greenhouse gases
GWP	Global warming potential
I-O	Input and output
ISO	International Organization for Standardization
JPY	Japanese yen
LIME	Life cycle impact assessment method based on endpoint modeling
LCA	Life cycle assessment
LCCA	Life cycle cost analysis
LCCO$_2$	Life cycle CO_2
LCI	Life cycle inventory analysis
LCIA	Life cycle impact assessment
LCT	Life cycle thinking
MANOVA	Multivariate analysis of variance
NAM	Norm-activation model

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NEP	New environmental/ecological paradigm
NEX	Normalized extinction of species
NOx	Nitrogen oxides
NPP	Net primary productivity
PA	Path analysis
PAF	Potentially affected fraction
PBC	Perceived behavioral control
PCA	Principal component analysis
PDF	Potentially disappeared fraction
PEB	Pro-environmental behavior
PM	Particulate matter
QoL	Quality of life
REPA	Resource and environmental profile analysis
RD	Responsibility of denial
PM	Particulate matter
PP	Polypropylene
SEM	Structural equation modeling
S-LCA	Social LCA
SNS	Social networking service
SOx	Sulfur oxides
SPM	Suspended particulate matter
TPB	Theory of planned behavior
TRA	Theory of reasoned action
TN	Total nitrogen
TP	Total phosphorus
US-EPA	United States Environmental Protection Agency
VBN	Value–belief–norm
VIF	Variance inflation factor
YLD	Years lived with disability
YOLL	Years of life lost
3EID	Embodied energy and emission intensity data for Japan using input–output tables

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