



# Design and poverty: a review of contexts, roles of poor people, and methods

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## Abstract

Design is essential to fulfil unmet or under-served needs of resource-poor societies, supporting their social and human development. A great deal of design research has been undertaken in such low resource settings, and is discussed under different names, such as ‘community development engineering’, ‘humanitarian engineering’, ‘appropriate technology’, ‘design for development’, ‘design at the Base of the Pyramid’, etc. This has created an important need to know what has been examined and learnt so far and to plan for further investigation. To address this, we review a broad range of literature, with close examination of 30 design studies in this field. This reveals a multifaceted picture, showing a great diversity in investigation and reporting of attributes of context (income, rural and urban, design sectors, countries, and gender), the roles of poor people (consumers, producers, and co-designers), characteristics of research methods employed (e.g. descriptive and prescriptive, data collection methods, qualitative and quantitative aspects, and unit of analysis), and design topics. Based on the review results, we offer recommendations for further research, identifying concerns that researchers ought to have about this field and suggesting ways in which research in this field can be undertaken and reported.

**Keywords** Poverty · Design process · Design research · Developing countries · Frugal innovations

## 1 Introduction

Forty percent of the world population subsists on less than 2 dollars a day, and twenty percent on less than 1.25 dollars per day, living in extreme poverty (World Bank 2010). Although poverty is decreasing, it is still a widespread and tenacious problem with causes, effects and potential solutions at individual, institutional, and structural levels. Whilst Mahatma Gandhi called the problems faced by these resource-poor people as ‘the worst form of violence’, Amartya Sen defines them as lack of freedom and inability to make life choices (Sen 2001). Others again define them in terms of high mortality rates, ill-health or as a monetary issue (e.g. Jönsson et al. 2012). These marginalised people

generally cannot change their living conditions and livelihood opportunities, as their access to financial and other resources is weak, with pressing need for immediate consumption (Karelis 2007, Jerneck 2014). They often face significant challenges to satisfy basic needs, such as food, shelter, and clothing, and lack access to basic facilities, such as public health (Maxted 2011; Zurovcik et al. 2011), education (e.g. Gordon 1997; Gustavsson 2007), safe drinking water (Baumgartner et al. 2007; Matlack et al. 2011), sanitation (e.g. Chaplin 1999; Burra et al. 2003; Lopes et al. 2012), infrastructure (Pralhad 2004), and security (Jerneck 2014).

Design is imperative to satisfy unmet or under-served needs of marginalised people living in resource-limited societies (Papanek and Fuller 1972). Appropriately designed products have the potential to create significant impact, contributing towards social and human development of disadvantaged societies (e.g. Schumacher 1973). Such products include, among others, smokeless cookstoves, income-generating products, medical devices, educational devices, communication products or any other products that support development of resource-poor individuals or enhance their capabilities (e.g. Jerneck and Olsson 2013; Aranda Jan et al. 2014). Such design is undertaken, for instance, by

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governments as their obligation to provide public services, by NGOs as a social service or charity, by companies as their persistent activity of exploring and tapping new markets, or by marginalised people for their livelihood (e.g. Karnani 2011; Viswanathan and Sridharan 2012; Prahalad 2004).

Although design investigations tend to be carried out in the context of developed countries or relatively affluent markets, numerous design studies have also been undertaken in the context of marginalised and resource-limited societies (e.g. Donaldson 2006). This design research into marginalised societies is discussed under a variety of names, such as ‘community development engineering’, ‘humanitarian engineering’, ‘design for extreme affordability’, ‘appropriate technology’, ‘design for development’, ‘design at the Base of the Pyramid’, etc. (e.g. Wicklein 1998; Nielsen and Samia 2008; Margolin 2007; Donaldson 2009; Falcioni 2011; Jagtap et al. 2013). Furthermore, over the past decade, interest in this subject has grown, with many universities offering courses or projects while undertaking design research in this field (e.g. Falcioni 2011; Jagtap et al. 2014). Although there is a great deal of design research in this field, its analysis is lacking, making it difficult to gain an overview of what has been investigated, how these investigations were undertaken, in what context they were undertaken, and how marginalised people were engaged and positioned in such investigations. This is addressed by reviewing the relevant literature, focusing on contextual and methodological aspects, while considering the roles of resource-poor individuals—all these aspects are crucial in undertaking design research in this field and in developing and evaluating methods to support the practice of designing products for enhancing social and human development of resource-poor societies. We identify important areas that are still unexplored, and highlight concerns that design researchers ought to have about this field. As such, the paper contributes towards a better understanding of ways in which design research in this field can be undertaken and reported. Our purpose is to support the field to explain some of its present issues and to suggest further areas for continuation of scholarly exploration of this field.

Following this introduction, the rest of this paper is organised as follows: Sect. 2 reviews early accounts of using design to enhance life conditions of resource-poor societies, including its development in recent years, providing an overview of research in this field. Section 3 reviews characteristics of context in which the studies are undertaken and how such contextual aspects are considered and reported in the articles. Section 4 discusses three roles of the resource-poor individuals as identified in this review—the resource-poor individuals as consumers, as producers and as co-designers. Section 5 reviews how the studies were undertaken, including empirics and methods used in the articles and their descriptive and prescriptive nature. Section 6 discusses design topics, including design process and life cycle stages

examined in the articles. Finally, Sect. 7 presents concluding thoughts and offers recommendations for further research avenues, while employing a variety of methods with more consistent and thorough reporting of the studies. As such, the paper will be useful to those who are new to this field as well as to those who are experts in this field.

## 2 Design and poverty

The concept of using design to improve life circumstances of marginalised people in developing countries can be traced back at least to ‘Design for the Real World’ and ‘Appropriate Technology’ movements, initiated and popularised by Victor Papanek and E. F. Schumacher, respectively, in the 1970s (Papanek and Fuller 1972; Schumacher 1973). In his book ‘Design for the Real World’, Papanek, an industrial designer, urged designers to address problems faced by the people in the Third World. Papanek’s proposition was unique at that time when the majority of designers in the industrialised world were engaged in designing products for high-income societies and serving for-profit industries (Amir 2004).

The concept of appropriate technology (AT) was initially articulated by the economist E.F. Schumacher, and was a basis for his well-known book ‘Small Is Beautiful’. In 1966, Schumacher established Intermediate Technology Development Group which now works under the name Practical Action where they aim at designing sustainable technologies to alleviate poverty in developing countries (Practical and Action 2017). Although the concept of AT was first coined by Schumacher, Mahatma Gandhi is considered as the founder of AT movement as he promoted the design of small and local technologies appropriate to satisfy needs of villages in India (Anthony 2000). Failures in transferring technologies from Western countries to developing countries in the 1950s and 1960s motivated the AT movement. The technologies, originally designed for the Western contexts, were not appropriate for contexts in developing countries due to large differences in cultural, political, social and other conditions (Nieusma and Riley 2010). In the 1970s, AT was typically considered as ‘intermediate technology’, placing them between traditional tools and techniques used in villages and advanced large-scale technologies used in the Western countries (Schumacher 1973).

Several case studies describe design requirements that ought to be considered in developing ATs (e.g. Darrow and Saxenian 1986; Rohwedder 1987; Murphy et al. 2009). Typically cited design requirements include, among others, simplicity, low-cost, use of locally available materials, small-scale, energy efficient, labour intensive to enhance employment opportunities, maintainable by local communities, and suitable for cultural and social contexts (e.g. Akubue 2000; Wicklein 1998; Hazeltine and Bull 1999).

Whilst the AT movement gained momentum after its concept was articulated in the 1970s, the concept was heavily criticised as the ATs failed to deliver sustainable and widespread impact on developing countries (Murphy et al. 2009). Some authors have argued that ideological and emotional biases that are common in the AT concept restrict a systematic design process which gives priority to consumers' needs (e.g. Donaldson 2006). The AT movement was criticised as it represented stone-age technologies, discouraged competitiveness and industrial growth of developing countries, and was perceived as 'intermediate' or 'second rate' in terms of efficiency and quality (Carr 1985). In contrast to Schumacher's axiom, "small is not necessarily beautiful" (Donaldson 2006).

Whilst the role of donor funded NGOs in undertaking design activities is recognised in Papanek's and Schumacher's movements (Donaldson 2006), the role of multinational enterprises (MNEs) in designing products and services for the markets of underprivileged people in developing countries is evident in Prahalad's Base of the Pyramid (BOP) concept. In 1998–1999, C. K. Prahalad, together with his colleagues, proposed that MNEs can enhance their profits, while alleviating poverty on a large scale (Prahalad and Lieberthal 1998; Prahalad and Hart 1999). A key idea in Prahalad's proposition was that MNEs can tap into the markets of poor people by selling them appropriately designed products and services, creating a win–win situation. While the concept that private sector can pursue profits and alleviate poverty on a large scale is not new, and economists, such as Milton Friedman and Friedman (1990) have argued that market forces lead to a wealthy society, Prahalad's BOP concept became popular in the literature (Kolk et al. 2014). Challenging the common views which typically perceive little potential for private enterprises in engaging with the underprivileged people on a mutually positive basis, Prahalad and his co-authors argued that MNEs can raise their profits, while satisfying needs of people living in poverty. Similar to the AT concept, the BOP concept has also been criticised, especially by Karnani (2006). He proposes that private sector can contribute towards poverty alleviation by focusing on the people living in poverty as producers as well as by creating employment opportunities for them.

An "alternative but complementary" perspective which evolved parallel to Prahalad's concept of BOP markets is subsistence marketplaces perspective, articulated by Viswanathan and his colleagues (e.g. Viswanathan and Sridharan 2009). This subsistence marketplaces perspective emphasises a micro-level approach through an understanding of individuals, consumers, sellers or entrepreneurs, communities, marketplace behaviors, and their broader context. It acknowledges that these marketplaces are not only markets but are also tightly-knit communities of individuals and families who are typically engaged in social and informal

ways of economic and other exchanges (Viswanathan and Rosa 2007; Viswanathan and Sridharan 2012). Viswanathan et al. (2011) consider subsistence marketplaces as more than just markets to sell to, but as places to learn from. They suggest using insights about life circumstances of the individuals and families in these marketplaces and interactions between them in designing products for them. In his book 'Bottom-Up Enterprise: Insights from Subsistence Marketplaces', Viswanathan (2016) elaborates on bottom-up approach for designing products and services for subsistence marketplaces. Subsistence marketplaces, in contrast to markets in developed countries or relatively affluent regions, are characterised by a multitude of deprivations, such as deficits in infrastructure and capabilities of individuals and societies. Such deprivations combined with absence of traditional distribution ways, media channels, and infrastructure for undertaking market research lead to the requirement of bottom-up learning and design. In addition, unfamiliarity about these marketplaces among outsiders (e.g. university students and professionally trained designers) necessitates bottom-up design approach. Bottom-up approach starts with people living in poverty, and aims at gaining micro-level insights about them, their life circumstances, their social networks, how they purchase products, how they make things or food, how they run enterprises, their interactions with others, how they think, feel and act, their cultural aspects, how they deal with environmental problems, and so on. In this bottom-up approach, needs and problems are analysed from the perspectives of poor people, rather than from the viewpoints of outsiders. This approach, after gaining micro-level understanding, aims to move up to use the ground level understanding to design and develop products and services.

Viswanathan (2016) has explained the steps in the bottom-up design approach. The first step in this approach is virtual immersion. Virtual immersion refers to simulated exposure to poverty to sensitize participants to subsistence marketplaces. Textual and audio-visual media (e.g. day-in-the-life videos) allows participants to develop an initial bottom-up understanding of life circumstances of poor people. Participants simulate some period in the lives of marginalised individuals, for example, by making financial decisions and interactions with other people. In addition, participants engage in analysing transcripts of interviews conducted with marginalised people, and develop an understanding of needs and broader level context within which poor people live. One of the goals of virtual immersion is to move away from sympathy to informed empathy (Viswanathan 2016). Whilst the sympathy refers to emotions that are naturally evoked when a person is normally exposed to poverty, the informed empathy results from an in-depth understanding about life circumstances of marginalised people, requiring scrutiny of data in multiple forms. Remaining steps in the bottom-up design approach are: emersion (e.g. reflection on virtual

immersion; comparing previous design, engineering, and business concepts with insights gained from virtual immersion), preliminary idea generation and evaluation (e.g. initial idea generation aided by extensive analysis of information used in the virtual immersion step), preparation for field research, actual immersion (e.g. field immersion experience using interviews and observations to understand broader life circumstances), reflections about immersion (e.g. summarising what is learned in immersion and correcting prior prejudices), and focussed concept generation and selection (e.g. balanced concept generation to avoid generation of a large, unmanageable set of ideas and fixation on some specific concepts)—see Viswanathan (2016) for related details.

Following Prahalad's original proposition focussing on MNEs, the BOP concept has evolved substantially, with the literature portraying a great variety in terms of initiatives undertaken not only by MNEs but also by NGOs, social enterprises and social entrepreneurs (Kolk et al. 2014). In recent years, research on the design of low-cost innovations using a variety of names such as, frugal innovation (e.g. van den Waeyenberg and Hens 2008; Zeschky et al. 2011; Radjou et al. 2013), jugaad innovation (Radjou et al. 2012) and grass root innovation (Utz and Dahlman 2007; Gupta 2016) is emerging. These types of innovations typically consider designing low-cost and affordable products in a resource-constrained environment, with higher value for a given price (e.g. Cunha et al. 2014). Whilst such products are generally less advanced technologically when compared with sophisticated products satisfying similar functions, they are considered as good enough to satisfy core functions (Agnihotri 2015). In addition to BOP concept and low-cost innovations, similar approaches using names, such as social entrepreneurship, social innovation, design for extreme affordability, community development engineering, engineering for development and humanitarian engineering are growing (e.g. Nielsen and Samia 2008; Donaldson 2009; Falcioni 2011). Many engineering and design departments in universities around the world promote development projects, and offer courses and even full programs in such areas (Jagtap et al. 2014; Nieusma and Riley 2010). This has led to many design investigations in the context of poverty in developing countries (e.g. Mattson and Wood 2014; Whitney and Kelkar 2004; Sethia 2005; Hussain et al. 2012).

Design studies in this field have been undertaken in many different design sectors in urban and rural regions of several developing countries, engaging and positioning poor people in different roles, while considering aspects related to their income and gender. They employ a range of research methods to investigate a variety of descriptive and prescriptive topics. The present paper discusses a broad range of studies, whilst closely analysing 30 articles. This selection of articles focuses on studies that have been carried out from design perspective, e.g. studies aimed at understanding

and improving how products are designed in the context of resource-poor settings. This selection ensured a focused approach, allowing close examination of these studies. The specifics of these studies are summarised in tables, with each row representing an article. This table pattern is repeated in the paper.

### 3 Context

Many studies consider contextual aspects, such as income of poor people, rural or urban region, design sector, specific developing countries, and gender aspects. These broad contextual aspects must be considered in undertaking design research in resource-poor societies and in developing and testing methods to create a positive impact on design practice in this field (e.g. Aranda Jan et al. 2016; Jagtap et al. 2013). These contextual aspects are discussed in each of the following subsections, with Table 1 presenting their summaries.

#### 3.1 Income

Income is easily quantifiable, and is a key measure of poverty. Income enables people to purchase or gain access to products and services, allowing them to satisfy their basic needs and making them less vulnerable and less powerless. As such, measuring poverty in terms of income has attracted interest of researchers as well as practitioners (Karnani 2011). The Sustainable Development Goals (SDGs) of the United Nations (UN) use the benchmark of \$1.25 a day to define poverty; people with income below this threshold are considered living in poverty (Assembly 2015).

Some design studies have reported income. For instance, income threshold of \$1.25 a day is stated in Mattson and Wood (2014), \$4 a day in Jagtap et al. (2013), and \$2 a day in Sethia (2005) and Crabbe (2012). While these studies have reported income as part of their background literature, a few studies have defined it for their research. Murcott (2007), for example, clearly considers the benchmark of \$1 a day for their study. Another example of offering definition of poverty in terms of income is the study by Thomas (2006) who defines poverty as “In the context of this paper, poverty is defined as living on less than \$1 dollar a day, a state affecting about 1.2 billion of the world's six billion people”. Although there is a wide variation and inconsistency in income specification in the case of studies which have specified it, these studies at least provide some insights into the contexts examined in their research. In contrary, not offering any information at all about income makes it difficult to gain an understanding of the context, potentially leaving much room for interpretation and meaning of the

**Table 1** Aspects of context and roles of marginalised people identified, interpreted from the articles

First author, year	Income	Location		Design sector	Countries	Gender		Roles of marginalised people						
		Rural	Urban			Male	Female	Consumers	Producers	Co-designers				
Guimarges, 1996	?	X		Light engineering products	Brazil	?	?							X
Wicklein, 1998	?	?		Many sectors	General	?	?			X				
Whitney, 2004	?	X		Water, access to financial services	India	X	X			X				
Girón, 2004	?	X		Artisanal Goods	Mexico	X	X			X				X
Amir, 2004	?	?		Design policy	Developing countries in general	X	X			X				X
Sethia, 2005	Less than \$2 per day	X		Many sectors	India	X	X			X				X
Rodriguez, 2006	?	X		Healthcare	India	X	X			X				X
Donaldson, 2006	?	X		Product design and manufacturing	Kenya	X	X			X				X
Thomas, 2006	Less than \$1 per day	X		Many sectors	Examples from many countries (e.g. Bangladesh, Nepal, Kenya, Zimbabwe, etc.)	X	X			X				X
Murcott, 2007	Less than \$1 per day	X		Water	Nepal	X	X			X				X
Ramachandran, 2007	?	X		ICT, microfinance	India, Uganda	X	X			X				X
Cai, 2007	?	X		ICT	China	?	?			X				X
Jiehui, 2008	Less than \$3 per day	X		Healthcare	China	?	?			X				X
Murphy, 2009	?	X		Agriculture, fuel efficient stoves, sanitation	Bangladesh, Nepal, Guatemala	X	X			X				X
Donaldson, 2009	?	?		Many sectors	'Design for development' across countries	?	?			X				X
Nieusma, 2010	?	X		Energy, education	Nicaragua, Sri Lanka	X	X			X				X
Hussain, 2010	?	X		Healthcare	Cambodia	X	X			X				X
Viswanathan, 2011	?	X		Many sectors	India	?	?			X				X
Hussain, 2012	?	X		Healthcare	Cambodia	X	X			X				X
Viswanathan, 2012	\$1–\$5 per day	X		Many sectors	India	X	X			X				X
Crabbe, 2012	Less than \$2 per day	X		Artisanal goods, energy, water	India, South Africa, Timor-Leste and sub-Saharan African nations	X	X			X				X
Austin-Breneman, 2013	Less than \$2 per day	X		Agriculture, fuel efficient stoves, ICT, solar lighting	Bangladesh, India, Indonesia, and Africa in general	X	X			X				X
Jagtap, 2013a	Less than \$2 per day	X		Healthcare, ICT	Mali	X	X			X				X
Mattson, 2014	Less than \$1.25 a day	X		Many sectors	Examples from many countries (e.g. Bangladesh, Brazil, India, Kenya, Mali, etc.)	X	X			X				X
Jagtap, 2014	Less than \$2 a day	?		Healthcare	Developing countries in general	?	?			X				X
Manen, 2015	?	X		Natural disasters	Costa Rica	X	X			X				X
Kang, 2016	?	X		Artisanal Goods	Cambodia	X	X			X				X
Ambole, 2016	?	X		Sanitation	South Africa	X	X			X				X
Aranda Jan, 2016	?	X		Healthcare	Developing countries in general	?	?			X				X



Table 1 (continued)

First author, year	Income	Location		Design sector	Countries	Gender		Roles of marginalised people		
		Rural	Urban			Male	Female	Consumers	Producers	Co-designers
Ssozi-Mugarura, 2017	?	X		ICT, water	Uganda	?	?	X		X

Legend: 'X'—contextual aspect or role of the marginalised people was identified, interpreted; '?'—contextual aspect could not be identified, interpreted. The table is continued on the next pages

context and preventing the comparison of contexts examined in the studies.

Whilst income, a quantifiable measure, is an important dimension of poverty, other qualitative aspects of poverty are also mentioned in many studies. For example, Jagtap and Larsson (2013) describe poverty in terms of social, political and cultural exclusion, in terms of little or no access to basic services, such as education, safe drinking water, public health, infrastructure, sanitation and security, and also in terms of absence of resources required to fulfil basic needs, such as food, clothing and shelter. In a similar fashion, Sethia (2005) describes the context of his study by highlighting the struggle of the people to survive on meagre income, and Narayan et al. (2000) describe poverty as individual experiences of hunger, ill-health, unemployment, insecurity and violation of dignity and as structural problems of state corruption, gender inequality, and climate vulnerability. Considering such qualitative aspects in understanding poverty demonstrates the expansion of poverty measurement concept from income oriented definitions to multifaceted construct that considers life circumstances of poor people, taking into account problems they face at individual and structural levels. While it is difficult to compare studies using such qualitative aspects of the context, such qualitative information helps gaining important understanding about the context. Overall, it seems crucial to specify income and describe other qualitative characteristics of the context of study.

### 3.2 Rural and urban

There are differences on many dimensions between rural and urban poverty. Alkire et al.'s (2014) comparison between rural and urban poverty in 105 countries revealed that 85% of those living in poverty reside in rural areas. This comparison is based on the Multidimensional Poverty Index (MPI) which considers three dimensions—education, health and standard of living, assigning equal weights to them. In developing countries, greater prevalence as well as intensity of poverty is observed in rural than urban areas; however, resource-poor people from rural areas are increasingly migrating towards urban areas. Furthermore, there are differences between rural and urban poverty in terms of geographic-spread of poor people, their occupation, and resources available to them. For example, deprivations in water, electricity and flooring contribute more to MPI in rural poverty; whereas deprivations in nutrition, child-health and school attendance contribute more in urban poverty (Alkire et al. 2014). There are also differences between social networks of poor people in rural and urban areas; for example, the social networks of the poor in urban areas are relatively weak (Sridhar 2015). In addition, poor people living in urban slums typically face the problems of social unrest, crime and related violence.

Design studies have been carried out in urban areas of developing countries. Whitney and Kelkar (2004) report an ethnographic study undertaken in urban slums in India to understand local context which informed the design of two systems: the first system aimed at providing supply of fresh and clean water to slum households, addressing the problem of slum dwellers' lack of access to such water, and the second attempted to provide them access to financial services, addressing the challenges posed by the informal economy which is typically cash based. The framework 'POEMS' (people, objects, environments, messages, and services) used in the study was found beneficial to collect information in the urban slums. Similarly, Ambole et al. (2016) report on the collaborative design process to improve sanitation in an urban informal setting in South Africa. Studies have also been undertaken to understand and support product design practice of small firms in urban areas in developing countries. For example, Guimarges et al. (1996) report on a survey of small firms in urban areas of north-eastern part of Brazil to develop an understanding of the process of designing products in those firms, their innovation ability and their training and experience in creating innovative products. The survey revealed that most of the firms in that region are very small, typically managed by one person, often the owner, who is responsible for a multitude of functions. Product design activities are usually performed by informally trained designers and design is generally seen as related to external appearance of products. In addition to studies in urban areas, many studies have been undertaken in rural areas. For example, Nieuwsma and Riley (2010) analysed two case studies to understand how engineering designers pay attention to technological and cultural aspects when they design technologies for disadvantaged communities. Of the two case studies, one focuses on an electrification project for a rural village in a south-western part of Sri Lanka. The analysis revealed the tendency to focus mainly on technological aspects, with little attention to cultural and social justice issues, contributing to imbalances in social power. Since the majority of those living in poverty reside in rural areas and earn their living from agriculture, many design projects deal with the design of appropriate irrigation systems and pumps to support farmers in enhancing their farm production and consequently their income (e.g. Fisher 2006; Jagtap and Kandachar 2010).

Although there is greater prevalence of poverty in rural than urban areas, it is crucial to direct design efforts in alleviating poverty in both these areas. Of the nine principles developed by Mattson and Wood (2014) to guide design for developing countries, one advocates to deal with poverty in both rural and urban areas. It is important to consider specific circumstances and requirements in these areas and accordingly design appropriate products for them. Requirements about distribution and delivery of products in these settings should be considered. For example, rural villages

in developing countries are geographically dispersed, and this increases costs associated with marketing, distribution and delivery of products (Karnani 2011). Overall, it seems that studies have been carried out in rural and urban areas of developing countries, but the literature has just offered general guidelines to design for the people living in these areas.

### 3.3 Design sectors

Design research has been undertaken in, or uses cases from, many sectors, such as energy, water, healthcare, etc., in developing countries. Many cases and examples are from a small set of sectors, focusing on healthcare, information and communication technologies (ICTs), artisanal-goods, and water. For example, in healthcare sector, some studies have developed methods to support designers in understanding healthcare context in developing countries, for example, by using role-play techniques (e.g. Rodriguez et al. 2006) or by using a taxonomy of contextual factors (e.g. Aranda Jan et al. 2016). Others have proposed methodologies to support design of healthcare products for rural areas (e.g. Jiehui and Kandachar 2008) or explored participatory design methods to generate ideas for a healthcare device for underprivileged children (e.g. Hussain et al. 2012). Likewise, studies in ICTs sector, for example, have explored collaborative design of ICT-based interventions (e.g. Ssozi-Mugarura et al. 2017) or developed methodologies to support the design of ICTs for underprivileged communities (Cai et al. 2007). In the artisanal-goods sector, collaborative design, in the form of participatory action research, is explored to support hand-craft community to improve their design practice (e.g. Kang 2016), and product design methodologies have been developed to support design process of craftspeople (e.g. Girón et al. 2004). In the sanitation sector, Lenau and Hesselberg (2015) describe a method of seeking inspiration from nature to generate novel ideas for inexpensive and attractive toilets to address the problems of poor sanitation in developing countries.

While the studies such as those mentioned above are undertaken in just one of the sectors, some studies deal with many sectors. For example, Jagtap et al. (2013) analysed data available in the United Nations Development Programme's (UNDP's) Growing Inclusive Markets (GIM) initiative to identify strategies used by businesses in designing products for marginalised people in developing countries. The GIM data are drawn from many sectors, such as agriculture, energy, manufacturing, solar power, etc. In a similar fashion, Mattson and Wood (2014), drawing on examples from multiple sectors, derive guidelines to design products for developing countries. Overall, it seems that design research has been undertaken in many sectors, with an emphasis on some sectors, but relatively little attention is given to sectors, such as education and housing.

### 3.4 Countries

Poverty rates vary between developing countries. While extreme poverty rates have decreased in many developing countries, they have risen in some developing countries (Olinto et al. 2013). The Development Assistance Committee (DAC) of the Organisation for Economic Co-operation and Development (OECD) has categorised developing countries in the four categories: ‘Least Developed’, ‘Low Income’, ‘Lower Middle Income’, and ‘Upper Middle Income’ (DAC 2016). The category ‘Least Developed’ is defined by the UN as “the poorest and weakest segment of the international community”, comprising about 12% of the world population, but contributing less than 2% to the world GDP (UN 2017). Other three categories in the DAC list are based on the Gross National Income (GNI) per capita. The OECD’s above classification is useful to categorise developing countries into four broad types.

Most of the design studies are either undertaken in, or refer to secondary data, from India which is a ‘Lower Middle Income’ country. For example, Rodriguez et al. (2006) develop a method grounded in role-play techniques to support designers in understanding healthcare context in rural India, Viswanathan and Sridharan (2012) analyse university-based projects undertaken in India, and Subrahmanian et al. (2017) use examples of cooking stoves and rural electrification in India to illustrate a framework to broaden the scope of engineering design to a more holistic view. From the ‘Least Developed’ category, many studies are carried out in a few specific countries, typically in Bangladesh (e.g. Murphy et al. 2009), Nepal (e.g. Murcott 2007) and Cambodia (e.g. Hussain et al. 2012; Kang 2016). Likewise, in the case of the ‘Upper Middle Income’ category, studies are undertaken mainly in Brazil and South Africa. In the ‘Low Income’ category, studies are based in Kenya (e.g. Donaldson 2006) and Zimbabwe (e.g. Thomas 2006). While many studies are undertaken in some specific countries or report their findings based on secondary data from these countries, there are a few studies applicable to developing countries in general and as such do not refer to any specific country. For example, Wicklein (1998) elaborates on criteria to evaluate products and technologies to ascertain if they are appropriate for developing countries in general. Similarly, Aranda Jan et al.’s (2016) developed a broadly applicable framework to support designers in gaining holistic understanding of the context in developing countries. Overall, whilst studies have been undertaken covering each of the categories of the DAC list, they are focusing on some specific countries within these categories. In addition, there is a lack of country-specific or category-specific guidance for designing products.

### 3.5 Gender

Women living in poverty disproportionately suffer many problems as compared to men living in poverty. Women in many societies are poorer in numerous aspects of capabilities, such as health, education, literacy level and freedom to make life choices, with biased allocation of resources against women and girls within households (Cagatay 1998). For example, in sub-Saharan Africa, girls still face multitude of problems in getting both primary and secondary school education (Assembly 2015). Poor women are more vulnerable to biases in labour markets, access to credit and share of earned income (Kabeer 1996). The mobility of poor women is often restricted by their reproductive and caring labour activities as well as by social norms, pushing them to typically engage in labour activities within informal settings, e.g. homeworking (Moser 1992). Compared to men, women face many trade-offs between various aspects of poverty as their choices are more constrained and as their work burden is always higher (Cagatay 1998). Furthermore, absence or failure of public services pose a major problem for women; for example, women face greater problems due to lack of access to toilets (Latapi and de la Rocha 2009). Given the importance of gender equality, one of the SDGs of the UN focuses on gender equality.

As with the income dimension of poverty, there is a wide variation in the literature in providing details about gender aspects. Much of the literature has not exclusively considered gender aspects, but rather has just touched such aspects, for example, by citing a few problems faced by the underprivileged women (e.g. Crabbe 2012) or by just stating that a few women were interviewed (e.g. Ramachandran et al. 2007) or by simply providing little information on the ways in which women use products in some specific cultural context (e.g. Viswanathan and Sridharan 2012). Such studies would have been more useful if they had given more attention to gender aspects, at least by providing detailed information on the reasons why they included some women in their studies or on particular methods, if any, that were used to include them in the studies.

Whilst most of the studies provide little or no information on gender aspects, a few studies have focussed on the development of women living in poverty. For instance, one of the guidelines developed by Mattson and Wood (2014) to support design of products for developing countries focuses on gender aspects, prescribing designers to give attention to the needs of women living in poverty. They offer three suggestions for using this guideline: involve women in co-design, identify problems typically faced by women living in poverty, and assess positive and negative impacts of solutions on them. This indicates a need for gender-sensitive products, requiring a gender-sensitive design process. In another study, Girón et al. (2004), in their 4-year longitudinal study with



60 craftswomen, developed a product design methodology exclusively for these craftswomen. The methodology supported these women to design new products, plan for production, and bring their products to markets. In the same vein, Thomas (2006) presents a design initiative that targets enhancing design capabilities of poor producers, including women, and Jagtap and Larsson (2013) analysed the design of a product service system which was aimed at monitoring health conditions of children in low income families in Mali. Women community leaders were involved in the design of this product service system. Mothers were informed about the benefits of monitoring health conditions of their child(ren). The implemented product service system allowed mothers to gain necessary advice and treatment for their child(ren). Taken together, a wide range exists in considering gender aspects in the literature, highlighting the need for emphasising these aspects in design research undertaken in the context of poverty.

## 4 Roles of poor people

In addition to the contextual aspects, the roles of poor people have also been examined. The following three roles emerge from this review: the poor people as consumers, as producers and as co-designers. These roles are discussed in the following subsections, with these subsections summarised in the last three columns of Table 1.

### 4.1 Consumers

The people living in poverty can simply be consumers of products. Prahalad's (2004) BOP concept mainly focuses on poor people as consumers of products, arguing that private companies can make profits by selling products to the poor, and can contribute toward poverty alleviation by bringing prosperity to them. Products can be sold to poor people in two ways (Jagtap and Larsson 2013). The first is about tapping markets of the poor with the sole aim of making profits. Karnani (2011) has rigorously argued that this approach is not sustainable, and may not alleviate poverty, even suggesting that it can exploit the poor. The second is about selling appropriate products to the poor, with the main aim of contributing toward their development. Karnani (2011) presents four categories of products, using two by two matrix, with one side of the matrix representing whether products are beneficial or harmful to the poor and other side representing if selling products to the poor is beneficial or not for companies. An example in the matrix cell—products are beneficial to the poor and profitable for businesses—is mobile phones, and in the cell—products are harmful to the poor but profitable for businesses—is alcohol. Likewise, he presents examples in other two categories, suggesting for the need of

government regulation in the case of products that are not beneficial, and of subsidies or innovative business models if products are beneficial but not profitable, as in the case of providing clean water.

As consumers, many articles draw examples of a diverse range of products or services, including, among others, cook stoves (e.g. Murphy et al. 2009), medical devices (Aranda Jan et al. 2016), access to healthcare services (Jiehui and Kandachar 2008; Jagtap et al. 2014), clean drinking water (Whitney and Kelkar 2004), sanitation (Ambole et al. 2016) and ICT services (e.g. Cai et al. 2007). These examples typically represent products or services that are beneficial for the poor. Thomas (2006), for instance, presents several examples of products designed for selling to the poor people, e.g. clockwork radio, computer and power systems, solar-lanterns and fuel-efficient cook stoves.

Many studies do not report on, or emphasise, the aspects related to financial sustainability that is necessary to sell products to the poor or give them access to the functions afforded by the products, although a few studies have considered such aspects of financial sustainability. For example, Jagtap and Larsson (2013) report on the process of designing a healthcare system to monitor health conditions of children from poor families and how aspects of financial sustainability were considered in the process. Likewise, Jagtap and Kandachar (2010) present a case study on irrigation systems designed for marginalised farmers, reporting on how subsidies and microcredit enabled the farmers to buy the irrigation systems and how such aspects of financial sustainability were considered in the design process. Another example is the holistic contextual framework, developed by Aranda Jan et al. (2016), aimed at supporting designers to consider such aspects early in the design process. Overall, the literature reports a wide variety of examples and cases of products for selling to poor people, but there is a lack of operational guidance on including a wider range of aspects (e.g. financial sustainability, business models, etc.) necessary to design and sell such products to the poor in a financial sustainable way.

### 4.2 Producers

The marginalised people in developing countries may engage in producing goods, such as furniture, handicrafts and common household products. Such activities of producing goods play an important role in alleviating poverty and creating jobs for the poor, providing them opportunities of income generation. While the majority of the articles consider the poor as product consumers, some have considered their role as producers. Some articles report development of methods to support the design practice of poor people so that they can create products that are new and more desirable for the consumers in potential markets, thereby increasing product sale and their income. Such studies thus focus

on enhancing design capability of poor producers. Factors that enhance adoption of design methods are also considered, e.g. skill and literacy level of poor people as well as other characteristics of the context in which they develop products. For example, Girón et al. (2004), using participatory approaches, developed a product design methodology for underprivileged craftswomen, taking into account their economic, social and cultural background. The developed methodology, specifically tailored to the needs of the craftswomen, allowed them to identify market needs, generate concepts, and test the concepts in markets. The methodology helped the women to design new products - the study reports that the women designed 85 new types of palm products. Similarly, Kang (2016) reports participatory action research with a community of ceramic potters, aimed at improving their ceramic production and trade. This action research involved: understanding the situation and expectations of the potters, creating mood boards, generating ceramic ideas, creating prototypes, exploring trends, and reflecting on the process and its outcomes. While the above studies aimed at enhancing design capability of the underprivileged product producers, Austin-Breneman and Yang (2013) developed guidelines to design products for micro-entrepreneurs in developing countries to enhance their profits. An example of such a product is a drip irrigation system for marginalised farmers. The guidelines for designing such products for micro-entrepreneurs are, among others, designing for the business plan of the micro-entrepreneur, and designing for reliability, maintainability and multi-functionality. While Girón et al. (2004) and Kang (2016) developed the methods collaboratively with the underprivileged producers, Austin-Breneman and Yang (2013) based their guidelines on the literature and interviews with the relevant experts.

In addition to the studies that have developed methods to enhance the design capability of marginalised producers, some studies report on offering them designs which they can manufacture and sell to increase their revenue. Such designs, for example, are given to them by professionally trained designers, design academics or design students. Thomas (2006) provides an example of jute bags designed or commissioned by the importers and made by low-income women in developing countries. The manufactured bags are then sold in the western countries via People Tree, a fair-trade online apparel retailer. While the market size of such products can be small, the income generated can be life-changing for the low-income people. Another example is collaborative design where design students worked with waste collectors to design products from waste material to add value and create additional income opportunities for the waste collectors (Thomas 2006).

A further group of studies have undertaken empirical research to understand design practice of low-income producers, including barriers in their design practice.

Donaldson (2006) undertook empirical research in Kenya to investigate product design practice in a variety of sectors, including that of the low-income producers. She observed four types of product categories: copying designs, imported products, basic original design and speciality design. The majority of the designs originated outside Kenya or were copied from imported products. She also found more emphasis on the later stages of the design and development process on activities, such as detail design and manufacturing, with little or no attention to initial phases of design process (e.g. need identification). She also reports on barriers in their design practice, including, among others, limited physical infrastructure and state corruption. Entrepreneurial activities of underprivileged people in developing countries are typically hindered by little specialised knowledge and skills (Banerjee and Duflo 2007). Imitation of products originally designed in foreign countries, as reported in Donaldson's (2006) study in Kenya, has also been observed by Thomas (2006) in Zimbabwe. Guimarges et al.'s (1996) study of the small firms in Brazil also found little or no original design of products, with absence of using formal design methods in almost all firms in the study. In contrast, the ability of underprivileged producers to design products, for example, in the form of redesigning an existing product to improve its quality or designing tools for own use, is demonstrated in other studies, e.g. Chuta and Liedholm's (1985) survey in Sierra Leone and Sverrisson's (1990) study in woodworking enterprises in Kenya. This indicates that poor people with no formal training in designing products may indeed possess design ability, but it seems that this ability might be suppressed by the circumstances in which they operate.

#### 4.2.1 Formal and informal sectors

Poor people in developing countries may work in the formal or informal sector. In the formal sector, a worker has a formal contract with the employer, gets guaranteed and decent fixed salary, and is protected by a social security for health and other risks. In a sharp contrast, a worker in the informal sector has no formal contract with the employer, has no orderly work conditions, gets irregularly paid, has no fixed hours of work, mostly earns hand to mouth, and is not protected by any social security system (Webb et al. 2013). Recent estimates suggest that the informal sector contributes to 40–60% of GDP in developing countries (Schneider and Enste 2013). One-third (31.5%) of the global non-agricultural workforce has a main job in an informal enterprise (Williams et al. 2015). While some see informality as an 'exclusion' (e.g. ILO 2014), others see it as a 'voluntary' decision (e.g. De Soto 1990). Donaldson's (2006) study identified several characteristics of design practice in informal as well as formal sectors in Kenya. For example, there is a wide variation in technical skills of product producers

in these sectors, they often avoid exploratory activities, such as prototyping or tinkering due to costs and available resources, quality of input material they receive is usually inconsistent, and they actively engage in recycling and reusing materials or parts. As compared to the formal sector, the quality of products in the informal sector is relatively poor. The production of goods in the informal sector is typically labor-intensive with poor craftsmanship, relying on locally available resources (e.g. Bhalla 1989).

While Donaldson (2006) and Thomas (2006) provide details of the sector that they studied, many articles do not provide information about the sector (e.g. Murcott 2007; Kang 2016; Crabbe 2012), making it incomprehensible to know if their study was undertaken in the formal or informal sector. Some articles have provided information on the type of sector only in passing. For instance, the type of sector is stated, in passing, in Guimarges et al. (1996) article; for example, one of the keywords of their article is ‘informal sector’ and it is indirectly stated in the paper as, “These firms provide employment for people who cannot be absorbed by the formal sector, and produce goods which are bought locally by the poor.” Likewise, Austin-Breneman and Yang (2013), in relation to their study about micro-entrepreneurs in developing countries, refer to the type of sector as part of their literature review: “Micro-entrepreneurs are individuals who generate small amounts of income from their own business activities, often in an informal market sector (Burra et al. 2003).”

In addition to the variation in providing details about the type of sector—formal or informal, there is diversity in offering information on the firm size, e.g. number of poor people working in firms producing products. For example, Donaldson’s (2006) study was undertaken in many types of firms—micro, small, medium as well as large, and Austin-Breneman and Yang’s (2013) study refers to micro-enterprises. The workforce in the firms surveyed by Guimarges et al. (1996) ranged between one to eleven people. Again, many articles do not provide any information on the firm size (e.g. Murcott 2007; Kang 2016; Thomas 2006), posing difficulties in gaining understanding of the circumstances in which poor people produced goods.

### 4.3 Co-designers

Using appropriate methods and design processes, co-design permits effective engagement between designers and community members, alleviating social, cultural and knowledge differences that might exist between them (Sanders and Stappers 2008). Two approaches of designing products for marginalised communities in developing countries are visible (Avgerou 2010). The first is about designing products, typically outside the context of marginalised communities, either in developed countries or in literate and affluent areas

of developing countries, and then transferring these products to the target communities. Designs that are externally conceived and simply implemented in the communities fail to achieve sustainable and continued adoption and impact when the implementers begin working on other projects or leave the community (e.g. Nieusma 2004; Murcott 2007; Thomas 2006; Ashraf et al. 2008; Dodson et al. 2012). The second is a more social approach, with involvement of marginalised people in the design process, resulting into more in-depth understanding of the target context (Dearden and Rizvi 2008). Some authors argue that for sustainable impact on marginalised communities, co-design activities are critical, with a significant need to look beyond technological aspects of design to community members and their context (Rivett et al. 2014). Many authors have called for co-designing with subsistence communities at every phase of the design process and for continuous learning from them, including suggestions for participatorily developed human-centered design policies for developing countries (e.g. Murcott 2007; Viswanathan et al. 2011; Amir 2004).

Some studies analyse design projects that have used co-design approaches with poor people, and report advantages associated with them (e.g. Sethia 2005). Co-design is beneficial for both designers and community members (Mattson and Wood 2014). It enhances designer’s knowledge and understanding of the needs and preferences of marginalised people, their aspirations and life circumstances. Furthermore, co-design improves designer’s understanding of the local setting and environment in which the eventually developed product will be used. In addition to such benefits for designers, co-design is valuable for the community members. For example, it empowers them for existing as well as future design projects or similar participatory activities, and can potentially enhance their design capability. The resource-poor people develop a feeling that the design project belongs to them, supporting their project ownership. Acceptance and adoption of products has been shown to improve when they are co-designed with the resource-poor individuals (Champanis and Rivett 2012; Ssozi-Mugarura et al. 2017). A recent experimental study in Zambia observed that co-design positively influences concept feasibility as well as likelihood of meeting the user needs (Brubaker et al. 2017).

Other studies describe co-design experiences. Thomas (2006), for instance, reports on a project aimed at developing a pedal-powered device to alleviate physical burden of washerwomen. Participatory approach with the washerwomen allowed gaining important insights into their problems, revealing their higher preference for economic benefits over health benefits. The device was designed collaboratively, with the washerwomen suggesting changes and improvements. Likewise, Nieusma and Riley (2010) describes co-design workshops used in the development

of a renewable energy system for a rural community, Hussain et al. (2012) report on a field study where co-design methods were used to generate ideas for a prosthetic device for children, and Ssozi-Mugarura et al. (2017) and Ambole et al. (2016) elaborate on participatory design of an ICT intervention to support water management and a sanitation intervention, respectively. In most such studies, authors of the articles either facilitated co-design or were involved in the co-design activities. Such projects are often undertaken for ‘academic’ purposes, not presenting ‘real’ participatorily designed and implemented design projects.

A further group of studies has offered guidelines for co-design with the resource-constrained communities in developing countries. Designers ought to have a more flexible and adaptive mindset when co-designing with such communities, with awareness that they will be co-designing under different conditions than those when co-designing in developed countries (e.g. Hussain et al. 2012). They must recognise that the people living in resource-limited environments are experts in surviving in such low-resource settings and in understanding local networks and available resources (Murcott 2007). Another important suggestion found in the literature is that designers must prefer to work with the poor people than with those who have not experienced the context of poverty. People working in NGOs or universities in developing countries typically do not have experience of living in poverty, and therefore they might not fully understand the complex challenges of poverty (e.g. Nieuwsma and Riley 2010; Mattson and Wood 2014). Several authors suggest actively involving marginalised people in every step of the design process, e.g. in task clarification, concept generation, concept selection, etc. (Nieuwsma and Riley 2010). Using appropriate methods of communicating and involving resource-poor individuals enhances effectiveness of co-designing with them. Methods such as drawings, pictures, cartoon-strips and narrative ways of communication are suggested as potentially useful co-design methods with marginalised people (e.g. Du Preez et al. 2015; Costandius 2010; Ambole et al. 2016).

Summing up, the literature argues for co-design with the resource-poor individuals, highlighting associated advantages for both the designers and marginalised people, but has just offered general co-design guidelines. It is still unclear how to undertake co-design in ‘real’ design projects that do not just end after the conceptual design phase, but require downstream development and implementation. Cases of co-design projects implemented in low-resource settings are few (Kolk et al. 2014), and this can be attributed to the difficulties associated with co-designing with the poor people or to the lack of simple, effective and efficient methods to engage with them in real design projects, which are typically time and resource constrained (e.g. Nieuwsma and Riley 2010).

## 5 Research methods

Whilst the studies have dealt with several contextual aspects, while considering different roles of the poor people, there is a great diversity in how they are conducted in terms of methods employed and whether they are descriptive or prescriptive in nature. These aspects are discussed in the following subsections, with Table 2 presenting their summaries.

### 5.1 Descriptive and prescriptive

Blessing and Chakrabarti’s (2009) frequently cited Design Research Methodology includes descriptive and prescriptive phases of research. Whilst the descriptive phase is about understanding some aspects of design with respect to research motivation, the prescriptive phase, based on the knowledge and understanding revealed in the descriptive phase, aims at developing and evaluating a method, tool or intervention to support some areas of design.

Compared to prescriptive research, there are many descriptive studies whose findings suggest to design holistic solutions to address many different challenges that are typically observed in low-resource settings, highlighting the need to focus on designing systems rather than just technologies, while taking into account larger social, cultural, institutional and structural issues of poverty (e.g. Whitney and Kelkar 2004; Nieuwsma and Riley 2010; Aranda Jan et al. 2016; Jagtap and Larsson 2013). Findings of other descriptive studies that focus on co-design suggest considering challenges of human, cultural, religious and resource nature in undertaking collaborative design with poor people (e.g. Hussain et al. 2012; Manen et al. 2015; Hussain 2010). Such co-design studies usually suggest psychological empowerment of participants as an outcome of co-design activities. Some articles report on design practice in micro or small enterprises in developing countries, revealing a range of problems these enterprises face, such as lack of capital, inconsistent availability of raw materials, corruption, inadequate infrastructure, and lack of knowledge regarding design methods and tools (e.g. Guimarges et al. 1996; Donaldson 2006).

Whilst most of the above descriptive studies have undertaken empirical research in developing countries, some studies have analysed student design projects or activities of students when they design products for underprivileged communities (e.g. Viswanathan et al. 2011; Jagtap et al. 2014; Viswanathan and Sridharan 2012). Jagtap et al.’s (2014) study with the design students found differences between their design processes when they design products for high-resource settings, commonly seen in

**Table 2** Research methods and their characteristics identified, interpreted from the articles

First author, year	Study nature		Data collection	Research type		Unit of analysis
	Descr.	Prescr.		Qual.	Quant.	
Guimarges, 1996	X		Interviews	X	X	Small firms
Wicklein, 1998		X	Secondary data	X		Design requirements
Whitney, 2004	X		Ethnography	X		Slums
Girón, 2004		X	Fieldwork, meetings, observations, surveys, etc	X		Participatory design team
Amir, 2004		X	Secondary data	X		Design policy
Sethia, 2005		X	Secondary data	X		Multiple (e.g. designers, users, product, etc.)
Rodriguez, 2006		X	Workshops, interviews, etc	X		Role play techniques
Donaldson, 2006	X		Interviews, site visits, observations, plus secondary data	X	X	Multiple (product design and manufacturing firms, design process stages, etc.)
Thomas, 2006	X		Case study	X		Sustainability dimensions
Murcott, 2007		X	Own experience	X		Stages of collaborative design process
Ramachandran, 2007	X	X	Field observation, interviews	X		Users
Cai, 2007	X	X	Action research	X		Design process stages
Jiehui, 2008		X	Case studies, field work	X		Rural healthcare system and design process stages
Murphy, 2009		X	Secondary data	X		Design considerations for ATs
Donaldson, 2009	X		Secondary data	X		Multiple (development goals, impact, etc.)
Nieusma, 2010	X		Case study	X		Design team
Hussain, 2010	X		Participatory methods involving interviews, data in the form of pictures taken by participants who were given cameras	X		Participatory design techniques
Viswanathan, 2011	X		Observations, secondary data	X		A university course
Hussain, 2012	X		Workshops, interviews	X		Participatory design team
Viswanathan, 2012	X	X	Probing during students' project presentations and assignments plus their project reports	X		Student teams
Crabbe, 2012	X		Secondary data plus own experience in design case study	X		Sustainability dimensions
Austin-Breneman, 2013		X	Interviews plus secondary data	X		Guidelines to design for micro-enterprise
Jagtap, 2013a	X		Secondary data	X		Product service system
Mattson, 2014		X	Secondary data	X		Success factors for effective design
Jagtap, 2014	X		Think aloud method	X	X	Designer
Manen, 2015	X		Participatory workshops	X	X	Participatory design team
Kang, 2016		X	Interviews, observation, creating mood boards, drawing, taking photographs, etc	X		Participatory design team
Ambole, 2016	X		Ethnography, observations, email communication, plus secondary data	X		Participatory design team
Aranda Jan, 2016	X		Interviews, secondary data	X	X	Design requirements
Ssozi-Mugarura, 2017	X		Interviews, workshops, focus groups	X		Participatory design team

Legend: 'X' indicates that a related aspect of research method was identified, interpreted from the article; 'Descr.'—descriptive study; 'Prescr.'—prescriptive study; 'Qual.'—qualitative; 'Quant'—quantitative. The table is continued on the next page

developed countries, and low-resource settings in developing countries. Based on their findings, they suggest to provide opportunities for students to work on design projects aimed at addressing challenges in resource limited societies. Such design projects can help students to develop

knowledge and skills required to design products for unfamiliar contexts as well as to handle information-intensive design tasks. Overall, it seems that there is a wide variety of descriptive studies, covering many different topics.



In prescriptive studies, some studies have developed guidelines to support design for resource-limited communities. In many cases, these prescriptive suggestions are not grounded in the authors' own empirical research; rather, they are derived from examples of design projects in the published literature. For example, Mattson and Wood (2014) offer nine principles to support design for developing countries. These principles, founded on the design cases as well as experience of practitioners published in the literature, are aimed at supporting the practice of designing products and technologies for people living in poverty, and are claimed to overcome the challenges of designers' unfamiliarity with poverty, foreign culture and other constraints such as affordability. The principles suggest, for example, to co-design with the people in target contexts and test the product in actual setting rather than just in a laboratory setting. Likewise, Wicklein (1998) compile a list of generic requirements (e.g. system independence, multi-purpose, etc.) that should be addressed in designing products for resource-poor communities in developing countries. Whilst the authors of these studies have prescribed guidelines by deriving them from secondary data (e.g. published design cases), some authors have developed such guidelines or methods based on their own empirical research. Cai et al. (2007), for instance, based on the findings of their 2-year action research, developed a framework to design IT services for the marginalised communities. Likewise, based on their own observations of how marginalised people use and interact with technological products, Ramachandran et al. (2007) offer guidelines to effectively employ such products with poor people to gain insights into their needs and social structure. More recently, based on own field work and secondary data about failures of engineering projects, Wood and Mattson (2016) identify typical pitfalls in engineering design aimed at resource-limited societies, and present a method to support designers to avoid the pitfalls.

Although the above studies do not report on the evaluation of prescribed methods, some authors attempt to support their methods by demonstrating them by using examples of design projects. For example, Murphy et al. (2009) formulate a set of criteria to evaluate appropriateness of a technology for developing countries, and explain these criteria using the published design cases on cook stoves, women's outhouse and innovative rice practices. In a similar fashion, Sethia (2005) presents examples of business initiatives in subsistence markets to exemplify his 'responsible design' framework representing different interests of a range of stakeholders involved in designing products for subsistence markets. Another group of studies has tested the developed methods or tools. For example, Girón et al. (2004), implemented a product development methodology specifically developed for craftswomen, considering the literacy level and life conditions of these women. The implemented

methodology helped the craftswomen to identify preferences of consumers and use raw materials more efficiently, consequently improving their standard of living through increased profits. Likewise, Kang (2016), tested a method of collaborative design workshops with a handcraft community, and Rodriguez et al. (2006) evaluated their role-play technique with students, which was aimed at gaining insights into unfamiliar healthcare contexts in rural areas of a developing country. Viswanathan and Sridharan (2012) developed and implemented a framework to support students in undertaking university-based design projects for marginalised communities in developing countries. A key feature of the framework is that the students try to understand the life circumstances of poverty and related social and cultural aspects by using virtual immersion using text-based and audio-visual methods. This virtual immersion sensitizes students to issues of poverty before they undertake field work in a developing country.

There is a great diversity in prescriptive studies in terms of the basis used to propose methods, e.g. whether the basis is secondary data or author's own empirical research, and in terms of the evaluation procedure, e.g. if the method is just explained for its effectiveness or evaluated by implementing it in a design project. However, what is lacking is systematic and controlled evaluation of methods and comparison between the methods that are intended to achieve the same goals. This lack of systematic evaluation of methods makes it difficult to identify which methods are more effective for a specific purpose.

## 5.2 Methods

Many diverse research methods have been used in the studies. Retrospective methods such as case studies and interviews are predominantly used. Austin-Breneman and Yang (2013), for example, employed interviews with practicing designers to propose guidelines to design products for micro-enterprises in developing countries. In a similar fashion, Donaldson (2006) used secondary data from Kenyan organisations and interviews to identify the types of products and nature of design processes in Kenyan manufacturing firms. Many articles employ case studies. Data on most of these cases are gathered from the published literature. For example, Jagtap and Kandachar (2010) developed a framework to represent the design of interventions in subsistence markets. The framework is based on the analysis of two design cases where businesses, local communities and NGOs collaboratively designed interventions in agriculture and healthcare sectors. Such case-study-based articles typically draw on a limited number of cases (e.g. Niesma and Riley 2010; Murphy et al. 2009; Jagtap and Larsson, 2013). An exception is Viswanathan and Sridharan's (2012) study based on 13 design projects, but these projects are

university-based student projects, typically covering concept and prototype development. Whilst the above studies use retrospective methods, a few studies use real time methods, such as ethnography (e.g. Whitney and Kelkar 2004) and participant-observation (e.g. Nieusma and Riley 2010).

Many co-design studies draw on both retrospective and real-time methods. These studies use a range of methods such as interviews, participatory workshops, focus groups, fieldwork, surveys, and participatory action research (e.g. Ssozi-Mugarura et al. 2017; Manen et al. 2015; Girón et al. 2004; Kang 2016; Ambole et al. 2016). Frequent application of real time methods in these co-design studies can be attributed to the fact that authors of these studies either facilitate the co-design process or are involved in co-design activities, allowing them to collect data using methods such as observations or workshops.

The other aspect of research methods that needs to be considered is their internal and external validity (Cook and Campbell 1979). Internal validity refers to the issue of causal relationships between variables. A research study, which eliminates many possible confounds and allows to select one explanation of the causal relationship over another, is considered internally valid (Coolican 2014). On the other hand, external validity aims at determining whether the findings of a research study are relevant for other persons, in other settings and at other times; thus, external validity is related to generalising (e.g. Cozby and Bates 2012). Some design studies have conducted experiments, controlling many variables in a laboratory setting, e.g. Jagtap et al.'s (2014) think aloud protocol study comparing design processes for developed country markets and subsistence markets in developing countries and Rodriguez et al.'s (2006) evaluation of role-play technique with students to develop an understanding of local context in developing countries. Although such experimental studies can be internally valid, their results may not represent design practice in real world. These studies, typically carried out with students in a laboratory setting while controlling many variables, exclude many aspects of real design practice in actual setting of marginalised communities, potentially reducing their external validity. On the other hand, Jagtap et al.'s (2013) study analysed data on a large number of cases from many developing countries, covering several design sectors to identify design constraints and related design strategies that are common across a range of subsistence markets. Some studies have not provided important information such as number participants or their age (e.g. Whitney and Kelkar 2004), making it difficult to assess external validity of their results.

The vast majority of studies have employed qualitative analysis of data. Quantitative analysis is observed in a few studies. Jagtap et al. (2013), for example, performed quantitative analysis of data from the UNDP's 'Growing

Inclusive Markets' initiative to identify which constraints are common in subsistence markets and which strategies are typically used in designing products for these markets. Aranda Jan et al. (2016) use both qualitative and quantitative approaches to develop a holistic contextual framework of factors that ought to be considered in the early phase of designing products for low resource settings. Quantitative analysis of data collected using think aloud protocol analysis is reported in Jagtap et al.'s study (2014). The study aimed at exploring differences between design processes for markets in developed countries and for subsistence markets in developing countries.

One of the aspects of research studies is the unit of analysis. The unit of analysis of a study can for example be individuals, artifacts, groups, social relationships, or geographical areas (Trochim 2006). Some studies may also have multiple units of analysis. According to Blessing and Chakrabarti (2009), units of analysis employed in design research include, among others, design team, designer, requirements, product, stages of design process, collaboration, decision making, documentation, information exchange, and organisational strategy. For instance, a design team is the unit of analysis of a study which intends to understand the behaviour of design teams, even if the collected data are at the level of individual designers. These data about individual designers are aggregated and analysed at the team level. Many diverse units of analysis are used in design studies undertaken in resource-limited societies in developing countries. While some studies have used the design team as the unit of analysis (e.g. Girón et al. 2004), some have used the designer as their unit of analysis (e.g. Jagtap et al. 2014). The later study, using think aloud protocol experiments with designers, has analysed the collected data at the individual level. Other units of analysis are, for example, design requirements (e.g. Aranda Jan et al. 2016) and stages of the design process (e.g. Cai et al. 2007).

Whilst it is important to characterise the sample in the study by providing details, such as number of participants, their age, profession, etc., some studies have not provided any information on the participants in the study, e.g. details of sample size (e.g. Whitney and Kelkar 2004; Murcott 2007; Cai et al. 2007). This finding highlights a strong need to more rigorously describe details of research methods employed. Another gap in the literature is lack of large-scale or longitudinal studies, involving collection of primary data (not secondary data published in the literature) in low-resource settings. This might be due to difficulties of undertaking large-scale studies that require collecting large-sample data in resource-limited and other non-traditional settings (Kriauciunas et al. 2011).

## 6 Design process and life cycle stages

As is the case with the diversity of research methods used, there are many diverse investigations covering different phases of the design process. Some studies cover many phases of the design process by developing an understanding of, or proposing, models of design processes (e.g. Murcott 2007; Nieuwsma and Riley 2010; Ssozi-Mugarura et al. 2017; Girón et al. 2004; Jiehui and Kandachar 2008) or by offering guidelines that cover many phases ranging from context understanding, conceptual design to product testing and distribution (e.g. Mattson and Wood 2014). In contrast to such studies with broad objectives, dealing with many phases of the design process, some studies have focussed only on initial context understanding phase. These focussed studies, for example, contribute toward context understanding by compiling a list of requirements that should be considered in developing products (Li et al. 2016; Wicklein 1998), by developing tools to help understand unfamiliar contexts (Rodriguez et al. 2006), by using participatory methods to gain insights into social context and user needs (Hussain 2010; Ramachandran et al. 2007), and by developing a taxonomy of contextual factors that range from technical aspects to economic, institutional and socio-cultural aspects (Aranda Jan et al. 2016; Jagtap et al. 2013). Another group of studies has contributed toward conceptual design phase in addition to context understanding phase (e.g. Whitney and Kelkar 2004; Hussain et al. 2012; Manen et al. 2015; Viswanathan and Sridharan 2012).

A few studies have attempted to assess impact of technologies. Thomas (2006), for instance, has outlined the five categories—benefits to poor people, economic sustainability, environmental sustainability, social sustainability and institutional sustainability—to help assess impact of products and technologies. In a similar vein, Crabbe (2012) suggests four principles to assess sustainability. Whilst three of these four principles are about natural resources (e.g. reducing use of metals and fossil fuels), one is about social sustainability (e.g. enhancing people's capabilities to meet basic needs). In contrast to these studies which focus on assessing impact of products, some studies have just touched upon such aspects. While a few studies have given specific details in assessing impact, e.g. the cook-stove consumed 50% less wood than traditional stoves (e.g. Murphy et al. 2009), the irrigation system used 50–60% less water (Austin-Breneman and Yang 2013), some have simply used tacit and 'fuzzy' aspects by saying that the design empowered poor people or enhanced their quality of life, or by just stating that the technology helped increase the income of the target community, without giving any information on specific increase in the

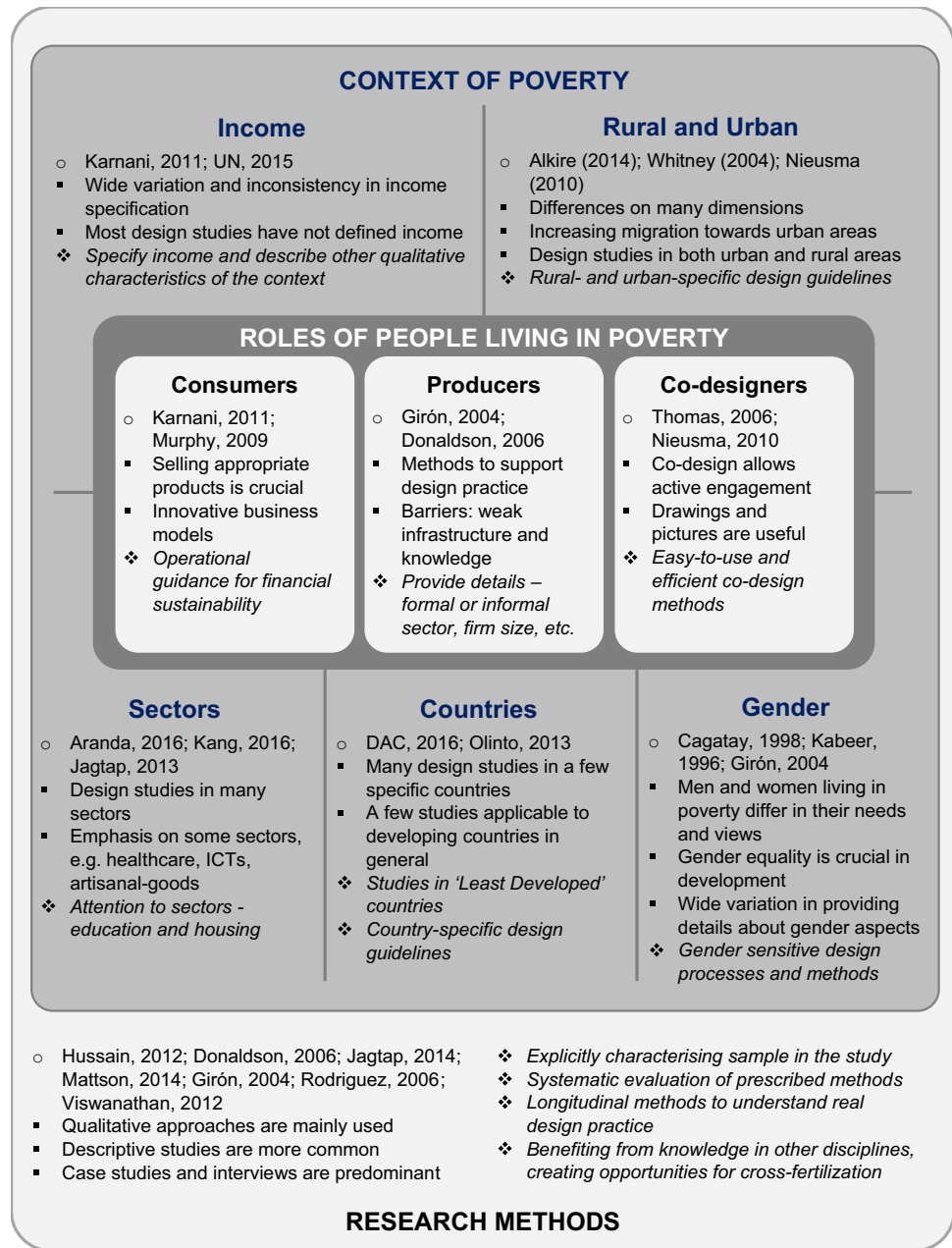
income (e.g. Girón et al. 2004). Likewise, some business initiatives designing solar energy solutions to the poor are considered profitable, without providing related details (e.g. Hart 2005). Overall, it seems that scarce attempts have been made to rigorously assess impacts of products and technologies on the lives of poor people. There is a clear need of reporting actual impact of designed interventions on the disadvantaged communities, and of relating this impact with the decisions made in the design process or other relevant aspects of the design process. This necessitates long-term longitudinal studies with rigorous field work. In addition, this review highlights a strong need of objective measures to assess social, economic and environmental impact of products designed for or with poor people. Furthermore, although successful implementation and sustained adoption of technologies and products by poor people is highly important to create positive impact (e.g. Nakata 2012), the literature has given little or no attention to these aspects. This suggests a crucial need to undertake research on how designers can consider and implement these aspects in the design process.

## 7 Discussion and recommendations

Many design investigations have been undertaken to understand and improve design in the context of marginalised sections of societies in developing countries. A better understanding of design in such contexts, characterised by many different constraints and opportunities, will permit the field to enhance design education and practice, with development and evaluation of design methods and planning for further research. The literature portrays a multifaceted picture, with great diversity in terms of contexts (Sect. 3), roles of poor people (Sect. 4), and methods and empirics in the articles (Sect. 5). In addition to the diversity of design topics (Sect. 6) covered in descriptive and prescriptive research, there is diversity in how related details are (not) reported and this can hamper understanding of important aspects such as context in which the studies are undertaken. Whilst the literature has attempted to address a variety of research questions, there remain many aspects that are not currently investigated. Although these gaps in the literature can be interpreted as a matter of concern, they represent opportunities for future research in this field. Figure 1 shows a framework, illustrating the context of poverty, roles of poor people, and aspects of research methods, along with some of the key references, findings and recommendations for further research.

The review of methodological and contextual aspects of the studies permits recommending actions that might usefully support research in this field. Some recommendations centre on reporting details of various aspects of

**Fig. 1** A framework representing context of poverty, roles of poor people and aspects of research methods



○ – references (first author, year) ; ■ – findings; ❖ – recommendations for further work

research. Overall, the review identifies a profound need to thoroughly report details of the context examined, giving precise and consistent definitions and detailed information on the characteristics of the context. This can help understand similarities and differences between contexts researched in various studies, allowing to make generalisations or explain differences in findings gleaned from similar or different contexts. In addition, the review findings lead to a call for characterising sample in the study, providing detailed information on relevant aspects, such

as number of participants, their age, their educational and professional background, income, gender, firm size, etc.

The concept of ‘shared memory’ in design—articulated by Konda et al. (1992)—can usefully explain the need of giving rich information on context and details of research methods employed (e.g. information on participants, sample size, etc.). Shared memory is about collective knowledge in the case of a specific discipline or shared knowledge and meaning in the case of individuals who are from different disciplines separated by space, time, experience, culture, etc.



In design, shared memory allows better understanding of contexts and design situations. According to Konda et al. (1992), methods that are successful in some contexts may not be successful in other contexts or universally. Design methods should not be developed in abstract, but for a specific context, highlighting importance of shared memory about contexts and related design endeavours. Providing rich details of the context of marginalised societies and (un)successful impact of design interventions in those contexts is necessary to ascertain if those interventions can be reused in other contexts. Thoroughly recorded design cases or shared memory about marginalised settings is crucial to avoid reuse of unsuccessful design approaches and methods. A lack of shared memory about such resource-limited contexts and design failures could lead to their reinvention or repetitive use. Various aspects of contexts, research methods employed, and the roles of poor people, as identified in this review, can help in creating shared memory and in providing an initial basis of standardisation for reporting a study undertaken in low resource settings. It is hoped that the present work will help and motivate scholars to identify and elaborate additional aspects (if any) of contexts and research methods employed in this field.

Reporting the above-mentioned details together with rich information on types of problems addressed, phases of the design process, life cycle stage of the product, and time of data collection is highly important to assess external validity of the research, i.e. evaluating the degree to which the conclusions and findings drawn from a study can be relevant to other marginalised communities and at other times (e.g. Cozby and Bates 2012). Threats to external validity need to be considered and minimised in undertaking research, e.g. selection of non-representative subjects or objects is a threat to external validity (e.g. Cook and Campbell 1979). Likewise, threats to internal validity need to be taken into account, e.g. passing on information from one participant to another before the later participates in the study is a threat to internal validity (e.g. Blessing and Chakrabarti 2009). It is worthwhile to undertake studies of design practice in actual marginalised communities to ascertain if the results of studies undertaken in laboratory settings are also observed in the real world (e.g. Jagtap et al. 2014), potentially allowing design researchers to assess external validity of experimental studies undertaken in laboratory settings.

Qualitative approaches account for the vast majority of methods used in the design investigations within this field. Future research might benefit from quantitative methods, such as experiments, closed questionnaires, etc. (Frankfort-Nachmias and Nachmias 1996), or from combining both qualitative and quantitative approaches to obtain a holistic picture of the study object (e.g. Tashakkori and Teddlie 1998). Furthermore, beyond merely demonstrating design support tools and methods by drawing on secondary design

cases, future research in this field ought to aim at systematic evaluation of such methods, by employing, for example, controlled experimental studies (Blessing and Chakrabarti 2009). In evaluating design support tools, design scholars may also benefit, if conditions permit, from quasi-experimental research setups used in fields, such as development economics to assess poverty impact of an intervention (e.g. Banerjee et al. 2010) or from Randomized Controlled Trials (RCTs) which usually need large sample data (e.g. White et al. 2014). However, researchers need to be cautious about limitations of these methods; for example, they need to consider limitations of RCTs associated with ethical aspects, external validity, and time and resources required for their implementation (e.g. Sibbald and Roland 1998; Clay 2010).

Future research efforts may also gain from using a variety of methods, while considering their appropriateness for the context being studied. Because men and women living in poverty greatly differ in their needs and perspectives on problems and because gender equality is a key factor in efforts of design for development, it is crucial to adopt gender sensitive research approaches in design investigations within this field (e.g. Leduc 2009; Cozby and Bates 2012; Musundi et al. 2013). Future work might also benefit from longitudinal methods using diary techniques, observations and other approaches to gain an in-depth understanding of real design projects (e.g. Girón et al. 2004). Additionally, real time methods using verbal protocols (e.g. Jagtap et al. 2014) offer promising opportunities to understand design processes and cognitive behaviours of marginalised producers when they engage in a design activity, while complementing existing retrospective methods.

Besides explorations and improvements in methodological approaches, further research efforts can gain from exploring areas that have not been investigated until now. For example, since many design cases and related design investigations originate from a few specific countries, future studies should broaden the empirical base to other countries, specifically to a range of countries in the ‘Least Developed’ group from the DAC’s categorisation of developing countries (DAC 2016). Given the diversity that exists across developing countries, across rural and urban areas, and across sectors, different design methods and tools are likely to be essential in different marginalised contexts, providing interesting opportunities for further research. For example, Minneman and Leifer (1993) and Bucciarelli (1994) suggest design as a social process, and Smaili (2002) proposes close association between culture and design practice, indicating a need of having design processes and methods suitable for a given context or culture. As such, future studies, for instance, may aim at understanding and supporting design practice in sectors, such as education (e.g. developing and assessing suitable design courses for students in vocational education institutes in developing countries) or



at developing region-specific guidelines to support design for the betterment of marginalised communities in rural and urban regions. As with the gender-sensitive methodological approaches, future research can benefit from developing gender-sensitive design processes or methods to support design practice aimed at both men and women living in poverty.

There are some design approaches for developing products in the context of marginalised societies in developing countries. One approach is to design products remotely, in developed countries or in relatively affluent areas of developing countries, and then simply transferring these products to marginalised communities. This remote design approach, which typically considers poor people as mere recipients of designed products, does not empower them, does not raise their design capability, and does not lead to a positive and sustainable impact on target communities. Designs resulting from such a remote and external design approach are not adopted and used, on a sustainable and continued basis, by marginalised individuals. Although some design tasks might be carried out remotely (e.g. Donaldson 2009), for example, computer simulations to understand physical behaviour of a specific component of a product (e.g. thermal analysis of a part inside a mobile phone), it is important to test products in actual setting. Further research needs to be undertaken to ascertain which design tasks (if any) might be undertaken remotely, without compromising effectiveness of eventually developed product and its sustained and continued adoption by marginalised people. The second approach, namely co-design approach, is more social, and aims at involving disadvantaged people in the design process. Co-design is beneficial both for designers and marginalised people. While it supports designers in gaining insights into the context of marginalised settings, it empowers poor people by enhancing their design capability and supporting their project ownership. Co-design is crucial to enhance acceptance and adoption of products by marginalised communities. Although co-design has been recommended in every stage of the design process, there are few examples of real co-design projects implemented in marginalised communities. Future research may gain from developing and evaluating co-design methods that can be easily and efficiently deployed in real design projects to actively involve marginalised people in every stage of the design process. This can require development of co-design methods specifically tailored for each phase of the design process, e.g. co-design methods for context understanding, concept generation, product implementation, etc. Whilst co-design approach recommends designing with poor people in actual setting, the bottom-up design approach of Viswanathan (2016) begins with remote virtual immersion. The two initial steps of this bottom-up approach, namely virtual immersion and preliminary idea generation and evaluation, which are undertaken prior to actual field work, are

some of its key features. Many different deprivations in the marginalised communities and unfamiliarity of outsiders about poverty demand bottom-up learning and design.

Because poverty and related problems encountered by marginalised communities are multidimensional in nature, they are subjects of research in many disciplines including, among others, development economics, anthropology, political science, etc. (e.g. De Mel et al. 2012; Bell and Newitt 2010; Ravaillon and Chen 2009). As such, in addition to exploring further areas as discussed above, design research in this field can take advantage of relevant knowledge in other disciplines, creating opportunities for cross-fertilization and generating holistic understanding of design practices in this field. Just as multidisciplinary teams are required for designing, developing and implementing products for marginalised communities (e.g. Mattson and Wood 2014; Jagtap et al. 2013), design researchers could engage in multidisciplinary learning or collaborative projects to generate and share knowledge for creating greater impact on design practice in this field.

To summarise, design research in this field has the potential to create impact on practice and education of designing products to satisfy unmet or underserved needs of millions of people living in disadvantaged sections of societies in developing countries, but it would gain from a more rigorous approach. This involves reporting details of the contexts examined and methodologies employed; systematically evaluating design support tools and methods; and recognising the diversity of methodological approaches that can be used (e.g. qualitative, quantitative, longitudinal, real time). It is hoped that this review and scrutiny of the literature in this field will motivate and help design researchers to investigate the discussed and suggested avenues, since they are important for research, education and practice of design in this field.

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