



## **HFU Business School**

Final Report

### **Analysis of the Relationship between Frugal Innovation and Sustainable Development**

#### **Concepts**

**Authors:** Maria Fernanda Quevedo, Nadezda Silkina, Tobias Rapp

**Supervisor:** Prof. Dr. Eva Kirner,

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**II. List of Abbreviations**

AECH	Aravind Eye Care Hospital
ATM	Automated Teller Machine
ECG	Electrocardiogram
etc	Et cetera
GE	General Electric
ICT	Information and Communication Technology
M&M	Mahindra & Mahindra
MB	Megabyte
MDG	Millenium Development Goal
NHH	Narayana Hrudayalaya Hospital
PV	Photovoltaic
SDG	Sustainable Development Goal
USA	United States of America
USD	United States Dollar
V	Volt
W	Watt

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## **Abstract**

The relation between Frugal Innovation and Sustainability is a widely discussed topic in current academic literature. To assess the correlation between these two concepts, a sample of the most frequently mentioned Frugal Innovations was selected. The criteria to evaluate the sustainability potential for each of these cases was built upon the UN Sustainable Development Goals, a global reference indicator. Frugal Innovations among the banking, transport, energy, ICT, water, appliances and healthcare sectors were evaluated. The results suggested a positive contribution and impact of Frugal Innovations towards economic, social and environmental development.

Keywords: Frugal Innovation, Sustainability, UN Sustainable Development Goals, Industry Sectors.



## 1 Introduction

### 1.1 Problem definition

The role of innovation continues to grow in managing sustainable development to meet the needs and aspirations of the present without compromising the ability to meet the needs and aspirations of the future.<sup>1</sup> Innovation considered as one of the key factors in performance on the UN's Strategic Development Goals (SDGs) over the next 15 years.<sup>2</sup> The factors such as resource scarcity, social inequality, the need for a sustainable future, and increasing consumer awareness of environmental issues, have already affected business thinking towards the environment and the society.<sup>3</sup> Lack of resources will inevitably require innovative processes based on the rich interaction of human ingenuity and frugality. The main idea of frugal innovation was to develop products and services at affordable prices that meet special needs and requirements of the poor in the emerging markets.<sup>4</sup> In recent years, however, the concept of frugal innovation has begun to attract the attention of businesses and researchers not only because it is an excellent solution to meet the basic needs of the poor, but also because creating socially valuable products and services open opportunities for business to grow, as they are also commercially viable and profitable.<sup>5</sup>

On the one hand, frugal innovations provide businesses with great opportunities to create new market segments in the developing and emerging countries such as India and China, which have the enormous economic potential due to a presence of 4 to 5 billion<sup>6</sup> underserved people. The competition is increasing among firms fighting for the middle-class consumers in these areas, thus making this market segment the “next global battleground”<sup>7</sup>. Furthermore, the balance of economic power is expected to change dramatically over the next half of century, where the USA concedes its place as the world's largest economy to China in the nearest future and to India over the long-term.<sup>8</sup> In order to succeed in these markets, Western companies should mercilessly reduce their costs and accept their profit margins close to zero.<sup>9</sup> However, the future

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<sup>1</sup> Cf. The International Institute for Sustainable Development (2018)

<sup>2</sup> Cf. Universities South Africa (2016)

<sup>3</sup> Cf. Khan, S./Haldar O. (2015), p.1

<sup>4</sup> Cf. Weyrauch, T./Herstatt, C. (2016)

<sup>5</sup> Cf. Khan, S./Haldar O. (2015), p.1

<sup>6</sup> Cf. Prahalad (2010), p. 21

<sup>7</sup> Zeschky et al. (2011), p.20

<sup>8</sup> Cf. Basu et al. (2013)

<sup>9</sup> Cf. The Economist (2010b)

opportunities promote escaping stagnation in demand at home, the creation of new and profitable revenue streams, and finding a competitive advantage. The satisfaction of the needs of the low-income customers through affordable products and services will promote the sustainable economic growth where all participants benefit.<sup>10</sup>

On the other hand, it is increasingly acknowledged that human activities have been detrimental to economic, environmental, and social aspects of sustainable development. This increase concerns that the damage to the environment and quality of life for future generations would be irreparable. According to the report of the United Nations, 767 million people live below the international poverty line of \$1.90 a day, 55 percent of the population have a lack of an effective social protection system, and the only 28 percent of people with severe disabilities collected disability benefits.<sup>11</sup> In the presence of resource scarcity, social and gender inequality, the high proportion of undernourished people, and water scarcity, frugal innovation can be considered as an excellent solution to meet the needs of the poor and support sustainable development.

Despite growing interest in both cost-effective innovation and sustainable development concepts, and growing awareness of the potential of frugal innovation to promote sustainable development goals, the connection between frugal innovation and sustainability society has not been discussed to a large extent in the existing literature. There is still a lack of empirical evidence to support their relationship.

## 1.2 Research Objectives

The objective of this research is to contribute to existing studies in identifying the connection between two concepts. Our research question is: Are Frugal Innovation and Sustainability correlated? Previous studies analyzed the relationship by using a limited number of cases or the limited number of industries. The current analysis includes 29 frugal innovations from seven sectors in order to establish the connection between frugal innovation and sustainability more precisely.

The remainder of this article is structured as follows: the next section provides a comprehensive literature review of the relevant streams of studies with focusing on reviewing the results of previous research. The overview of frugal innovation and sustainable development goals will be described in section two. In section three, we explain the methodological approach and

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<sup>10</sup> Cf. Eyring et al. (2011)

<sup>11</sup> Cf. The United Nations (2017), p.3

describe selected cases. The findings of the analysis are outlined in section four, including a discussion of all characteristics of selected frugal innovations which promote social, economic and environmental pillars of sustainable development. Furthermore, in this section, we link the selected innovations in each sector to particular sustainable goals. Thereby, the researchers will evaluate a tendency of promoting social, environmental and economic systems through frugality by determining the proportion of cases for each SDG. The conclusion and limitations are contained in section five. Visualization of the results is presented in the Appendix.

### 1.3 Literature Review

Literature analysis has revealed some studies that are already trying to establish a connection between frugality and sustainability, and evaluate this relationship. Khan and Haldar (2015) find out that a lack of resources and a presence of forces to cost minimization push companies to create socially valuable products, which meet needs of customers at the base of the pyramid. By analyzing a few cases of frugal innovations, the researchers concluded that a sustainable development could be archived through frugality. Furthermore, frugal innovations reduce socio-economic inequality, shortage of resources, and the problem of sustainability. Thereby, the frugal innovation concept can contribute to the sustainable growth of emerging and developing countries such as India and China.<sup>12</sup> Khan (2016) determined a relationship between frugal innovations and social sustainability, which is one of the fundamental components of sustainable development. The author discussed the social benefits provided by frugal innovation to the society. By reducing inequality, meeting the basic needs of the poor, building social inclusion, and creating the capacity for education, frugal innovation significantly contributes to the social pillar of sustainable development.<sup>13</sup> Levänen et al. (2016) have analyzed frugal innovations of water and energy sectors, and have found that the capacity of the innovations in terms of energy production and water purification are more sustainable than existing solutions. The authors drew attention to limitations in the measurement of frugal innovation sustainability and material efficiency, as well as noted the importance of establishing tools that are more effective for analysis of the relations between frugal innovations and sustainable development.<sup>14</sup> Rosca et al. (2017) highlighted that frugal innovations do not have an inherent impact on sustainability. Different sustainability archetypes relate to the different direction of innovation.

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<sup>12</sup> Cf. Khan, S./Haldar. O (2015)

<sup>13</sup> Cf. Khan, R. (2016)

<sup>14</sup> Cf. Levänen et al. (2016)

The social impact of frugal innovations can be significant by providing basic products and services in different sectors to low-income customers in emerging markets, at very low prices and good-enough quality. Through the effective use of local materials, frugal innovations create ecological value for society.<sup>15</sup> Hyvärinen et al. (2016) looked at potentials and pitfalls of frugal innovations in the water sector. The researchers focused on the sustainability implication through value chains of frugal innovations. The results illustrate that a frugal innovation approach can allow organizations to find new opportunities for innovation and its effect on product development for new market segments. Furthermore, the researchers concluded that considered innovations have a clear potential to contribute towards sustainable development.<sup>16</sup>

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<sup>15</sup>Cf. Rosca et al. 2017, p.144

<sup>16</sup>Cf. Hyvärinen et al. (2016), p.12

## 2 Definitions

### 2.1 Frugal Innovation

This paper adheres to the definition of Frugal Innovation by Hossain et al. which defines the phenomenon “as a product, service or a solution that emerges despite financial, human, technological and other resource constraints, and where the final outcome is less pricey than competitive offerings (if available) and which meets the needs of those customers who otherwise remain un-served”<sup>17</sup>.

### 2.2 Sustainable Development

All literature and findings in this paper will be based on the definition of Sustainable Development from the “World Commission on Environment and Development from the United Nations”. In this context, sustainable development is understood and defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”<sup>18</sup>. The concept is understood as the interception of three key dimensions: Ecological, Social and Economic Development.<sup>19</sup>

### 2.3 Conceptual Discussion

Throughout the years, policy-makers, scholars, and practitioners, in general, have understood and defined both concepts (frugal innovation and sustainable development) in various ways. Definitions for both concepts are still under great debate and both lack a clear conceptualization in which all stakeholders agree.<sup>20</sup>

In relation to the Frugal Innovation concept, certain articles suggest that its definition is based on the attributes of the frugal innovation such as accessibility, user-friendliness, easy instructions, offered at a significantly lower cost than its alternatives, less environmentally damaging, etc.<sup>21</sup>. Other articles seek to develop frameworks to differentiate frugal innovations from concepts as low-cost innovation, frugal engineering, jugaad innovation, or reverse

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<sup>17</sup> Hossain et al. (2013)

<sup>18</sup> World Commission on Environment and Development (1987)

<sup>19</sup> Cf. United Nations (2010)

<sup>20</sup> Cf. Hossain, Mokter (2017)

<sup>21</sup> Cf. Weyrauch, T./Herstatt, C. (2016)

innovation.<sup>22</sup> Even though a uniform criterion for defining the concept has not been reached, the variety of current available definitions act as an approach to understanding the frugal innovation phenomenon.

On the other hand, sustainability is regarded as an inherently vague concept<sup>23</sup> with lack of clarity by some researchers. Attempts to create a single definition or a unified model for sustainability assessment have been carried out in different areas of academia, however, as a complex concept, these usually have presented differences on the variables included into the analysis. For instance, some of these evaluations have included a political component meanwhile others have not, or some models have considered environmental elements such as land, water, and air into the assessment while leaving the waste component outside of the equation.<sup>24</sup>

In general, sustainability assumes that resources are scarce and finite, and thus, should be used with moderation and mainly focusing on long-term priorities.<sup>25</sup>

As an effort to operationalize the concept of Sustainable Development and with the intention of creating a set of common guidelines at the global level, the United Nations drafted the Millennium Development Goals (MDGs) in the year 2000.<sup>26</sup> The initiative resulted in mixed opinions regarding the achievement of the MDGs. In 2015, the Sustainable Development Goals (SDGs) replaced the MDGs at the UN Sustainable Development Summit in New York. The SDGs are a list of 17 goals that focus on developing and industrialized countries and should be achieved by 2030.<sup>27</sup>

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<sup>22</sup> Cf. Weyrauch, T./Herstatt, C. (2016)

<sup>23</sup> Cf. Phillis, Y./Andriantiatsaholiniaina, L. (2016)

<sup>24</sup> Cf. Phillis, Y./Andriantiatsaholiniaina, L. (2016)

<sup>25</sup> Cf. Levänen, J. et al. (2015)

<sup>26</sup> Cf. UN Sustainable Development (2018)

<sup>27</sup> Cf. UN Sustainable Development (2018)

### 3 Methodology

#### 3.1 Data Collection

The research was carried out through analysis of secondary-data with two purposes: First, to select the most commonly mentioned cases of Frugal Innovations in academic literature and second, to assess the capacity of each of these Frugal Innovations to promote the SDGs.

To select Frugal Innovation cases, the EBSCO Host and Science Direct Databases were the only channels used. For the assessment of sustainability, research was carried out on online articles, websites and databases.

#### 3.2 Case Selection

The selection of cases was based on the top 30 most mentioned frugal innovations in literature as mentioned in the “Mapping the Frugal Innovation Phenomenon” article by Hossain (2017)<sup>28</sup>. Appendix one shows the selected cases. Two cases were excluded from the analysis due to lack of information for the particular model in mention (Logitech Mouse and Nokia 101). Since the 28 resulting Frugal Innovations have surged in China and India, and with the objective to include a Frugal Innovation from Germany into the analysis, the researchers counted “Sono Motors Sion”, as an additional case to consider. In total, 29 Frugal Innovations were examined.

#### 3.3 Criteria to Evaluate Sustainability and Framework

In this study, the criteria to evaluate sustainability was based on the Sustainable Development Goals by the United Nations as they represent a concise common reference of sustainability for all countries. The list of 17 SDGs is presented in Appendix two.

To analyze the selected frugal innovations under the lens of sustainability, data was analyzed through a framework based on the article “Implications of Frugal Innovations on Sustainable Development: Evaluating Water and Energy Innovations” by Jarkko Levänen et al. (2015)<sup>29</sup>. The framework is displayed in Appendix 3. The objective of the framework is to evaluate each frugal innovation through the Ecological (Energy Saving, Material Efficient, Climate Neutral),

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<sup>28</sup> Cf. Hossain, M. (2017)

<sup>29</sup> Cf. Levänen, J. et al. (2015)

the Social (Fulfillment of Basic Necessities, Improves Health and Education, Promotes Inclusion and Equality) and the Economic (Time Saving, Increases Income or Saves Money, creates new Jobs) dimensions and to link them to the SDGs.

The evaluation of the cases proceeded in four stages. First, the researchers analyzed the information and understood how the frugal innovation worked. Second, the cases were analyzed and information was gathered for each of the three sustainable dimensions; if the frugal innovation had a positive impact, a “+” value was given, for a neutral or unclear impact a value of “0” was given and for a negative impact a value of “-“ was written. Additionally, the researchers assigned the SDGs considered applicable for each characteristic. Third, the findings were discussed by all researchers and adjustments were made if necessary.

### 3.4 Data Presentation

Findings are described in detail in Section five and in Tables in the Appendix.



## 4 Presentation of the Cases

### 4.1 Banking Sector Overview

First of all, it is important to take a closer look at the banking sector. In general, banks are central to modern economies, because they manage money from savers and provide it as a loan to other actors, such as companies and individuals whose own resources are insufficient.<sup>30</sup> In this function, banks make a significant contribution to the functioning of the economic cycle. Banks act as mediators between those who save and those who invest.<sup>31</sup> In doing so, they perform three main functions: the transformation of amounts, risks and deadlines.<sup>32</sup>

Another important economic function of banks is that they generally select their borrowers in their own interest which is namely the repayment of the debt plus interests. In this way, they ensure that money flow into the most productive use possible and thus also influence the implementation of future-oriented investments.<sup>33</sup>

In view of the objectives of this paper, namely the impact of frugal innovation in terms of sustainability, the main focus is on the banking sector and the banking system in developing countries. To this end, six different innovations were considered for this sector. They are all located on the Asian and African continents.

#### 4.1.1 M-Pesa

*M-Pesa* is a system developed by the Kenyan mobile phone company “Safaricom” in cooperation with the communications company “Vodafone” and introduced in Kenya at the beginning of 2007 to handle the basic functions of money transfer and cashless payment via mobile phones without the need for a regular bank account.<sup>34</sup> In fact, the “M” stands for mobile and “Pesa” is the Swahili word for cash or money.<sup>35</sup> A key point is that this service improves liquidity management in rural areas.<sup>36</sup> *M-Pesa* is expanding rapidly and is now also represented in Tanzania and South Africa, but also in the Democratic Republic of the Congo and since 2013 in India.<sup>37</sup>

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<sup>30</sup> Cf. Andreasen, M. et al. (2012), p. 5f.

<sup>31</sup> Cf. European Central Bank (2015), p. 1f.

<sup>32</sup> Cf. Segura, A./Suarez, J. (2017), p. 3538f.

<sup>33</sup> Cf. Al Ani, M./Hussien, M (2018), p. 51f.

<sup>34</sup> Cf. Hughes, N./Lonie, S. (2007), p. 63

<sup>35</sup> Cf. Verhoef, G. (2017), p. 154

<sup>36</sup> Cf. Ashta, A. (2011), p. 161f.

<sup>37</sup> Cf. Ford, N. (2017), p. 38f.

#### 4.1.2 Vortex ATMs

“Vortex Engineering Private Limited” is an Indian manufacturer of Automated Teller Machines (ATMs) and provides also related services for banks.<sup>38</sup> Compared to conventional ATMs, the *Vortex ATMs* consume less power and have fewer mechanical and electrical parts.<sup>39</sup> In addition, the *Vortex ATMs* come with solar power options for better availability in rural areas with severe power failures and are therefore suitable to promote the financial inclusion of the unbanked population in rural and semi-urban areas.<sup>40</sup> Another aspect of these areas is a high level of illiteracy and therefore the *Vortex ATMs* have an integrated fingerprint sensor so that an identification number does not necessarily have to be entered.<sup>41</sup> Thus, the *Vortex ATM* consumes only 10% of the energy of a comparable and conventional ATM since no separate air conditioning is needed.<sup>42</sup> As a result, around 18,500 kg of CO<sub>2</sub> emissions can be reduced each year.<sup>43</sup> All in all, operating costs can be cut by half compared to a conventional ATM and therefore the operation is more profitable.<sup>44</sup> Another advantage and expression of the adaptation to the critical requirements of the environment is the issue of crumpled and soiled banknotes, since in remote areas the supply of freshly printed banknotes is usually not guaranteed.<sup>45</sup>

#### 4.1.3 Grameen Bank’s Microfinance

The “Grameen Bank” provides loans of only a few hundred USD (in the local currency) to poor households in rural areas of Bangladesh.<sup>46</sup> This loan opens up new possibilities. Financial resources and services are available to poor people in rural areas at reasonable terms and conditions.<sup>47</sup> As a result, socially disadvantaged people have the opportunity to start their own business or to take on new job opportunities. Women, in particular, take advantage of this opportunity to self-employment and gain access to start-up capital, which is why micro-finance is a tool for empowering women.<sup>48</sup> In fact, at the end of 2017, “Grameen Bank” had 8.97 million micro-finance contracts, with 97% of the borrowers being women.<sup>49</sup> The business model of

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<sup>38</sup> Cf. Vortex Engineering (2018a)

<sup>39</sup> Cf. Vortex Engineering (2018b)

<sup>40</sup> Cf. Tiwari, R./Herstatt, C. (2013), p. 74 and cf. Vortex Engineering (2018b)

<sup>41</sup> Cf. Vortex Engineering (2018c)

<sup>42</sup> Cf. Shivapriya, N. (2010) and cf. Simhan, T.E. (2012)

<sup>43</sup> Cf. India Brand Equity Foundation (2012)

<sup>44</sup> Cf. Mittal, V. (2012) and cf. Kannan, L. (2016)

<sup>45</sup> Cf. Tiwari, R./Herstatt, C. (2012), p. 17f. and cf. India Brand Equity Foundation (2012)

<sup>46</sup> Cf. United Nations (2017) and cf. Grameen Bank (2018a)

<sup>47</sup> Cf. Grameen Bank (2018b)

<sup>48</sup> Cf. Marcillo, M. (2017), p. 42f.

<sup>49</sup> Cf. Grameen Bank (2018b)

Professor Yunus, founder of the “Grameen Bank”, is therefore based on the socio-economic development of the poor through the provision of financial resources at reasonable conditions.<sup>50</sup>

#### 4.1.4 Easypaisa

Launched in 2009 in Pakistan, *Easypaisa* offers a simple and fast payment service based on a mobile phone account or over-the-counter transactions and therefore a safe and convenient way of transferring money.<sup>51</sup> The main objective of *Easypaisa* is the financial inclusion of the Pakistani population, who previously had no opportunity to meet their financial needs, as well as bank-related services such as health insurance.<sup>52</sup> In cooperation with the “Telenor Microfinance Bank”, small credits are also brokered to customers with the aim of mutually exploiting synergies with regard to customer base and branch network.<sup>53</sup> As a result, *Easypaisa* has a growing presence of over 70,000 merchants throughout Pakistan and also offers many employment opportunities to the population.<sup>54</sup>

#### 4.1.5 Rickshaw Bank Project

In India, rickshaws meet the need for urban and sub-urban mobility in the middle and lower middle classes of the population.<sup>55</sup> According to the “Centre of Rural Development”, 95% of rickshaws are hired by rickshaw-pullers from merchants, as they have neither appropriate savings or access to loans.<sup>56</sup> The *Rickshaw Bank Project* addresses this issue by developing a new rickshaw on the one hand through the India Institute of Technology, using lighter materials and aerodynamic approaches, and on the other hand, providing state-subsidized loans for the rickshaw-pullers with included insurance.<sup>57</sup> This will support ownership and it will undercut a sustainable model to alleviate poverty.<sup>58</sup>

#### 4.1.6 EKO Mobile Phone Banking

In 2007, “Eko India Financial Services Private Limited” was established to facilitate the

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<sup>50</sup> Cf. Kadvekar, S. (2016), p. 387 and cf. Pande, S. (2015), p. 34f.

<sup>51</sup> Cf. Hussain, N. (2013)

<sup>52</sup> Cf. Easypaisa (2018)

<sup>53</sup> Cf. Mithe, A. (2015), pp. 9-13

<sup>54</sup> Cf. Easypaisa (2018)

<sup>55</sup> Cf. Centre for Rural Development (2018)

<sup>56</sup> Cf. Sarma, N. (2011), p. 134f.

<sup>57</sup> Cf. Poirier, Y. (2009)

<sup>58</sup> Cf. Kalita, K. (2013)

possibility of financial transactions for the unbanked population of India.<sup>59</sup> Any commercial mobile phone can be used to provide these basic banking services, and thus the advantage of *Eko* is simplicity, security, and speed.<sup>60</sup> The focus is therefore on the use of a multiple-used device - a mobile phone - in order to allow the unbanked population, the ability to do simple financial transactions.<sup>61</sup>

## 4.2 Transport Sector Overview

Transport plays an important role in today's world - both for the economy and for society. Therefore, an efficient transport system, via cars and trucks or generally the transport of people or goods, is essential for a functioning economy.<sup>62</sup> This also includes the financial aspects of the transport systems as well as their compatibility with respect to ecological aspects, which also interact with each other.<sup>63</sup> Urbanization and the growing world population are confronting the transport system with challenges in terms of transport infrastructure as well as carbon dioxide emissions.<sup>64</sup> Furthermore, the development of more fuel-efficient or new powertrains, as well as the development of renewable fuels, are of great importance with regard to the transport sector and thus the carbon dioxide emissions.<sup>65</sup> In fact, greenhouse gases, which are specifically attributable to the transport sector, have more than doubled since the 1970s.<sup>66</sup> Therefore, the following special attention is paid to the frugal innovations of the transport sector. These are mainly from developing countries and thus from those countries where the highest demand for vehicles will exist in the coming years.<sup>67</sup>

### 4.2.1 Tata Nano

The *Tata Nano* is a subcompact two-door and four-seater car of the Indian automobile manufacturer "Tata Motors" and has been sold since 2009, mainly in the destination market India.<sup>68</sup> The vehicle was advertised and sold as a "people's car", as it had about half the price

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<sup>59</sup> Cf. Eko India Financial Services (2018)

<sup>60</sup> Cf. Chen, G. (2012)

<sup>61</sup> Cf. Ranganathan, K./Kapoor, A. (2014), p. 143f.

<sup>62</sup> Cf. European Commission (2018)

<sup>63</sup> Cf. Neves, S. et al. (2017), p. 64

<sup>64</sup> Cf. Lin, B./Omoju, O. (2017), p. 331

<sup>65</sup> Cf. Shafiei, E. et al. (2017), p. 237

<sup>66</sup> Cf. Broin, E./Guivarch, C. (2017), p. 389 and cf. Worldbank (2014)

<sup>67</sup> Cf. Kalkman, J. et al. (2013), p.20f.

<sup>68</sup> Cf. Shafiulla, B. (2014), p. 80f.

compared to the direct competition at that time.<sup>69</sup> In fact, the *Tata Nano* cost 100,000 rupees plus tax at launch, which was about 2,000 US-Dollars (USD) at that time exchange rate.<sup>70</sup> The car has only the bare minimum for the cost-cutting strategy, for example, no radio, no air conditioning or just a windscreen wiper.<sup>71</sup> The *Tata Nano* seeks to improve the quality of life of the Indian population, who were exposed daily to the dangers and the dirty and bad roads on their two-wheelers.<sup>72</sup>

#### 4.2.2 Mahindra & Mahindra's tractor Yuvraj 215

“Mahindra & Mahindra Limited” (M&M) is an Indian mixed company and the group manages its businesses in ten segments, whereas the automotive, farm equipment and steel trading segments being among the largest.<sup>73</sup> The case we are looking at is a tractor model called *Yuvraj 215*, which was launched in 2012.<sup>74</sup> In the automotive sector, “M&M” has a leading role on the Asian continent but is the world's largest tractor producer by volume.<sup>75</sup> “M&M” dominates the Indian tractor market, and the *Yuvraj 215* is considered to be inexpensive and, due to its innovative base-function design, is versatile and ideal for small-scale farmers wishing to be more productive.<sup>76</sup>

#### 4.2.3 Sono Motors Sion

“Sono Motors” is included in this paper because it is a novel case and reflects the objective of this elaboration with its characteristics and features. However, it is also the only case that has not yet received any scientific mention due to its actuality and novelty. The Munich-based company was founded in 2016 and has spent the protection of the environment as the most important goal.<sup>77</sup> The first model, the electric car *Sion*, will be launched in 2019 and can already be pre-ordered.<sup>78</sup> In terms of conception, “Sono Motors” is breaking new ground in many respects; for example, the *Sion* is manufactured with partly sustainable and lightweight

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<sup>69</sup> Cf. Kalla, N. (2015), pp. 47-50

<sup>70</sup> Cf. Thomson Reuters (2009)

<sup>71</sup> Cf. Kurczewski, N. (2009)

<sup>72</sup> Cf. Kalla, N. (2015), p. 47

<sup>73</sup> Cf. MarketLine (2017), p. 3

<sup>74</sup> Cf. Chetan, K. (2012)

<sup>75</sup> Cf. MarketLine (2017), p. 4 and cf. Bloomberg Businessweek (2013), p. 17f.

<sup>76</sup> Cf. Chetan, K. (2012) and cf. Sharma, N./Khatti, V. (2013), p. 44 and cf. Mahindra Tractor (2018)

<sup>77</sup> Cf. Sono Motors (2018a)

<sup>78</sup> Cf. Sono Motors (2018b)

materials in a CO<sub>2</sub> neutral production, has solar modules and is designed for durability.<sup>79</sup> The business model also includes maintenance and repair services and further mobility concepts.<sup>80</sup>

#### 4.2.4 Tata Ace

The *Tata Ace* was designed by the Indian automobile manufacturer “Tata Motors” as a small four-wheeled commercial vehicle as a competitor for the market of three-wheeled commercial vehicles and can transport loads up to 0.75 tons.<sup>81</sup> At the launch in 2005, the *Tata Ace* cost the equivalent of USD 4,000 (then exchange rate) and was about half cheaper than other four-wheeled commercial vehicles in India at that time.<sup>82</sup> Therefore the *Tata Ace* has shaped a new vehicle category and has successfully filled these niches through the efficient use of ingenuity and materials.<sup>83</sup> In summary, the small truck was well suited to the needs of customers and Indian road traffic, as it was robust, easy to maintain and the characteristics of low cost and simple technology.<sup>84</sup>

### 4.3 Energy Sector Overview

Energy is essential for developing a sustainable and productive society as it provides input for our economic activities, it adds positive factors to social development and acts as a necessary resource to meet human needs.<sup>85</sup> However, this sector lacks development in growing economies worldwide. Inhabitants of rural villages from developing countries usually have no access to energy sources in their households. In several occasions, energy access is only possible through polluting methods or energy sources are located in areas far away from the place of origin of the underserved population.<sup>86</sup>

#### 4.3.1 Husk Power Systems

*Husk Power Systems* was founded in 2007 in the Indian State of Bihar with the objective of

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<sup>79</sup> Cf. Sono Motors (2018c) pp. 2-14 and cf. Sono Motors (2018a)

<sup>80</sup> Cf. Conrad, B. (2018) and cf. Sono Motors (2018c) pp. 2-14

<sup>81</sup> Cf. Tiwari, R./Herstatt, C. (2014), p. 96f.

<sup>82</sup> Cf. Freiberg, K. et al. (2012), p. 87

<sup>83</sup> Cf. Palepu, K./Srinivasan, V. (2008), p. 1f. and cf. Tiwari, R. et al. (2014), p. 6

<sup>84</sup> Cf. Khanna, T./Palepu, K. (2010), p. 136f.

<sup>85</sup> Cf. Matheson, G./Giroux, L. (2011)

<sup>86</sup> Cf. Matheson, G./Giroux, L. (2011)

providing power to people from rural parts in India<sup>87</sup>. Through the implementation of cost-effective technology, the startup developed a way of generating electricity by creating fuel from crop waste, specifically, rice husks.<sup>88</sup>

#### 4.3.2 SELCO

*SELCO*, a social enterprise from India, was established in 1995 with the aim of providing energy solutions to the underserved population<sup>89</sup>. The product they offer comprises a package of fluorescent lights for the household that work with electricity generated by a small PV (photovoltaic) module and by a lead-acid battery that ensures uninterrupted power by storing electricity<sup>90</sup>. They also offer the installation service (product generally placed on rooftops) and as a third element, they also offer financing packages for low-income customers through agreements with local banks.<sup>91</sup>

### 4.4 ICT Sector Overview

The world is currently facing an era of Digital Transformation and it affects the Information and Communication Technology Sector through rapid changes that allow people to have access to better and improved ways of communicating. As a result of technology advancements in this area, bridges for development are built.<sup>92</sup> Nevertheless, keeping up with the fast pace at which these technologies appear is quite a challenge for developing countries, where a majority of the population needs access at a significantly lower price.<sup>93</sup>

#### 4.4.1 Aakash Tablet

Under the awareness that affordability constitutes a critical issue for connectivity, particularly in rural India, the *Aakash* Tablet was launched in 2011<sup>94</sup>. Following an initiative promoted by the Indian Government to link academic institutions into an e-learning program, the company Datawind manufactured this low-cost tablet that could be afforded by students at a price as low

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<sup>87</sup> Cf. Husk Power Systems (2018)

<sup>88</sup> Cf. Husk Power Systems (2018)

<sup>89</sup> Cf. SELCO Solar (2008a)

<sup>90</sup> Cf. SELCO Solar (2008a)

<sup>91</sup> Cf. SELCO Solar (2008a)

<sup>92</sup> Cf. Kathuria, V. (2016)

<sup>93</sup> Cf. Kathuria, V. (2016)

<sup>94</sup> Cf. Datawind (2016)

as USD 35.<sup>95</sup> The initial version of *Aakash* was a 7-inch touch screen with 256 MB RAM, an ARM 11 processor and high-definition video. In addition, it was powered by an Android operating system and had a weight of 350 grams.<sup>96</sup>

#### 4.4.2 Bharti Airtel

With over 413 million customers as of 2017, *Bharti Airtel* is known as one of the largest mobile network operators in India and provides connectivity-related services in more than sixteen countries in Asia and Africa.<sup>97</sup> Founded in 1995, its target was to generate high-volume revenue by providing low-cost mobile services therefore, the company pioneeringly adapted the strategy of outsourcing all business operations with the exception of marketing, sales and finance.<sup>98</sup> Through the implementation of this strategy, which allowed them to reduce costs, *Bharti Airtel* started offering low call rates starting at USD 0.015 cents per minute. The company's equipment and IT maintenance are provided by firms as Ericsson, Nokia, IBM and Huawei.<sup>99</sup>

#### 4.4.3 Nokia 1100

Even though it was launched in 2003<sup>100</sup>, when mobile phones already had features like a color-screen, audio files and an internal camera, the popularity of the *Nokia 1100* rose unprecedentedly due to the fact that it was oriented towards developing countries and it was designed for users that did not require these advanced features.<sup>101</sup>

#### 4.4.4 Micromax X1i

By creating a revolutionary product category with the aim of improving communication for the inhabitants of rural villages without access to electricity in India, Micromax launched the *X1i phone*. The main characteristic of the *X1i* model is its capacity to run for a month (or longer) without needing to recharge it<sup>102</sup>. This unique characteristic was achieved by increasing the battery's size to 1800 mAh. Additionally, it was offered at an accessible price of USD 32, which

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<sup>95</sup> Cf. Datawind (2016)

<sup>96</sup> Cf. Datawind (2016)

<sup>97</sup> Cf. Airtel India (2018a)

<sup>98</sup> Cf. Airtel India (2018a)

<sup>99</sup> Cf. Airtel India (2018a)

<sup>100</sup> Cf. Thomson Reuters (2007)

<sup>101</sup> Cf. Thomson Reuters (2007)

<sup>102</sup> Cf. Joseph, L. (2011)



turned it into an instant success within people from Indian rural towns.<sup>103</sup>

#### 4.4.5 Vodafone VF247

In 2010, Vodafone launched a solar-powered handset that charges by itself through exposure to ambient light.<sup>104</sup> The *VF 247* model can also be charged inside a room (under normal daylight) because of its special inbuilt software and hardware characteristics. The integrated solar-powered battery has a long duration and it was offered to the public at a price of USD 32<sup>105</sup>. The cellular phone service is sold through pre-paid vouchers for as low as USD 0.2.<sup>106</sup> The model provides all essential mobile phone features including a color screen, FM Radio, speakerphone, flashlight and a mini solar panel.<sup>107</sup>

### 4.5 Healthcare Sector Overview

An important element of building prosperous societies is an access to healthy lives and wellbeing for everyone and at all ages. Although much progress has been made in recent years in improving access to health care and well-being, however, inequalities persist. Worldwide, more than six million babies die before their fifth day of life every year. Only half of all women in developing countries have access to health care.<sup>108</sup> A high percentage of China's population get a health care in poorly funded, low-tech hospitals or basic clinics in rural villages.<sup>109</sup>

#### 4.5.1 Aravind Eye Care Hospital (AECH)

Established in 1976 by Dr. Venkataswamy, the hospital began its activities with only eleven beds. Currently, it is the largest provider of eye care in the World who provides treatment to rich and poor. To provide free medical care of world-class quality to the poor people, *AECH* reduced costs of cataract surgeries by focusing on paraskilling, innovations in the organizational of working processes and massive scale. For instance, the efficiency of doctors improved by reducing the time between surgeries, while doctors are operating one patient, nurses are

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<sup>103</sup> Cf. Joseph, L. (2011)

<sup>104</sup> Cf. Mobile Scout (2010)

<sup>105</sup> Cf. Mobile Scout (2010)

<sup>106</sup> Cf. Mobile Scout (2010)

<sup>107</sup> Cf. Mobile Scout (2010)

<sup>108</sup> Cf. The United Nations (2018a)

<sup>109</sup> Cf. Immelt, J. et al. (2009), p. 63

preparing the next one. *AECH* performs around four million eye surgeries, the significant amount of which are free.<sup>110</sup>

#### 4.5.2 Narayana Hrudayalaya Hospital (NHH)

Founded in 2000 by Devi Shetty, *NHH* today is a provider of world-class cardiac care at radically low costs. Heart surgery cost between USD 2,000 and USD 5,000 instead of USD 20,000–100,000 of the same operation in the United States. *NHH*'s business model enables to finance operations for the poor at the expense of full-price paying patients. The cost reduction achieved by minimization of involvement of surgeons to only very complex elements of heart surgery, while other tasks as preparation and paperwork performed by less expensive staff. Additionally, *NHH* cuts its costs by leasing equipment and reducing building costs, fixing salaries of surgeries instead of compensating them per surgery and performing a high volume of surgeries.<sup>111</sup>

#### 4.5.3 Jaipur foot

Developed in 1968 by Professor P.K. Sethi, *Jaipur foot* was designed to simulate normal foot movements and meet the needs of poor to the active lifestyles such as squatting, walking and sitting. The average cost *Jaipur foot* including prosthesis and fitting is USD 30, unlike the cost of a prosthetic foot in the USA starts from USD 2,700. In contrast to most orthopedic centers, where patients must come back several times for customization, the customization process of *Jaipur foot* completes in three or four hours in one day. *Jaipur foot* is a suitable solution for the poor patients who should not return a second time from long distances.<sup>112</sup>

#### 4.5.4 Mac 400 – GE Handheld Electrocardiogram (ECG)

*MAC 400* – called as “a masterpiece of simplification”. It is a small and portable electrocardiogram like an average laptop launched in 2008 by GE Healthcare. The device construction has less plastic, smaller LCD screen, and lower material costs. Its price is USD 1500 compared with USD 10,000 of its ancestor, thus enables to reduce the cost of an ECG examination to just USD 1 per patient. The electrocardiogram works on battery power that

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<sup>110</sup> Cf. Khan, R. (2016), p. 13

<sup>111</sup> Cf. Khan, R. (2016), p. 15

<sup>112</sup> Cf. Prahalad (2010), pp. 243-264

enough to take up to 100 images and can be used in rural areas without power supply.<sup>113</sup>

#### 4.5.5 GE Portable Ultrasound machine – Vscan

*Vscan* is a handheld and easy to use ultrasound device, launched in 2008, which enables healthcare specialist to assess and accelerate treatment decisions at the point of care. The producer reduced the cost by almost 85%, compared with a low-end traditional ultrasound device at that time<sup>114</sup>. Due to the small size and battery operation, *Vscan* enables doctors to check patient health at home or at an accident site. The performance level meets the needs of clinics in rural areas in emerging markets and needs of quick diagnosis in developed markets.<sup>115</sup>

#### 4.5.6 Embrace Baby Warmer

Looking like a miniature sleeping bag the *Embrace Baby Warmer* launched in 2011 and made from phase-change material initially developed for NASA spacesuits. The quality of textile enables to retain heat by utilization babies' body heat and release it when the infants get hot. After heating for approximately 30 minutes, the warmer saves an optimal temperature for six hours. It is the great solution for hospitals and parents in areas with electricity shortage. Whereas a cost of a conventional incubator is above USD 15,000, a cost of *Embrace Baby Warmer* is an average USD 25.<sup>116</sup>

#### 4.5.7 GE's Lullaby baby warmer

A low-cost and high-performance baby incubator, launched by GE Healthcare in 2003, provides sick infants a warmth and allows doctors easy access to babies and their health examination. The novel technology is available and affordable basically for any healthcare facility. Its price is 70% less than the price of conventional baby warmers. It consumes 50% less electricity and can be used in unstable power supply conditions.<sup>117</sup>

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<sup>113</sup> Cf. The Economist (2010a)

<sup>114</sup> Cf. Weyrauch and Herstatt (2016), p.11

<sup>115</sup> Cf. Weyrauch and Herstatt (2016), p.11

<sup>116</sup> Cf. Narang, S./Balasubramanyam,K. (2013)

<sup>117</sup> Cf. Asia Pacific Biotech News (APBN) (2009)

## 4.6 Water Sector Overview

Water plays an essential role in human well-being, health, and life, and therefore is a key factor for sustainable development. Billions of people have a limited access to water resources or to basic sanitation. The solution to these huge water problems lies not only at the level of business but also at the individual level. Access to safe water and acceptable sanitation affects food security, reduces poverty, provides educational opportunities for poor families around the world, it improves their social well-being and sustainable livelihoods.<sup>118</sup>

### 4.6.1 Tata Swach

Launched in 2009 by Tata Chemical, *Tata Swach* filter became one of most inexpensive water purifiers in the world. The device does not require electricity or running water, thus people with low-income or who live in the area with a lack of access to electricity can benefit from the product. Nanotechnology and rice husk are the key to its treatment technology which allows to eliminate bacteria and viruses from water and provide safe drinking.<sup>119</sup>

### 4.6.2 Hindustan Unilever Pureit

The *Pureit Classic* was launched in 2008 by Hindustan Unilever (HUL) purifier in India. The filtration process is based on a gravity-driven “table-top” system that operates without electricity or running water. A four-stage purification process includes a microfiber mesh, a carbon filter, a chlorine dispenser “Germkill Kit” and a carbon polisher. These four main components allow to decrease a larger amount of particles, certain protozoan parasites, sanitize water and remove excess chlorine and chlorination by-products. The technologies used meet the strict international criteria of the U.S. Environmental Protection Agency (USEPA) for the elimination of harmful viruses and bacteria.<sup>120</sup>

## 4.7 Appliances Sector Overview

In order to ensure a decent life for the population, they must have access to basic needs services in appropriate quantity and quality to guarantee their survival and satisfy the human right to

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<sup>118</sup> Cf. The United Nations (2018b)

<sup>119</sup> Cf. Levänen, H. et al. (2016), p.5

<sup>120</sup> Cf. Levänen, H. et al. (2016), p.6

“life with dignity”.<sup>121</sup> An access to affordable washing machines, refrigerators, and other appliances meet this requirement.

#### 4.7.1 ChotuKool

*ChotuKool* is portable and battery-powered refrigerator launched in 2010 by “Godrej & Boyce” manufacturer. It is the great product for those who live in small dwellings or area with power shortage or very often have to move from one place to another. The main advantages of *ChotuKool* are its small size (60x46cm), a high level of insulation that allows working for 2-3 hours without electricity, low energy consumption and convenient price around USD 70-76 which is twice cheaper than a conventional refrigerator at the launched time. The producer concentrates on core function – cooling process and uses only 20 components instead of 200, compared with a regular solution.<sup>122</sup>

#### 4.7.2 Mitticool

The MittiCool refrigerator is entirely made from clay and operates without electricity. Launched in 2005 by “Mansukhbhai Prajapati” in India at the price least Rs6,000 (around USD 70-80) at the price low than Rs6,000 (around USD 70-80) and reduced costs by almost 60% than a conventional refrigerator. The cooling process is based on water evaporation and does not require electricity thus can be used in areas with a lack of electricity. Generally, it designed to cool water, fruits, vegetables, and milk products and does not have any further frills or functions.<sup>123</sup>

#### 4.7.3 Haier Washing Machine

"Mini Magical Child" launched in 1998 by Haier. Even though its success lasted no more than a few years, however, it is a frugal innovation. Its design was as a real alternative to large and costly washing machines and allowed users to use it for small daily loads, for instance, if the user needs to wash just one pair of socks. The concentric washing technology allowed to increase an efficiency, reduce noises and save water.<sup>124</sup>

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<sup>121</sup> Cf. The United States Institute of Peace (USIP) (2018)

<sup>122</sup> Cf. Tiwari and Herstatt 2012), pp.106-107.

<sup>123</sup> Cf. Weyrauch and Herstatt 2016), p.11

<sup>124</sup> Cf. Hang et al. (2010), p.24

## 5 Analysis Results and Discussion

### 5.1 Sectors

#### 5.1.1 Banking

It is important for a better understanding to restructure the sector itself. First of all, the purpose of each case should be clearly presented. In the brief presentations of the cases in the previous chapter, it became apparent that they are partly in the same product groups within the banking sector.

Both the *Grameen Bank* and the *Rickshaw Bank Project* can be counted as microfinancing. Even though *Rickshaw Bank* goes as a project beyond the pure microcredit business. A tripartite group gives the largest share with the aim of giving the unbanked population easy access to a financial transaction. These include *Eko* for India, *Easypaisa* for Pakistan and *M-Pesa* for Kenya. The business models are all based on the same principle of using the mobile phone for banking transactions. This makes it easy to manage large distances and availabilities. It is striking that each of these three service providers is in cooperation with a mobile phone company and a larger bank.<sup>125</sup> Lastly, *Vortex ATMs* stands for a product that, through its special adaptation to the environment, meets its challenges.

If these product groups are now applied to the various framework characteristics, it becomes clear that these are also similar in economic, social and ecological aspects.

#### *Ecological Sustainability*

Considering our framework, the ecological characteristics remain inconspicuous for the three payment service providers. Due to their service design, the ecological characteristics are not significant. Therefore, the findings for them in the ecological characteristics are not available as neither material is consumed nor is energy consumption negligible compared to other uses. Furthermore, the connection between the *Rickshaw Bank Project* to the ecological characteristics should be emphasized, since an environmentally friendly and sustainable type of transport is promoted by this project. That is because the *Rickshaw* loan project is taking things a step further, as the production of a lighter rickshaw was started in cooperation. Particularly noteworthy is the *Vortex ATM*, as it consumes little energy compared to other ATMs and is

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<sup>125</sup> Cf. Ranganathan, K./Kapoor, A. (2014), p. 144f.

optimally adapted to the environmental conditions through its material-efficient construction.

### *Social Sustainability*

Following the social sustainability, the benefits of the three payment service providers and bank-related services are clearly in the social characteristics. All of them - *Easypaisa*, *M-Pesa* and also *Eko* - have in these characteristics on the framework three out of three pluspots. The benefits are therefore clear, since a bank account and thus the possibility to do financial transactions is a fulfillment of the basic necessities and also supports the inclusion and equality. However, *M-Pesa* should be emphasized, starting with the financial accessibility as well as the promotion of inclusion and equality and educational aspects. For example, the mobile money service has great influence on women who run their own small business.<sup>126</sup> But the mobile banking infrastructure also enables cashless, transparent and low-cost education for children through the Bridge International Academies.<sup>127</sup> Therefore, several sustainable development goals are represented at this point. The two microfinance companies are also strong in their social characteristics. In particular, the gender equality is of great importance to the *Grameen Bank* and should be emphasized here. In consideration of the framework, it is striking that the social aspects have the strongest weight for the *Grameen Bank* and women's empowerment and reduction of inequality are at the forefront. Equality also plays a big role for *Rickshaw Bank*. In addition, the possibility of owning a vehicle and thus fulfilling a basic need as well as to improve the urban life.<sup>128</sup> The last case is the *Vortex ATM*, which emerges in the social aspects mainly through the cash supply of the rural areas.

### *Economic Sustainability*

At the *Rickshaw Bank Project* are in terms of the economic characteristics around ownership and the associated financial conditions as well as the associated employment worth mentioning. That is why this project is a service that provides access to loans for an essential area of daily use eight out of nine benefits (+) a frugal innovation with a sustainability character. But also at the *Grameen Bank* whereby economic characteristics also having an impact on the sustainable development.

The *Vortex ATM* has advantages in terms of time savings since its technology makes it possible to provide cash in rural areas in the first place. Furthermore, its operation is cheaper compared

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<sup>126</sup> Cf. Gichuki, N./Mulu-Mutuku, M. (2018), p. 21

<sup>127</sup> Cf. Mas, I. (2016), p. 1f.

<sup>128</sup> Cf. Centre for Rural Development (2018)

to conventional ATMs.<sup>129</sup> There is no information available on job creation.

In the economic analysis for the mobile service providers, the time savings should be mentioned. Since the service can be accessed anywhere and the customer does not have to be physically present in a branch, which saves long distances in India and Pakistan. Due to the low fees as well as the possibility of not having to carry permanent cash with you, are of advantage. In particular, the long-term savings effects of *M-Pesa* should be emphasized. *M-Pesa* makes saving patterns for the mostly poor population possible and promotes therefore independence.<sup>130</sup> This also applies to the two other payment service providers, *Eko* and *Easypaisa*.

### *Sustainable Development Goals*

The three payment service providers are also similar with regard to sustainable development goals. Thus, the main points are all in the socio-economic area (see appendices four, seven and nine). The ability to save money and to have a financial overview, as well as security, will end poverty, promote equality and create a resilient financial infrastructure. That's why by all of this three the SDG one, nine and ten are listed. Of course, aspects regarding a sustainable society are also worth mentioning.

Among the cases in the microfinance product group, the economic and social aspects of benefits are also in the majority. The social development goals highlight is, above all, the aspects of poverty and equality. Furthermore, the economic growth points are significant for both. Thus, the fulfillment of basic necessities in connection with the SDG one to four.

The case of the *Vortex ATM* it is striking that the pluses lie above all the characteristics with eight out of nine possible points. This suggests that this case is strong both in terms of ecological, economic and social aspects. Therefore, the SDGs relate mainly to sustainable consumption patterns or energy as well as to the end of poverty and improved infrastructure.

## 5.1.2 Transport

### *Ecological Sustainability*

The ecological consideration of the four cases in the transport sector is inconsistent. This is, on

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<sup>129</sup> Cf. Shivapriya, N. (2010) and cf. Simhan, T.E. (2012)

<sup>130</sup> Cf. Matheson, R. (2016) and cf. Ashta, A. (2011), p. 162



the one hand, because three out of four cases are vehicles with a normal internal combustion engine. On the other hand, it is also because a consideration of the transport sector from an ecological point of view generally turns out to be difficult. It is therefore noted that the comparisons of the four cases are made with comparable other vehicles in the same segment and country, in terms of material efficiency, energy consumption and climate neutrality.

First of all, energy saving in terms of fuel efficiency is considered on the cases *Tata Nano* and *Tata Ace*. Due to their design-related low weight, the consumption appears low or justifiable, but here it is important to differentiate more precisely.<sup>131</sup> Therefore, their market environment in India is considered more closely. Both vehicles have small engines and low horsepower.<sup>132</sup> The *Tata Ace* created a new market niche or its own segment, as it is designed as a direct competitor to tricycles and therefore energy saving needs to be compared with three-wheelers. Therefore, the fuel consumption of the *Tata Ace* is higher compared to the lighter and more efficient tricycle.<sup>133</sup> According to the framework, this aspect is, therefore, worse or different from that of the *Tata Nano*, which stands in comparison with standard small cars. Furthermore, the *M&M Yuvraj 215* tractor has the lowest fuel consumption in its segment.<sup>134</sup> A special consideration is the only electric vehicle - the *Sono Motors Sion*. The battery is additionally charged by solar panels, giving a range extension of up to 30km per day.<sup>135</sup>

In terms of material efficiency, all four cases are positive according to the framework. For example, the three cases with internal combustion engines save material by deliberately omitting certain components or an intelligent design.<sup>136</sup> In addition, the *Sono Motors Sion* is characterized by partially renewable materials.<sup>137</sup>

The climate neutrality cannot be assessed in the case of the Tata vehicles, as there is no information on different emission values.<sup>138</sup> Therefore, it is generally similar to comparable vehicles, but again with the same note for the *Tata Ace* with the three-wheelers. The *M&M Yuvraj 215* tractor should also be viewed in a differentiated way, since the low price means that more farmers can use their own tractor instead of oxen. Positively, locally emission-free (moreover, the power source is relevant) and also emission-reduced production, is the *Sono*

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<sup>131</sup> Cf. Kalla, N. (2015), p. 48f. and cf. Tata Motors (2018a)

<sup>132</sup> Cf. Kalla, N. (2015), p. 48f. and cf. Tata Motors (2018a)

<sup>133</sup> Cf. Tiwari, R. et al. (2014), p. 6

<sup>134</sup> Cf. Chetan, K. (2012)

<sup>135</sup> Cf. Sono Motors (2018c)

<sup>136</sup> Cf. Kurczewski, N. (2009) and cf. Tiwari, R. et al. (2014), p. 6

<sup>137</sup> Cf. Sono Motors (2018c)

<sup>138</sup> Cf. Palepu, K./Srinivasan, V. (2008), p. 1f.

*Motors Sion.*<sup>139</sup>

### *Social Sustainability*

As in the case of the ecological characteristics, the same applies to the social characteristics that comparisons are made with comparable vehicles from the same segment and country. In this way, all cases fulfill their respective task regarding fulfillment of the basic necessities in transportation. The two Tata models offer security advantages and population strata can afford them, which otherwise would not have had access to vehicles in this segment. The same applies to the *M&M Yuvraj 215* tractor. A special case is the *Sion* as the only electrically powered vehicle in this paper with a range of about 250km per charge and this locally emission-free.<sup>140</sup> Of course, the electricity must be produced, but on this point, the *Sion* is ahead of gasoline-fueled cases in terms of an exhaust. Nevertheless, the safety aspect of the *Tata* cases should be mentioned, as well as the easier physical work on the field in the case of the *M&M Yuvraj* tractor in comparison to power tillers or ox plowing.<sup>141</sup>

### *Economic Sustainability*

What all the considered cases have in common is a comparatively low price and therefore they are affordable. Furthermore, the cars and small truck do not save time, whereas the *M&M Yuvraj* tractor increases the efficiency and productivity of agriculture.<sup>142</sup> Regarding the jobs, there is hardly reliable information. Nevertheless, the vehicles generally have to be produced and therefore there is a job to be done. “Tata” has a large workforce in India.<sup>143</sup> However, there are no indications as to whether and how many jobs have been created for which model. Likewise, for “M&M”. “Sono Motors” is again a special case, as it has a startup mentality and will take an interesting path in the next few years, which must prove successful.

### *Sustainable Development Goals*

The described cases of the transport sector are all responsible for the creation of infrastructure and its affordability to broad populations and thus reduce inequality (SDGs 9 and 10). Likewise, they ensure that there is sustainable production as well as consumption (SDG 12). The *M&M Yuvraj* tractor unites most of the sustainable development goals as it goes beyond the other

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<sup>139</sup> Cf. Sono Motors (2018c)

<sup>140</sup> Cf. Sono Motors (2018a)

<sup>141</sup> Cf. Chetan, K. (2012)

<sup>142</sup> Cf. Chetan, K. (2012)

<sup>143</sup> Cf. Tata Motors (2018b)

cases. Achieving efficient and productive agriculture will alleviate poverty, but above all hunger (SDGs 1 and 2). This efficiency in combination with the goals already stands for sustainability, in terms of food and the improvement of living conditions in general.

In fact, the transport sector combines the features of frugal innovations - focusing on core functions, performance levels, and cost reduction. In sum, it is important to emphasize, albeit with some deductions, they also lead to sustainability.

### 5.1.3 Energy

#### *Ecological Sustainability*

*Husk Power Systems* and *SELCO* contribute positively towards the generation of an energy-sustainable society. Both companies provide access to modern and sustainable energy for the population in rural towns and villages that previously had no access to a proper source of electricity. Meanwhile, *HPS* provides general electricity access, *SELCO* provides a source of constant light through sustainable lightbulbs that replace candles or other sources of light powered with kerosene. Additionally, since electricity theft is a common problem in rural India *HPS* counts with a door-to-door operation to ensure that consumers are not using more electricity than they pay for<sup>144</sup> and *SELCO* offers a range of products that provide electricity to carry out different tasks (e.g. water pumping, lighting, communications, small business appliances) through systems that have solar photovoltaic (PV) modules attached and all products can be purchased by individual users and do not require connection to a larger network.<sup>145</sup>

Through the implementation of cost-effective technology, *HPS* developed a way of generating electricity by creating fuel from crop waste, specifically, rice husks. In the process, they have also reduced significantly the use of diesel and kerosene.<sup>146</sup> *SELCO* provides customized solutions based on end user needs<sup>147</sup>, however, no comprehensive evidence was found in the literature regarding material efficiency.

In relation to climate neutrality, *HPS* has replaced an automated water-aided process to remove rice husk char from gasifiers with a process that uses 80 percent less water and can be operated

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<sup>144</sup> Cf. Bornstein, D. (2011)

<sup>145</sup> Cf. SELCO Solar (2008b)

<sup>146</sup> Cf. Bornstein, D. (2011)

<sup>147</sup> Cf. SELCO Solar (2008b)

with a hand crank.<sup>148</sup> *SELCO* is empowering households to function without being dependent on fuel-based products.<sup>149</sup>

### *Social Sustainability*

Both companies have an indirect impact in the fulfillment of basic necessities by providing bioenergy solutions that allow the underserved population to have a better quality of life. In the vast majority of poorest states in India, villagers have no electricity<sup>150</sup> therefore, both *HPS* and *SELCO* indirectly contribute to the enhancement of a variety of essential needs (for instance, enhancing the safety of a shelter through lightbulbs or improving the quality of nutrition by providing electricity for stoves, etc).

In relation to health, approximately two million people die prematurely every year as a consequence of pulmonary diseases caused by the indoor burning of fuels for cooking and light<sup>151</sup>, therefore, by providing a source of reliable bioenergy, both companies have positively affected the quality of life for the rural population in India. Parallely, longer working hours in better quality light results in higher incomes and better education.<sup>152</sup>

*HPS* and *SELCO* promote inclusion and equality. At least 25,000 villages have been identified as appropriate for the *HPS* model and it is forecasted that the company could bring light to 125,000 unelectrified local villages<sup>153</sup>. Moreover, *SELCO* offers financing packages for low-income customers through agreements with local banks.<sup>154</sup>

### *Economic Sustainability*

Both firms enable consumers to use their time for other activities. Apart from channeling most of its wages and payments for services back into the villages, the energy solutions provided by these companies allow a wide number of shopkeepers to close their stores until later hours, and they also allow farmers to irrigate more land<sup>155</sup>. Furthermore, they procure the channel by which technology can be reached, therefore, increasing work hours and hence productivity<sup>156</sup>.

By creating a system to transform rice husks into eco-friendly and affordable electric power,

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<sup>148</sup> Cf. Bornstein, D. (2011)

<sup>149</sup> Cf. *SELCO Solar* (2008b)

<sup>150</sup> Cf. Cf. Bornstein, D. (2011)

<sup>151</sup> Cf. Cf. Bornstein, D. (2011)

<sup>152</sup> Cf. *SELCO Solar* (2008c)

<sup>153</sup> Cf. Cf. Bornstein, D. (2011)

<sup>154</sup> Cf. *SELCO Solar* (2008b)

<sup>155</sup> Cf. Bornstein, D. (2011)

<sup>156</sup> Cf. *SELCO Solar* (2008c)

*HPS* offers energy services that can be obtained by households at only USD 2 a month<sup>157</sup>. As part of its business model, *SELCO* acts as a credit facilitator for low-income households through banking institutions and the technology that they implement allows families to save on their electricity bill.<sup>158 159</sup>

*HPS* is committed with the employment of locals who would be considered unemployable by other firms. The company often recruits workers that often come from a very poor background and have a modest level of education and trains them in the operation of machines, in electricity-auditing (assuring that villagers do not use more electricity than what they are paying for) or they also work as fee collectors. Besides, *HPS* has found additional ways of making rice husk char profitable and as a side business they are also turning the char into incense sticks, which is a business that provides supplementary income to women from these villages.<sup>160</sup> No available information regarding the creation of jobs for local people was found for *SELCO*. *SELCO* Skill force of over 375 employees.<sup>161</sup>

### *Sustainable Development Goals*

By ensuring access to affordable and reliable energy (SDG seven), *HPS* and *SELCO* have a direct and indirect impact on the health of the population (SDG three) and promote education for all (SDG four). Moreover, both are active agents in promoting economic growth (SDG eight) and in building resilient infrastructure that promotes innovation (See Annex for a summarized table of results).

#### 5.1.4 ICT

##### *Ecological Sustainability*

Regarding energy-saving properties, three of our five selected cases were found to have a positive impact. No information about energy-sustainability was found for the *Aakash Tablet* and *Bharti Airtel*. In contrast, we observed that one of the main features from the *Nokia 1100* mobile phone was that it offered a long operating time between each charging<sup>162</sup> allowing customers to reduce energy in this way. Similarly, the *Micromax Xli* can work for longer than

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<sup>157</sup> Cf. Cf. Bornstein, D. (2011)

<sup>158</sup> Cf. *SELCO Solar* (2008d)

<sup>159</sup> Cf. *SELCO Foundation* (2017)

<sup>160</sup> Cf. Cf. Bornstein, David (2011)

<sup>161</sup> Cf. *SELCO Solar* (2008e)

<sup>162</sup> Cf. Sehgal et al. (2010), pp 1–5.

a month without recharge<sup>163</sup> and the *Vodafone VF247* model charges itself through exposure to normal daylight and its solar-powered battery is also of long-duration.<sup>164</sup>

In relation to material efficiency, four of our five selected cases were found to have a positive impact. No related information was found for the *Micromax x1i*. The *Aakash Tablet* was found to have a positive impact in relation to its objective of acting as an academic tool for children in rural areas; since the tablet does not only allow connectivity but also functions as an Ebook Reader, thus, reducing the cost of printing paper and distributing the material.<sup>165</sup> The *Bharti Airtel* business model reduces costs and material usage by outsourcing its core competencies to experts and service providers in the early phase.<sup>166</sup> Also, the *Nokia 1100* used simple and basic mobile technology and materials for its manufacturing<sup>167</sup> and Vodafone has an indirect positive impact by offering a buyback proactive procedure by encouraging customers to return handsets and accessories that are no longer used or wanted for recycling.<sup>168</sup>

In our analysis, to be considered climate neutral is to take action towards reducing and combating climate change. Meanwhile, some innovations have a positive impact on the two dimensions above, one should include into the equation the fact that in general, the manufacturing of a mobile phone creates 60 kilograms of CO<sup>2</sup> on average. On this same note, mobile phone usage per year has calculated to produce about 122 kilograms of CO<sup>2</sup> per year, per device. From another point of view, a large variety of hazardous substances such as arsenic, antimony, beryllium, cadmium, copper, lead, nickel and zinc are contained in mobile phones.<sup>169</sup>

### *Social Sustainability*

All five analyzed innovations from the ICT sector enable users from the poorest areas in India to access the global information society by providing them with technology and connectivity. Particularly, the *Aakash* tablet was designed with the main objective of providing educational resources through e-learning programs to enhance the access of children to information on the internet<sup>170</sup>, allowing several necessities to be fulfilled at once. Additionally, apart from mobile reception and internet, *Bharti Airtel* provides other services like mobile payments<sup>171</sup> and *Nokia's*

<sup>163</sup> Cf. Hossain, Mokter (2017), pp. 199–208.

<sup>164</sup> Cf. Dhavale, Shilpa (2013), pp. 21–24 and Nusca, Andrew (2010)

<sup>165</sup> Cf. Singh, S. (2009)

<sup>166</sup> Cf. Sinha, R. (2013), p. 74

<sup>167</sup> Cf. Soydan, I. (2012), p. 40

<sup>168</sup> Cf. Manivannan, S. (2016), pp. 69–79.

<sup>169</sup> Cf. Manivannan, S. (2016), pp. 69–79.

<sup>170</sup> Cf. United Nations Economic and Social Council (2013)

<sup>171</sup> Cf. Airtel India (2018b)

*1100* counted with a flashlight that was particularly useful in rural areas due to frequent power outages and it had a silicone and plastic case for a damp and dusty environment.<sup>172</sup>

Out of the five analyzed innovations, the *Aakash* tablet is the only one that addresses directly the crucial demand for education in poor communities with large populations facing high illiteracy rates in India, by delivering high-quality educational content and providing access at a significantly low cost.<sup>173</sup> In relation to the health component, it is important to consider that the use of mobile devices can harm the brain and their excessive use has been associated with irregular sleeping patterns and dizziness.<sup>174</sup>

All five ICT innovations and enterprises behind them suppress the digital division in India and thus, help promote a more inclusive and egalitarian society within millions of individuals. Datawind, the creators of the *Aakash* tablet had targeted to distribute five million tablets in India by 2017, where 80% of these devices would reach those living on less than USD 8 a day.<sup>175</sup> *Bharti Airtel* announced at the beginning of 2018 that the number of customers for all their offered services had reached over 418 million<sup>176</sup>, as a result of their innovative business strategy that allowed them to offer significantly lower prices, on the same note, the *Nokia 1100* was reachable by consumers from the base of the socio-economic pyramid<sup>177</sup> and both the *Micromax xLi* and the *Vodafone VF247* enabled people from areas where electric supply is unstable by providing them with connectivity.

### *Economic Sustainability*

Whereas communicating by a phone call, an email or simply retrieving information from the Internet, the speed of communication increases with the use of ICT technology. More specifically, the wiring behind the *Aakash* tablet provides a faster and richer user experience meanwhile less data is consumed 1.5MB/hr (vs. 40MB/hr)<sup>178</sup>, *Bharti Airtel* Mobile provides signal reception even in the most remote locations<sup>179</sup> and Nokia offers vans called "showrooms on wheels" that drive through remote areas in rural villages to provide support and repair for mobile devices.<sup>180</sup>

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<sup>172</sup> Cf. Prabhu, J. (2013), p. 26 and Soydan, I. (2012), p. 40

<sup>173</sup> Cf. Newman, K. (2014)

<sup>174</sup> Cf. Manivannan, S. (2016), pp. 69–79.

<sup>175</sup> Cf. Newman, K. (2014)

<sup>176</sup> Cf. Airtel India (2018b)

<sup>177</sup> Cf. *The Economist* (2011), p.16

<sup>178</sup> Cf. Singh, S. (2009)

<sup>179</sup> Cf. Sinha, R. (2013), p. 74

<sup>180</sup> Cf. Mahmood et al. (2014), p. 3

Providing a low-cost alternative that helps increase income or save money is one of the main characteristics for innovations to be considered frugal according to the definition provided at the beginning of this article. In this analysis, the five cases from the ICT sector have been found to impact consumers positively. Following an initiative promoted by the Indian Government to link academic institutions into an e-learning program, the company Datawind manufactured the *Aakash* tablet and it can be afforded by students at a price as low as USD 35. The costs are subsidized by the Indian government, as well as their expansion plans. In addition, to provide valuable data services for low-income users, the company has patented a unique delivery and they are able to reduce the price because of their advertising-based revenue models as well.<sup>181</sup>

<sup>182</sup> <sup>183</sup> *Bharti Airtel* offers low call rates starting at USD 0.15 cents per minute, as a result of their pioneer strategy that has allowed them to reduce costs by outsourcing all business operations apart from marketing, sales and finance.<sup>184</sup> The *Nokia 1100* had an introductory price of approximately USD 20<sup>185</sup> and Micromax generated high-volume revenue by attracting customers from the lower segments which lead to a rapidly increased company's financial performance (by 271%) and market share (the 3rd position in the industry).<sup>186</sup> Vodafone sells pre-paid mobile service vouchers for the *VF247* for as low as USD 0.2 cents<sup>187</sup> and users save money by not needing electricity to recharge the solar-powered phone.

In relation to the creation of new jobs, three of the analyzed innovations have been developed by Indian firms and in general, domestic production tends to motivate Governments as it generates tax revenue and creates local employment, as in the case of Datawind, the creators of the *Aakash* Tablet<sup>188</sup>. In addition, the success of *Bharti Airtel* and *Micromax Xli* in the mobile sector has allowed them to expand into other countries such as Russia, Bangladesh, Sri Lanka, and several African nations, creating new jobs in that process<sup>189</sup>. No information available was found for the *Nokia 1100* and the *Vodafone VF247*.

### *Sustainable Development Goals*

Particularly, the *Aakash* Tablet is the only ICT innovation that has been classified as having a direct impact on ensuring inclusive education (SDG four) as a result of the main objective of

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<sup>181</sup> Cf. Trucano, M. (2011)

<sup>182</sup> Cf. Singh, S. (2009)

<sup>183</sup> Cf. Newman, K. (2014)

<sup>184</sup> Cf. Sinha, R. (2013), p. 74

<sup>185</sup> Cf. Soydan, I. (2012), p. 40

<sup>186</sup> Cf. Singh, Ajay K. (2013), p. 119-120

<sup>187</sup> Cf. Dhavale, S. (2013), pp. 21-24

<sup>188</sup> Cf. Singh, S. (2009)

<sup>189</sup> Cf. Benudhar, S./Qumer, Syeda M. (2016)



their business model. However, all five ICTs frugal innovations presented in this paper contribute to the reduction of inequality within and among countries (SDG ten; see Appendix 39 for a summarized table of results).

#### 5.1.5 Water sector

##### *Ecological Sustainability*

*Hindustan Unilever Pureit* and *Tata Swach* filters are water treatment devices for household use. Both frugal innovations do not require electricity or running water to function.<sup>190</sup> Therefore, they provide access to safe water to users who live in remote areas with the lack of electricity. They are more energy efficient than water boiling with solid fuels, thus have a positive impact on energy saving.

Boiled water is very sensitive to contamination from hands, for instance, since it has no residual disinfectant. Usually, people store boiled water in open containers in which it cannot be protected from high levels of fecal contamination.<sup>191</sup> The treatment technology of *Swach* solution is based on rice husk ash and nanotechnology. *Pureit* filter uses a gravity-driven "table-top" water filtration system. Both filters have a replaceable purification "bulb" or "kit" and can be used from 1500 up to 3000 liters depending on the model.<sup>192</sup> The multi-stage purification process of *Pureit* removes 1 crore virus of water and harmful pesticides to make water safe for consumption. The use of filters is more reusable and material efficient than boiling with solid fuel.<sup>193</sup>

*Swach* and *Unilever* have a positive indirect impact on climate change. Compared to the process of water boiling with solid fuels, the use of both frugal solutions reduces carbon emission and prevent forest deforestation.<sup>194</sup> (Clasen et al. 2008) The carbon footprint from the use of *Unilever Pureit* is at least 80% smaller than boiled or bottled water.<sup>195</sup> These two filters are more climate neutral than the existing solutions.

##### *Social Sustainability*

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<sup>190</sup> Cf. Clasen et al. (2006), pp. 1399–1405 and Tata Swach (2018)

<sup>191</sup> Cf. Clasen et al. (2008,) p.1

<sup>192</sup> Cf. Tata Swach (2018) and cf. Hindustan Unilever (2018)

<sup>193</sup> Cf. Levänen et al. (2016), p.7

<sup>194</sup> Cf. Clasen et al. (2008), P.1

<sup>195</sup> Cf. Unilever (2018)

*Swach* and *Pureit* provide access to safe and healthy drinking water, therefore meet basic needs of people who live in water scarcity area or have a lack of basic sanitation. Due to unique GermKill Kit™ technology *Pureit* remove harmful viruses, bacteria, parasites, thus the filter meets strict international standards established by the US Environmental Protection Agency (USEPA) for water purifiers.<sup>196</sup> Although *Swach* does not reach international standards for microbiological purification efficiency, however, the quality of water is good enough for drinking and significantly improved in comparison with non-boil water.

There is no evidence of a significant impact on education. However, *Swach* and *Hindustan Unilever* created awareness amongst doctors and potential clients about the significance of safe and healthy drinking water, as a part of their marketing companies.<sup>197</sup> Both innovations are efficient in decreasing the adverse effects on health by reducing bacteria and viruses in water and improving water quality. In addition, the traditional water boiling process can lead to some health hazards such as respiratory infections, anemia, and stunting as results of poor indoor air quality and burns.<sup>198</sup> The use of purification systems improves indoor air condition and decreases health risks.

The price of *Pureit* is around USD 40-44, it is very expensive for almost a half of Indian population since the average monthly income of 22.1% of households is less than USD 70 per month and of approximately 25.5% up to USD 111.71.<sup>199</sup> Consequently, *Pureit* cannot promote inclusion and equality between poor and rich people. However, researches evaluate *Swach* filter as positive, since its price is twice cheaper than the price of *Pureit*, thus is more affordable to poor people and reduce inequality.

### *Economic Sustainability*

Both *Swach* and *Pureit* filters are more time efficient, compared with the water boiling process. The use of purification filters does not require time to collect coal, wood, and other biomass, as well as time to control the fire. Both purification filters easy to use and clean.

Researchers estimate the impact of these innovations on money savings as positive due to lower prices compared to conventional bulky filters. Even though *Unilever Pureit* is still not available to a large number of poor people, however, it is cheaper than existing devices. For instance, it

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<sup>196</sup> Cf. Clasen et al. (2006), p.1402

<sup>197</sup> Cf. Levänen et al. (2016), p.8

<sup>198</sup> Cf. Clasen et al. (2008), p.1

<sup>199</sup> Cf. Statista (2016)

is less expensive ultraviolet water purifiers which price is higher than INR5,000 or USD 102<sup>200</sup> or than commercial firewood, charcoal or liquid petroleum gas.<sup>201</sup>

Due to lack of evidence that these frugal innovations create or promote new jobs or new businesses for people, *Unilever* and *Swach* filters have a neutral impact on job creation.

### *Sustainable Development Goals*

The use of *Unilever Filter* and *Tata Swach* improve water sanitation thus increase a food security and improve nutrition (SDG two). Affordable safe and healthy drinking water promote healthy lives and well-being (SDG three). The reduction of a high level of viruses ensures sustainable management of water and sanitation for all (SDG six). Since both solutions operate without electricity, thus promotes sustainable energy consumption (SDG seven). Both *Unilever* and *Swach* have built resilient infrastructure and promote inclusive and sustainable access to safe water (SDG nine). Furthermore, these two frugal innovations promote the safety and sustainability of human settlements (SDG eleven), sustainable consumption (SDG twelve), and protect terrestrial ecosystems (SDG 15). However, only *Tata Swach* promotes a reduction of inequality within the country (SDG ten), since its price more affordable than the price of *Unilever*. The researchers have found that the *Unilever* implements and activates the global partnership for sustainable development, thus promote SDG 17. Overall, the selected frugal innovations contribute to achieving the broad spectrum of the SDGs.

### 5.1.6 Appliances

#### *Ecological Sustainability*

The analysis of the selected frugal innovation revealed that the use of both *Mitticool* and *ChotuKool* leads to a decrease in energy consumption compared to existing refrigerators. *ChotuKool* consumes 65 watts (W) or 12 volts (V) DC, it can also work on battery, inverter or even solar power, thus lowering the running costs against 90 – 100W of the conventional model. It has a sleep mode that allows the refrigerator to disconnect from a power supply after reaching cooling temperature 10°C.<sup>202</sup> The use of *ChotuKool* promotes preserving a critical resource like electricity. *Mitticool* case, it is 100% energy efficient solution, since it does not require

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<sup>200</sup> Cf. Ernst & Young (2011)

<sup>201</sup> Cf. Ahlstrom, D. (2010), pp. 11–24.

<sup>202</sup> Cf. Godrej ChotuKool (2018)

electricity to operate.<sup>203</sup> The cooling process carried out through water evaporation since it does not require electricity at all thus it is affordable for areas without electricity.<sup>204</sup> *Haier's* washing machine also achieves an energy-saving indicator compared to conventional washers which were used in 1996.<sup>205</sup>

The use of *Mitticool*, *ChotuKool* and "*Mini Magical Child*" washing machine reduce harmful impacts to the environment through a decrease of energy and raw material consumption. *Mitticool* is the eco-friendly solution since it is made completely from clay. In addition it is durable in nature and long service life.<sup>206</sup> By comparison with regular refrigerators, *ChotuKool* has only 20 components instead of 200 components.<sup>207</sup>

Taking into account that *Mitticool* does not emit any carbon gases, therefore does not harm health and environment, the frugal innovation has a neutral impact on climate change. The two remaining innovations, due to the lack of information, were assessed with indirect impact on climate. However, both *ChotuKool* and *Haier's* washing machine are more climate neutral than existing solutions, since less electricity needed for their operation.

### *Social Sustainability*

According to the Indian Brand Equity Foundation (IBEF), only around 29% of Indian householders have access to refrigerators.<sup>208</sup> This issue affects not only poor people from rural areas but also urban householders. Only eight percent of people in rural India have refrigerators.<sup>209</sup> Likewise, there are only two billion people in the world today who have access to washing machines. The remain population of five billion wash linen and clothing by hand.<sup>210</sup> For instance, only 11% of Indian householders have a washing machine.<sup>211</sup> Hand washing is a time consuming and exhausting process, since women spend an enormous amount of time on water heating, lifting and pressing heavy wet linen or clothes. *Mitticool*, *ChotuKool* and *Haier's* washing machine appliances allow people to have access to basic services, thus providing them with a decent life.

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<sup>203</sup> Cf. Mitticool (2018)

<sup>204</sup> Cf. Weyrauch/ Herstatt, (2016), p.10

<sup>205</sup> Cf. Hang et al. (2010), p. 24.

<sup>206</sup> Cf. Mitticool (2018)

<sup>207</sup> Cf. Tiwari, R./Herstatt, C. (2012), p.106

<sup>208</sup> Cf. India Brand Equity Foundation (2018), p. 36

<sup>209</sup> Cf. Khan, R. (2016), p. 29

<sup>210</sup> Cf. UN-Habitat (2018)

<sup>211</sup> Cf. Unilever (2018)

The access to fresh food and reduction of a heavy burden and time-consuming job improve health outcomes. Additionally, the access to refrigerator and washing machine reduce time in household labor which women can spend on education, leisure (television) or entry into the job market.<sup>212</sup>

By providing core functionality at an affordable price to people who never used a refrigerator and washing machine, *Mitticool*, *ChotuKool* and *Haier's washing machine* promote inclusion and equality between rich and poor people; between people from the area with lack of access to electricity and free access to electricity; forward gender equality and raise women emancipation.

### *Economic Sustainability*

Using of *Mitticool*, *ChotuKool* and *Haier washing machine* significantly save women's time in their housework, as they do not need to spend time on the boiling water or everyday shopping for fresh products. The studies revealed the introduction of such durable goods such as washing machine and refrigerator, between 1900 and 1970, significantly cut down the time spent on household work by 70 percent.<sup>213</sup>

*ChotuKool* was launched at a price between Rs. 3,500 and Rs. 3,800, at that time it was 50% cheaper than the next entry-level existing fridge.<sup>214</sup> *Mitticool* was launched at a much lower price of Rs.2,500. Additionally, around one-third of food in India spoils due to hot and humid weather and frequent power cuts.<sup>215</sup> Affordable price and ability to keep food longer improve family savings. Additionally, all three frugal innovations improve family savings through the reduction of energy consumption.

*ChotuKool* support a creation of new income-generating opportunities, since it can be used by small shops or kiosk which sell beverages, chocolates or flowers thus increase income.<sup>216</sup> Additionally, salespersons of the product are rural villagers who have been trained by the producer and earn a commission of about USD 3 per each fridge sold.<sup>217</sup> However, *Mitticool* and *Haier's washing machine* evaluated by researches with the neutral impact of job creation, since no evidence have been found.

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<sup>212</sup> Cf. Dhanaraj, S. et al. (2017), p.3

<sup>213</sup> Cf. Greenwood, S. et al. (2005), p. 109–133

<sup>214</sup> Cf. Tiwari R./ Herstatt C. (2012), p.107

<sup>215</sup> Cf. Tiwari R./ Herstatt C. (2012), p.107

<sup>216</sup> Cf. Wipo, Magazine (2013)

<sup>217</sup> Cf. Tiwari R./ Herstatt C. (2012), p.107

### *Sustainable Development Goals*

The three selected frugal innovations promote SDG seven, SDG nine and SDG ten since they operate without electricity or require low energy consumption than conventional products; foster innovations and reduce inequality within the country due to affordable prices and time reduction of exhausting work. *Mitticool* and *Godrej ChotuKool* encourage food security and improved nutrition by keeping food fresh for a few days (SDG two); contribute to a healthy lifestyle by providing access to a safe diet (SDG three). Protected food contributes to the creation of safe and sustainable human settlements (SDG eleven), and the availability of the products provides sustainable consumption (SDG twelve). In sum, three innovations contribute more to the environmental/economic, social and environmental aspects of sustainable development than to economic ones.

#### 5.1.7 Healthcare

### *Ecological Sustainability*

Both *Narayana and Aravind hospitals* have used process innovations in their business model creation in order to achieve frugality. Therefore, it is not possible to evaluate their energy-saving characteristics. The analysis of the remaining five innovations shows that all of them are more energy efficient than existing solutions. *MAC 400* has rechargeable batteries that could be charged in three hours that enough to perform over 100 ECGs or a week of use between charges.<sup>218</sup> *Lullaby warmer* consumes 158W, whereas conventional warmers consume around 600 to 700 kilowatts, additionally, it can work with solar energy.<sup>219</sup> The use of these devices allows rural doctors from areas with no electricity or frequent power cuts to diagnose patients and they are convenient for hospitals in remote settings. *Embrace Baby Warmer* works without electricity. It uses an innovative wax integrated into a sleeping bag to regulate a baby's temperature. It has no moving parts and it is portable. The warmer can be used as in a clinical setting, for transporting babies as well in a community setting.<sup>220</sup> Due to a lack of information, it is difficult to compare the energy efficiency of *Jaipur foot* production with existing products and energy consumption of *Vscan* with existing ultrasound devices.

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<sup>218</sup> Cf. Singh, J. (2011), p.4.

<sup>219</sup> Cf. Ooko, Sarah (2014)

<sup>220</sup> Cf. Embrace innovations (2018)

*NH* efficiently uses its financial, material or human resources. The hospital works on a “hub-and-spoke” model where physicians do only their core jobs. The hubs include sophisticated surgery and spoke facilities concentrate on diagnosis routine treatment and follow-up care. This model has helped the hospital to achieve high physician productivity with high-quality services.<sup>221</sup> *Aravind center* has its own perfected surgery method which allows avoiding suture and does not require expensive equipment and instrumentation. Additionally, the speed of the surgical procedure is improved by making operation on two operation tables alternately. The doctors’ productivity also raised.<sup>222</sup> Due to easier and quicker production process of *Jaipur foot* patients can walk away with new foot within hours of having a cast of her limb prepared. Instead of long and complicated procedures such as reception, admission, and fitting which are typically used by most orthopedic centers, the *Jaipur foot* reduced these unnecessary processes.<sup>223</sup> The material efficiency of three GE innovations has been achieved by reducing a size of large boxes, implementing sophisticated technologies, removing unnecessary features, in comparison with conventional large, bulky and complex conventional solutions. While conventional incubators separate babies from their mothers, the *Embrace warmer* allows them to be closer to each other and avoid the anxiety of infants without mother.<sup>224</sup>

The impact of *Jaipur foot* on the environment have been evaluated negatively. Currently, *Jaipur foot* is produced from polyurethane that is durable and can be used in wet or dry conditions. Even though polyurethane is a great alternative to preserve the natural resources for future generations, However, due to its resistance to extreme conditions, recycling of polyurethane requires special methods and conditions such as mechanical, chemical and feedstock recycling.<sup>225</sup> There is no information that the producer of *Jaipur foot* provides any instructions on how to dispose of the product at the end of its service life, for instance, where it can be sent for reuse. While the producer of *GE Vscan* and *ECG* provides to users a disposal guidance that the devices should be returned to local GE representative for disposal.<sup>226</sup> Therefore, these two frugal innovations evaluated with positive impact. The two baby warmers *Lullaby* and *Embrace* are more climates neutral than the existing solutions. Over 24 hours the total power consumption of *Lullaby* reduced by 24%.<sup>227</sup> *Embrace* does not require electricity at all.<sup>228</sup>

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<sup>221</sup> Cf. Khan, S. / Haldar, O. (2015), pp. 1–6.

<sup>222</sup> Cf. Sanal et al. (2011), p.4

<sup>223</sup> Cf. Prahalad, C. (2010), p. 251

<sup>224</sup> Cf. Westcott, L. (2015), p. 43

<sup>225</sup> Cf. ISOPA (2018)

<sup>226</sup> Cf. General Electric Company (2014)

<sup>227</sup> Cf. GE Healthcare (2018)

<sup>228</sup> Cf. *Embrace innovations* (2018)

Researches could not evaluate the impact of *NH* and *AECH* business models on climate.

### *Social Sustainability*

The seven selected examples improve people lives by providing access to affordable healthcare services. Due to *AEC system*, the blind people get a precious gift of vision. *Jaipur foot* enables the poor to walk and to take control of their better-quality lives. The world-class cardiac care at a radically low cost between USD 2,000 and USD 5,000 is offered by *Narayana Hospital*, much more accessible in comparison with up USD 20,000 to USD 100,000 in American clinics.<sup>229</sup> Poor people from rural areas have access to easy health check-in using *Ultrasound* and *Electrocardiogram* since more clinics and private doctors can afford its prices. Additionally, due to compact sizes and weight, doctors can examine patients at their homes. The basic needs of a newborn – availability of warmth. Due to limited access to affordable technologies such as baby warmers, more than 50% of the babies are born in inappropriate conditions.<sup>230</sup> *Lullaby and Embrace baby warmers* meet the basic needs of babies to live and their parents to have a baby.

45 million people worldwide and 9 million in India have needless blindness by its elimination *AECH* promotes to human well-being. Together with the “World Health Organization” the hospital offers structured trainings to eye care professionals at all levels and concentrate on the professional growth of all its doctors and nurses.<sup>231</sup> *NHH* group is also an academic institution and actively promoting clinical education in all spheres of healthcare. It holds around 49 training programs such as nursing, post-graduate medical education, paramedical and management.<sup>232</sup> The manufacturing of *Jaipur foot* is a labor-intensive process, which includes artisans with several years of experience and who have been additionally trained for several more years for molding, sculpturing, and forming the *Jaipur Foot*.<sup>233</sup> Additionally, it indirect promotes people’s education by allowing them to go to school or universities. The impact of remaining four innovations on education and health was evaluated with plus. Although there is no available information about the direct impact on education, however, the better health the better opportunities provided to education.

All selected innovations contribute social inclusion and justice by returning sight to blind

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<sup>229</sup> Cf. Bound, K./Thornto, I. (2012), p. 10.

<sup>230</sup> Cf. Asiabiotech (2009), p. 46

<sup>231</sup> Cf. Prahalad, C. (2010), p. 242

<sup>232</sup> Cf. NHH annual report, p.31

<sup>233</sup> Cf. Prahalad, C. (2010), p. 253



people, treating both rich and poor people, early detection of heart diseases, offering affordable prices for rural clinics and poor families who cannot dream of expensive technologies or clinical services. They enable all groups of people in society to feel valuable and important.

### *Economic Sustainability*

In comparison with the existing solutions, all selected frugal innovation leads to time-saving. Due to a high productivity, each doctor at *Aravind hospital* carries out from 1,000 to 1,400 eye surgeries a year, while US doctors perform an average of 400 surgeries. *Narayana's* surgeons perform in average 500 procedures a year, compared with 100 to 200 by surgeons in the USA.<sup>234</sup> Due to lightweight and portability, both GE ECG and GE Ultrasound can be used for home examinations of patients or at accident sites, thus to patients do not need to go to a hospital.<sup>235</sup> *Lullaby warmer* designed for staff efficiency and comfort, for instance, it has well-positioned lighting for easier examination and rapid pre-warming setting.<sup>236</sup> While the *Lullaby warmer* works for health care centers, the *Embrace incubator* is a great solution not only for hospitals but also for families who live far from hospitals and cannot go there for the baby birth.<sup>237</sup> A mobile initiative called '*Jaipur Foot on Wheels*' enable to provide quick and cheap manufacture to those who are unable to travel to a hospital.<sup>238</sup>

Due to cost advantages, all selected frugal innovations have an impact on families' incomes and make a lot of economic sense. Free eye or heart surgeons, low energy consumption, low production cost allow patients and hospitals to save money. For instance, the average price of open-heart surgery at *NHH* is USD 2,000, compared with USD 20,000-100,000 in the USA, but its success rates are as good as in the best US hospitals. Even though 45% of services are free at *AECH*, however, the company has paid for all its expansion projects from its profits.<sup>239</sup> *Jaipur foot* has not only a cost advantage, but it also enables people to have better employment prospects, therefore supports their families and increased their incomes. General Electric earns a great profit from sales of its three innovations, for instance within the first two years its revenue reached a few million dollars. Clinics can benefit from purchases of life-saving equipment as *GE's Lullaby Baby Warmer* since its price is 70% less than the imported warmers of the same class. Additionally, families save money and their infants by using an inexpensive

<sup>234</sup> Cf. Govindarajan, V./Ramamurti, R. (2013), p. 119

<sup>235</sup> Cf. Zeschky, M. et al. (2015), p. 41 and Cf. Immelt, J. et al (2009), p.63

<sup>236</sup> Cf. General Electric Company (2018b)

<sup>237</sup> Cf. Shilpa, K. (2013)

<sup>238</sup> Cf. Coutinho, J. (2011)

<sup>239</sup> Cf. Khan, S./Haldar, O. (2015), pp. 1–6.

incubator at home that cost USD 25, compared with a price of USD 20,000 of a traditional warmer and costly stay in a hospital.<sup>240</sup>

Beginning with eleven beds in 1976, *AECH* has grown to a great hospital chain with eleven hospitals; a center for manufacturing synthetic lenses and pharmaceuticals; a training and research institutes; an international eye bank. It continues to grow.<sup>241</sup> The similar success has *Narayana hospital*, starting with around 225 operational beds in 2000, currently, it has 25 hospitals, 7 heart centers across India and one hospital on the Cayman Islands. It provides jobs to more than 13,000 employees including 3,011 doctors.<sup>242</sup> *Jaipur foot* has reached a staff of 200 and additionally, it provides opportunities to people who had lost their limbs to continue to earn. Without an efficient social security system, being able to work is essential for the poor in India.

### *Sustainable Development Goals*

The all analyzed innovations of healthcare sector promote SDG three, SDG nine and SDG ten, which are Social and Ecological/Economic dimensions of sustainable development. For instance, ensuring healthy lifestyles and promoting well-being for all at all ages have been achieved by providing vision to millions of people, quick diagnosis of health at affordable prices, and providing the necessary warmth to newborns to improve their health in the future life. Other goals such as SDG one, SDG seven, SDG eight, SDG eleven, SDG twelve and SDG 16 are also promoted, but not by all selected frugal innovations.

## 5.2 Discussion of the Results

In the previous chapter, the different cases concerning the framework and the link to the SDGs have been considered. Based on this, a further processing of the sectors follows. By means of these results, conclusions are drawn with regard to sustainability. In addition, further findings are presented in the course of this preparation and consideration. Therefore, the following elaboration is at the sectoral or general level for any considered frugal innovations.

Depending on the sector, there are different distributions of the SDGs. For example, the healthcare and water sectors are increasingly associated with social SDGs such as food security and healthy living. Whereas the transport and energy sectors linked with the economic SDGs

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<sup>240</sup> Cf. Shilpa, K. (2013)

<sup>241</sup> Cf. Gowri, A. (2017), pp. 1-104

<sup>242</sup> Cf. Narayana Hrudayalaya (2018)

seem to be around infrastructure and growth. However, across all sectors, it can be seen that the SDGs are clustered at goals nine and ten (see Appendix 37). These relate to the promotion of reducing inequality within and outside countries. Furthermore, they refer to the establishment of resilient, inclusive and sustainable economic development with an improved infrastructure. The different characteristics across all sectors should also be emphasized. In our framework, the ecological, social and economic characteristics were examined. The survey has shown that, for all three areas of importance, about three-quarters of the cases have a positive impact on their respective environment and comparable cases (see Appendix 36). Especially the social aspects with a very high positive value are worth mentioning, but also the economic characteristics.

To build the bridge back from the SDG level and characteristics level to other findings it is important to look at the motivation and meaningfulness of the cases. In a nutshell, it should be noted that the frugal innovations are specific to the direct economic, climatic and environmental conditions. In the contemplation, therefore, essential coincidences are accentuated, even across different sectors. Precisely, because it affects almost all sectors with the same motivation. In the foreground are correspondingly the provision of access (energy, transport, water, financial transactions, communication, healthcare). Furthermore, the support of inclusion and reduction of inequality. In addition, a decrease in energy consumption over almost all corresponding cases. Hence, the points of providing access, reducing energy consumption as well as promoting the reduction of inequality deserve special mention.

Moreover, the preparation by the framework has revealed further findings. The transport, banking and energy sectors with their cases ensure a foundation for other sectors as well as further steps and support in their implementation. This is particularly evident in the fact that the access to the corresponding products and services creates a sustainable infrastructure on the basis of which it can be built in order to realize other goals in an economy or social development.

It can also be stated that many cases are not just a product or service, while a comprehensive and partially novel business model was developed around. Examples include financing models or distribution channels.

In summary, the overweights in the SDGs in economic and social terms are worth mentioning. This is also reflected in the three characteristics of the framework. Furthermore, these points are consistent with the motivational points. These have indicated that providing access to diverse technology and infrastructure as well as promotion to reduce inequality and inclusion complement each other. This became clear both at the level of the individual cases and across

the individual sectors. Consequently, the definition of both frugal innovation and sustainable development has succeeded. The focus is on meeting the needs from the customer's point of view as well as the resource view. On the one hand, it has been shown that in some cases the needs are not obvious and rather hidden. Secondly, the difficult achievement on the market environment, target group and local conditions, both climatically and structurally. This is where the frugal innovations start. In the interplay, as evidenced by the results, this development leads to the possibility of a sustainable further development. It is therefore associated that frugal innovation and sustainable development correlate.

## 6 Conclusion

### 6.1 Summary

When working on a complex around frugal innovations in connection with sustainable development, one inevitably encounters new insights. Therefore, it is first of all important to explain the basics as a starting point and then to name the findings step by step. The frugal innovations were defined in this elaboration as a new perspective or a new source of innovation. The main criteria are the cost reduction, the concentration on the core functionalities and the performance level. It has turned out that the focus on frugal innovation is currently in developing countries. Accompanying this is the identification of customer needs, which affects both the structural and resource-constrained environment and the respective market. Previous studies on frugal innovation underline this result. In this elaboration, another step was taken to find out to what extent the importance of frugal innovations in their methodology has an impact on sustainable development and whether a correlation can be associated here. Sustainable development is defined as the meeting of needs without compromising the resources. In these studies, this challenge was not clearly mentioned or worked on in a wide range of sectors, which is why this elaboration attempts to fill this gap.

Our research has shown that frugal innovation has a positive contribution and positive impact from an environmental, social and economic point of view. This could be ascertained across all sectors considered. Furthermore, it can be stated that frugal innovations contribute to the improvement of the general living conditions on site as well as the construction or improvement of the infrastructure. Likewise, the result emphasizes that many of the cases considered are not exclusively product or service but include a complete business model. Above all, it can be concluded that these innovations can make a lasting contribution to promoting the further development of the areas and improving the living conditions of the population. Not only through further frugal innovations, but through the general promotion of the necessary foundations for the people. Therefore, it was possible to show that frugal innovations are linked to sustainable development. This is also underlined by the fact that the study of SDGs has majorities in its clusters around social and economic aspects.

## 6.2 Limitations

The selection of frugal innovations as well as the various sectors should not be considered as comprehensive and conclusive. At the time of preparation of the elaboration, the most frequently mentioned cases in the literature were considered with few new cases which we came across and which fit the definition. Due to the factor time, it cannot be ruled out that some of the cases have already disappeared from the market, become obsolete or improved. Likewise, the cases are on the market for different lengths of time and therefore a final consideration under the same reference points is not possible. That is why it is important to keep a constant eye on the innovations on this complex. Further research is required at this point. Besides, future research could lead to different conclusions because it is a complex topic with constant changes. Another point is the processing of the framework, in which small differences can arise from different analysts in subjective aspects. It is also a question of comparability with conventional products or services, if they exist in the respective position and which characteristics they have.

## 6.3 Outlook

It has been shown that frugal innovations are adapted to the local environment and population to meet their needs. Furthermore, the foundations are to be created for the further development of the regions. It was additionally noticed that the participation in the healthcare sector by “General Electric” or “Tata Motors” in the transport sector, because by concentrating on the core function and omitting features as well as cost reduction, existing know-how can create another source of income. This could serve as a model for other multinational companies.

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## Appendix

Case	#	Case	#	Case	#
Tata Nano	25	Ganz's microwave	1	CheX	1
GE's ECG machine	20	Haier's air conditioners	1	D-Rev	1
GE's Ultrasound machine	13	Haier's fridge	1	Diagnostics for paper-based diagnostic tests	1
Aravind Eye Care	10	Lenovo \$300 laptop	1	Dry-Tri	1
Tata Swachh	10	Zhongxing X-Ray Machine	1	Fetal Heart rate Monitor	1
Aakash	7	Nokia 1200	1	Fixed-dose combinations of Anti-retroviral drugs for AIDS	1
M-Pesa	7	Nokia basic phones	1	Food fortification with Iodine and Iron	1
ChutuKool	6	Siemens' Computed Tomography Scanner	1	Generic drugs	1
Husk Power Systems	6	Siemens' wastewater treatment	1	Harman's infotainment systems	1
MittiCool	6	"mssed call" service in India	1	Health care	1
Narayana Hospital	6	A little World-rural banking through mobile phone	1	HMI Line panel	1
Vortex ATMs	6	Acne power interface unit	1	Hole in the wall	1
GE's Lullaby baby warmer	5	ATM on wheels	1	HospIS project	1
Jaipur foot	5	Avaz.De - Voice Message Board for Education	1	Invention Labs	1
Mahindra & Mahindra's small tractors	5	Bamboo Bike	1	Kutcha house	1
Embrace	5	Electronic Voting Machine (India)	1	Low cost sanitary toilets	1
Grameen Bank's microfinance	4	Kerala Palliative Care	1	Low-cost bubble continuous positive airway pressure device (CPAP)	1
Easy Paisa	4	Motorcycle-based tractor	1	Mettler Toledo Weighing Scale	1
Haier's washing machine	3	Nandi - a system for clean water in Andhra Pradesh	1	Micro-PCR device	1
Logitech mouse	3	Scooter-powered flour-mill	1	Mindray- healthcare products	1
Bharti Airtel	3	Superseva	1	Missile	1
Rickshaw Bank in India	3	Kopo Kopo	1	Multix Select DR machine	1
SELCO	3	ToughStuff	1	Oral misoprostol	1
Nokia 1100	2	Medicall in Brazil	1	Oral rehydration therapy	1
Nokia's 101	2	\$ House- housing for the poor	1	OSDD	1
EKO mobile phone banking	2	bcAP for new born breathing	1	Patient Monitoring System	1
Micromax's mobile phone (India)	2	Bahria Town	1	Ponseti method - gold standard treatment of club foot	1
Tata Ace	2	Dacia Logan	1	Probe for Detecting Tuberculosis	1
Unilever's Purit	2	Sovatten	1	Pureit	1
Vodafone Rs.10 pre-paid cellular phone balance	2	Lif Straw	1	Radio Telescope	1
Effectively treat neonatal jaundice is under trial in Philippines and Vietnam	2	HTC \$30 mobile	1	Reverse engineered vaccines	1
Solar Sister	2	Bamboo Microscope	1	Robotic Hand	1
BYD-Lithiumion Battery	2	Beating Heart Surgery	1	Small sachets of Tide for one rupee	1
Immunoassay-based fabric chips	2	WE CARE Solar Suitcase	1	Smart medicine pack by Microsoft Research India	1
Shakerscope	2	Well Baby Bassinet	1	Stove and Fuel	1
eRanger - ambulance for rural Africa	1	\$5K Awami Villas	1	Super Religare Laboratories' Blood collection	1
Unilever's washing-powder sachets	1	Biofortification - to produce staple crops rich in micronutrients	1	Vivian Fonseca- SMS message to control diabetes	1
Mobile e-learning in Bangladesh	1	Bone Drill	1	WiMax	1
Dachangjiang- Motorcycle	1	careHPV	1	XCyto Screen series	1

Appendix 1: Most mentioned Frugal Innovations in Literature

<b>Classification</b>	<b>Goal</b>	<b>Description</b>
Social/Economic	1	End poverty in all its forms everywhere
Social	2	End hunger achieve food security and improved nutrition and promote sustainable agriculture
Social	3	Ensure healthy lives and promote well-being for all at all ages
Social	4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Social	5	Achieve gender equality and empower all women and girls
Social/Economic	6	Ensure availability and sustainable management of water and sanitation for all
Ecological/Economic	7	Ensure access to affordable, reliable, sustainable and modern energy for all
Economic	8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Ecological/Economic	9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
Social	10	Reduce inequality within and among countries
Ecological/Social	11	Make cities and human settlements inclusive, safe, resilient and sustainable
Ecological	12	Ensure sustainable consumption and production patterns
Ecological	13	Take urgent action to combat climate change and its impacts
Ecological	14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Ecological	15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Social/Economic	16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Social/Economic/Ecological	17	Strengthen the means of implementation and revitalize the global partnership for sustainable development

*Appendix 2: Sustainable Development Goals Overview*

Characteristics	Evaluation	Arguments	SDG Indicators
<b>Ecological</b>			
Energy Saving	+		
Material Efficient	-		
Climate Neutral	0		
<b>Social</b>			
Fulfillment of Basic Necessities			
Improves Health and Education			
Promotes Inclusion and Equality			
<b>Economic</b>			
Time Saving			
Increases Income or Saves Money			
Creates New Jobs			
Legend: "+" means positive impact, "0" means neutral/unclear impact and "-" means negative impact			

*Appendix 3: Evaluation Framework*

M-Pesa				
Characteristics	Evaluation	Arguments	SDG Indicators	
<b>Ecological</b>				
Energy Saving	0	neutral impact/no information available	1, 4, 5, 8, 9, 10, 12, 16	
Material Efficient	+	Use via mobile phone		
Climate Neutral	0	Easy money transfers; no bank office needed		
<b>Social</b>				
Fulfillment of Basic Necessities	+	Empowering customers with mobile banking services		
Improves Health and Education	+	Involved with Bridge Int. Academy to organize a transparent and cashless education for only 5\$ a month		
Promotes Inclusion and Equality	+	Providing access to financial services and improves equality.		
<b>Economic</b>				
Time Saving	+	Mobile phone based financial services.		
Increases Income or Saves Money	+	Notable long-term effects on savings and poverty reduction in Kenya		
Creates New Jobs	+	Over 140,000 direct job and business opportunities		

*Appendix 4: Framework M-Pesa*

Vortex ATMs				
Characteristics	Evaluation	Arguments	SDG Indicators	
<b>Ecological</b>				
Energy Saving	+	".. world's lowest power-consuming ATMs..."	1,3,7,9,10,11,12,13	
Material Efficient	+	"..industry-grade motherboards: Configured with extended temperature range for rugged and failure-free performance.."		
Climate Neutral	+	"Electronic journal – saves paper"		
<b>Social</b>				
Fulfillment of Basic Necessities	+	"... indigenously designed and built in India and can operate at any conditions in the world. It helps the banks to reach out anywhere(Rural, semi-urban & urban)..."		
Improves Health and Education	+	"...the unbanked population, which comprises of a large section in India, depends on cash for their daily needs and hence it will always remain a strong part of the Indian economy. In these difficult times, we need a quick solution that can help banks deploy cash in the inaccessible areas..."		
Promotes Inclusion and Equality	+	"Very easy to use, even for users unfamiliar with tech devices - provides biometric authentication.." and "LinguaPrint – Gives customer receipt in the local language chosen by the customer"		
<b>Economic</b>				
Time Saving	+	" The Ecoteller Through the wall ATM consumes very low power ensuring maximum availability in a wide range of environmental conditions"		
Increases Income or Saves Money	+	"....also makes it a profitable initiative due to its lower power consumption..." and" ...provides an extendable to include Cash deposit function"		
Creates New Jobs	0	N/A		

*Appendix 5: Framework Vortex ATMs*



Grameen Bank's microfinance				
Characteristics	Evaluation	Arguments	SDG Indicators	
<b>Ecological</b>				
Energy Saving	0	neutral impact/no information available	5, 8, 10, 11, 16	
Material Efficient	0	neutral impact/no information available		
Climate Neutral	0	neutral impact/no information available		
<b>Social</b>				
Fulfillment of Basic Necessities	+	The Grameen Bank provides loans of only a few hundred Euros (in local currency) and is given to poor households, mainly women, in rural areas of Bangladesh. This loan opens up new possibilities.		
Improves Health and Education	0	neutral impact/no information available		
Promotes Inclusion and Equality	+	The possibility of self-employment and access to money helps to empower women		
<b>Economic</b>				
Time Saving	0	neutral impact/no information available		
Increases Income or Saves Money	+	Financial resources and services are available to poor people in rural areas at reasonable terms and conditions. As a result, socially disadvantaged people have the opportunity to start their own business or to take on new job opportunities		
Creates New Jobs	+	Poor people can start their own business		

Appendix 6: Framework Grameen Bank's Microfinance

Easy Paisa				
Characteristics	Evaluation	Arguments	SDG Indicators	
<b>Ecological</b>				
Energy Saving	0	Indirect impact. Using mobile phone service leads to energy consumption	1; 3; 8; 9;10; 12	
Material Efficient	+	Don't need to open new bank branches to reach customers		
Climate Neutral	0	N/A		
<b>Social</b>				
Fulfillment of Basic Necessities	+	Improved the quality of lives of BOP customers. Enables financial services to be accessible and affordable to many poor people. (41% of EasyPaisa users live on less than \$2.50 per day; 69% live on less than \$3.75 per day, but few customers (5%) were living below \$1.25 per day.		
Improves Health and Education	+	"Agents are then specifically trained for Easypaisa by the Telenor teams"; "gave agents the phone first and trained them to process OTC transactions, so that they would become comfortable with the service."; "branchless/mobile account holders are provided monthly life insurance coverage based on the average monthly balance in their mobile accounts"		
Promotes Inclusion and Equality	+	Reduce Financial exclusion. Enables people who lack access to financial products such as transaction banking, savings or insurance.		
<b>Economic</b>				
Time Saving	+	"customers save on transportation time and expense because Agent's shop is close by."		
Increases Income or Saves Money	+	"agent set-up and maintenance costs for agents are much lower than those required for branches and satellite touch points. For example, an average set-up costs \$70,000 along with maintenance costs estimated at about \$10,000 per month. " 2) " each active agent earning about \$125 on a monthly basis." 3) Still expensive for many people.		
Creates New Jobs	+	"220 full-time employees involved in Easypaisa (including 80 from the Merge with Tameer); In general: EasyPaisa's "structure is mostly built on a foundation of Telenor's existing agent network structure, which originally defined the territories to be handled by master agents"; "built up a large agent network on OTC volumes reaching some 30,000 points of service across Pakistan"		

*Appendix 7: Framework Easy Paisa*

Rickshaw Bank in India				
Characteristics	Evaluation	Arguments	SDG Indicators	
<b>Ecological</b>				
Energy Saving	0	N/A	1,2,3,4,7,8,9,10,11,12,13	
Material Efficient	+	"...a new rickshaw has been developed with the help of the India Institute of Technology using materials that are lighter and more aerodynamic. The model was found to be 40 per cent lighter than the conventional rickshaws and had ergonomic advantages.."		
Climate Neutral	+	"...decrease in fossil fuel emission by popularizing rickshaws, promoting the usage of environmental-friendly cooking fuel.."		
<b>Social</b>				
Fulfillment of Basic Necessities	+	the Rickshaw Bank seeks to improve urban life.." and ".. it would rent rickshaws to participating pullers with a daily rent treated as repayment towards the cost of the rickshaw and in just one year, the puller would become the owner of his vehicle"		
Improves Health and Education	+	"...improving the health of drivers and their families; better opportunities for children to go to school, improving law and order (less control by the mafia) and creation of a more positive working environment.."		
Promotes Inclusion and Equality	+	"Bank loans now exist to buy their rickshaw, with the help of a development NGO, following agreements with financial institutions and ministries. The loan is fully repaid within a 12 - 24 month period as pullers use a payment plan equivalent to the same amount of 25 rupees a day..."		
<b>Economic</b>				
Time Saving	+	"...lighter model of the vehicle enables the puller to carry more trips leading to more income.."		
Increases Income or Saves Money	+	"...access to ownership of a rickshaw increases income and living standards and access to financial resources.."		
Creates New Jobs	+	"...job creation for young people and opportunities for local companies to increase their sales.."		

*Appendix 8: Framework Rickshaw Bank Project*

EKO Mobile Phone Banking				
Characteristics	Evaluation	Arguments	SDG Indicators	
<b>Ecological</b>				
Energy Saving	0	N/A	1,2,5,7,8,10,11	
Material Efficient	0	N/A		
Climate Neutral	0	N/A		
<b>Social</b>				
Fulfillment of Basic Necessities	+	"...struggle for financial inclusion is the rule, not the exception, for India's 100-120 million migrant workers. According to a recent study by the Centre for Micro Finance (CMF), only 22% of India's migrant labourers have bank accounts" Migrants hoping to open a bank account face myriad challenges. Most migrant labourers work in the informal economy—as cooks, rickshaw pullers and in construction—living onsite or in urban slums. Without local identification, or official "residential" addresses, it's nearly impossible to meet banks' rigorous "know your customer" requirements. According to the CMF study, 77% of migrants say not having official identity and		
Improves Health and Education	0	N/A		
Promotes Inclusion and Equality	+	"...there are a few SMS-based bank applications in India, but Eko differs because the phone isn't just another channel for the account—it is the account. You make payments and transfer money simply by dialing numbers. It's so simple, you don't even need to understand SMS to use it..."		
<b>Economic</b>				
Time Saving	+	"...most migrants—57%, according to the study—rely on informal means such as hawala couriers and truck drivers, often risky and almost always more expensive than transferring money through banks"		
Increases Income or Saves Money	+	"...the entire process takes approximately 10 minutes, thanks to mobile banking.."		
Creates New Jobs	+	"...not only are clients adopting the service, but the business is a popular new source of income for Eko's agents – upwards of \$20 in fees can be earned in a day, a figure much higher than the \$1-5 often earned by agents in India..."		

*Appendix 9: Framework EKO Mobile Phone Banking*

Tata Nano			
Characteristics	Evaluation	Arguments	SDG Indicators
<b>Ecological</b>			9, 10, 12
Energy Saving	+	The Tata Nano has a small 30 hp engine and consumes about 5 liters of gasoline per 100 km (refers to model and year of construction) and low weight	
Material Efficient	+	The Tata Nano has only the bare minimum on board for the cost-cutting strategy (for example just one windshield wiper)	
Climate Neutral	0	Neutral impact - emits about the same amount of pollutants as comparable vehicles	
<b>Social</b>			
Fulfillment of Basic Necessities	+	The Tata Nano was designed to replace the overloaded two-wheelers of families for safer transportation and more comfortable for an affordable price (around 2.000 USD)	
Improves Health and Education	+	Safer compared to two-wheelers	
Promotes Inclusion and Equality	-	Only affordable for the middle class (more expensive than a two-wheeler, but much cheaper than other cars)	
<b>Economic</b>			
Time Saving	0	neutral impact/no information available	
Increases Income or Saves Money	+	The low initial price made the Tata Nano affordable for India's middle class families	
Creates New Jobs	0	No further information available - the Tata Motors Group has over 40,000 employees and a large product and model portfolio	

Appendix 10 : Framework Tata Nano

Mahindra tractor (Yuvraj 215)				
Characteristics	Evaluation	Arguments	SDG Indicators	
<b>Ecological</b>				
Energy Saving	+	Best fuel economy and better than current small tractors/power tillage (Chetan, 2012)	1, 2, 3, 7, 8, 9, 10, 11, 12, 15, 16 17	
Material Efficient	+	light in weight at 780 Kg, leading to low soil compaction and hence better yield " (Chetan, 2012)		
Climate Neutral	-	Since more people can afford the tractor, emission of carbon increases.		
<b>Social</b>				
Fulfillment of Basic Necessities	+	Allows farmers to use a tractor on their land less than 5 acres. (Chetan, 2012)		
Improves Health and Education	+	The use of a tractor much easy than conventional plowing with bullocks or power tillers. (Chetan, 2012)		
Promotes Inclusion and Equality	+	With the compact size and functionality the tractor is best suited for small field pans, vegetable farmers; those who own orchards, or cultivate crops such as soyabean or cotton; for specific applications like inter-culture, power generation or water pumping. Thus allowing different kind of farmers to benefit from the use. (Chetan, 2012)		
<b>Economic</b>				
Time Saving	+	Compared to traditional farming, mechanical farming does four times as much work. "Enhances productivity per hectare in comparison to other small tractor/ power tillers (Chetan, 2012)		
Increases Income or Saves Money	+	Farmer enjoys the benefit of low operational cost among all tractors in its range (Chetan, 2012)		
Creates New Jobs	0	N/A		

Appendix 11: Framework Mahindra & Mahindra's tractor Yuvraj 215

Sono Motors Sion				
Characteristics	Evaluation	Arguments	SDG Indicators	
<b>Ecological</b>				
Energy Saving	+	The Sion is a solar car that additionally charges its battery through the sun. So up to 30 kilometers of range can be generated daily by solar energy	9, 12, 13, 15, 16	
Material Efficient	+	The body is made of polycarbonate and the interior uses mainly renewable materials. Low maintenance costs compared to conventional fueled vehicles		
Climate Neutral	+	Local emission-free (depends on how electricity is produced) and solar panels		
<b>Social</b>				
Fulfillment of Basic Necessities	0	An electric car for the usual normal everyday use with a range of 250 km		
Improves Health and Education	+	No harmful exhaust gases as it drives locally emission-free		
Promotes Inclusion and Equality	0	neutral impact/no information available		
<b>Economic</b>				
Time Saving	0	Compared to conventional combustion engines long charging time		
Increases Income or Saves Money	+	A low sale price of 16,000 euros (plus battery about 4000 euros) and the possibility to make the car as a battery also for public access and thereby earn money		
Creates New Jobs	+	It is a growing startup financed by crowd funding		

Appendix 12: Framework Sono Motors Sion

Tata Ace				
Characteristics	Evaluation	Arguments	SDG Indicators	
<b>Ecological</b>				
Energy Saving	0	The standard Ace has at ist market launch a two-cylinder engine with 16 hp (further engines and specifications are now available)	8, 9, 10, 12	
Material Efficient	+	The Tata Ace has shaped a new vehicle category and has successfully filled these niches through the efficient use of ingenuity and materials		
Climate Neutral	0	The engineers have found solutions to achieve low emissions and thus standards		
<b>Social</b>				
Fulfillment of Basic Necessities	+	The Tata Ace was designed as a small commercial vehicle for the market of three-wheeler and can transport loads of up to 0.75 tons. At the launch 2005, the Ace cost the equivalent of 4,000 USD and was about half cheaper than other four-wheeled commercial vehicles in India at that time		
Improves Health and Education	0	neutral impact/no information available		
Promotes Inclusion and Equality	+	Due to the low entry price, this commercial vehicle is more affordable for many users than comparable other utility vehicles		
<b>Economic</b>				
Time Saving	0	neutral impact/no information available		
Increases Income or Saves Money	0	The Tata Ace has a low entry price for a small four-wheeled commercial vehicle		
Creates New Jobs	0	Unclear impact - the Tata Motors Group has over 40,000 employees and a large product and model portfolio		

Appendix 13: Framework Tata Ace



SELCO				
Characteristics	Evaluation	Arguments	SDG Indicators	
<b>Ecological</b>				
Energy Saving	+	The systems utilize solar photovoltaic modules to provide electricity.	3, 4, 6, 7, 8, 9, 16	
Material Efficient	0	The core of SELCO is to provide customized solutions based on end user needs		
Climate Neutral	+	Through provision of solar lights, SELCO has been able to successfully empower individuals to run their households and businesses without dependence on fuel based products for lighting		
<b>Social</b>				
Fulfillment of Basic Necessities	+	A business model which brings the benefits of clean energy at an affordable price to rural India through financial and technological innovation		
Improves Health and Education	+	Longer working hours in better quality light has led to higher incomes and better education while lesser dependence on conventional fuels has improved health conditions		
Promotes Inclusion and Equality	+	SELCO played a key role in persuading the large commercial and rural banks to finance sustainable energy systems for poor rural households		
<b>Economic</b>				
Time Saving	+	The technology allows you to work longer and more efficiently regardless of daylight and other energy supplies		
Increases Income or Saves Money	+	The income of customers has effectively increased and they receive bonus income from the additional features of the facility. Also save on electricity costs and SELCO has facilitated lending as part of its business model		
Creates New Jobs	+	Skill force of over 375 employees		

Appendix 14: Framework SELCO

Husk Power Systems				
Characteristics	Evaluation	Arguments	SDG Indicators	
<b>Ecological</b>				
Energy Saving	+	"...ensures villagers aren't using more electricity than they pay for. (Electricity theft is a national problem in India, Husk Power states it has managed to keep such losses down to five percent)"..	1,2,3,4,5,6,7,8,9,10,11,12 ,13,15,16	
Material Efficient	+	"Found ways to extract value from the rice husk char — the waste product of a waste product — by even setting up another side business turning the char into incense sticks."		
Climate Neutral	+	"..less smoky, less of a fire hazard, and better for the environment" and "...replaced an automated water-aided process for the removal of rice husk char (burned husks) from gasifiers with one that uses 80 percent less water and can be operated with a hand crank".."		
<b>Social</b>				
Fulfillment of Basic Necessities	+	"..no country has more citizens living without power than India, where more than 400 million people, the vast majority of them villagers, have no electricity. The place that remains most in darkness is Bihar, India's poorest state, which has more than 80 million people, 85 percent of whom live in households with no grid connection..."		
Improves Health and Education	+	" ..about a billion and a half people— still lack electricity. This isn't just an inconvenience; it takes a severe toll on economic life, education and health. It's estimated that two million people die prematurely each year as a result of pulmonary diseases caused by the indoor burning of fuels for cooking and light. Close to half are children who die of pneumonia.."		
Promotes Inclusion and Equality	+	"Husk Power has identified at least 25,000 villages across Bihar and neighboring states in India's rice belt as appropriate for its model which could go a long way in bringing light to 125,000 unelectrified villages in India.."		
<b>Economic</b>				
Time Saving	+	"..allows shop keepers to stay open later and farmers to irrigate more land, and lighting increases children's studying time and reduces burglaries and snakebites.."		
Increases Income or Saves Money	+	"..created a system to turn rice husks into electricity that is reliable, eco-friendly and affordable for families that can spend only \$2 a month for power.."		
Creates New Jobs	+	"..kept labor costs down by recruiting locals, often from very poor families with modest education levels (who would be considered unemployable by many companies) and training them to operate and load machines, and work as fee collectors and auditors.."		

Appendix 15: Framework Husk Power Systems

Aakash				
Characteristics	Evaluation	Arguments	SDG Indicators	
<b>Ecological</b>				
Energy Saving	0	N/A	1,4,5,7,8,10	
Material Efficient	0	"Ebook Reader: Offset device cost against cost of printing paper and distribution – and save trees"		
Climate Neutral	0	N/A		
<b>Social</b>				
Fulfillment of Basic Necessities	+	"Expected to revolutionize education in India by not only changing how children are educated, but also enhancing their access to information through the Internet"		
Improves Health and Education	+	"Company is focused on expanding the roll-out of the Aakash tablet, which is designed to be affordable, deliver high quality content, and provide access at the lowest cost or for free, where possible"		
Promotes Inclusion and Equality	+	"A target to distribute five million tablets in India and expects that more than 80% will reach individuals who live at the base of the pyramid-- living on less than \$8 dollars a day"		
<b>Economic</b>				
Time Saving	+	"Richer, faster user experience while consuming much less data: 1.5MB/hr (vs. 40MB/hr) "		
Increases Income or Saves Money	+	"Patented a unique delivery system to provide low-income consumers valuable data services at the lowest cost possible"		
Creates New Jobs	+	"Domestic production motivates Governments : Creates local employment, Generates tax revenue , Creates opportunities for local innovation"		

Appendix 16: Framework Aakash

Bharti Airtel			
Characteristics	Evaluation	Arguments	SDG Indicators
<b>Ecological</b>			9, 10, 11, 12
Energy Saving	0	neutral impact/no information available	
Material Efficient	+	Core competencies were already outsourced to experts and service providers in the early phase, thereby reducing costs and material usage	
Climate Neutral	0	neutral impact/no information available	
<b>Social</b>			
Fulfillment of Basic Necessities	+	Bharti Airtel is a fully-fledged telecommunications company providing mobile reception and internet in developing countries (and other services like mobile payments)	
Improves Health and Education	0	neutral impact/no information available	
Promotes Inclusion and Equality	+	In the first quarter of 2018, Bharti Airtel announced the number of customers for all offered services at over 418 million	
<b>Economic</b>			
Time Saving	+	Mobile reception even in remote locations	
Increases Income or Saves Money	+	The intelligent network construction through the involvement of experienced service providers reduced the user costs of the end customer	
Creates New Jobs	0	neutral impact/no information available	

*Appendix 17: Framework Bharti Airtel*

Nokia 1100				
Characteristics	Evaluation	Arguments	SDG Indicators	
<b>Ecological</b>				
Energy Saving	+	Long operating time between charging	9, 10, 11, 12	
Material Efficient	+	A mobile phone which uses simple and existing mobile technology, few other features and monochrome display		
Climate Neutral	0	neutral impact/no information available		
<b>Social</b>				
Fulfillment of Basic Necessities	+	A functional mobile phone with features designed to suit the environment, such as a flashlight (frequent power outages), multiple address books for multiple users (family phone) and a silicone and plastic case for a damp and dusty environment		
Improves Health and Education	0	neutral impact/no information available		
Promotes Inclusion and Equality	+	A mobile phone that can be used by several people (for example families) at an affordable price.		
<b>Economic</b>				
Time Saving	+	Nokia has vans ("showrooms on wheels") that drive through remote areas to support and repair mobile phones as well as handle sales with partners		
Increases Income or Saves Money	+	With an introductory price (2003) of about 20 USD it's affordable		
Creates New Jobs	0	neutral impact/no information available		

Appendix 18: Framework Nokia 1100

Micromax X1i				
Characteristics	Evaluation	Arguments	SDG Indicators	
<b>Ecological</b>				
Energy Saving	+	"Do not need recharging for a month or longer"	7, 8, 9, 10, 16	
Material Efficient	0	N/A		
Climate Neutral	-	"The manufacture of a mobile phone produces about 60 kg of CO2 and using a mobile phone for a year produces about 122 kg of CO2e." "mobile phones contain a large number of hazardous substances, including antimony, arsenic, beryllium, cadmium, copper, lead, nickel, zinc "		
<b>Social</b>				
Fulfillment of Basic Necessities	+	Enables people living in previously unrelated fields to join the global information society		
Improves Health and Education	-	"Using mobile phones can harm the brain, and excessive use of mobile phones has been associated with dizziness."		
Promotes Inclusion and Equality	+	Enables people from areas where electric supply is unstable to be reachable.		
<b>Economic</b>				
Time Saving	0	Indirect impact (people communicate faster than through brief communication)		
Increases Income or Saves Money	+	People with low income could afford the phone; Rapidly increased company's financial performance (by 271%) and market share (the 3rd position in the industry)		
Creates New Jobs	+	Success in the mobile sector has enabled the company to go globally (Russia, Bangladesh, Sri Lanka)		

*Appendix 19: Framework Micromax X1i*

Vodafone Solar Powered Mobile VF 247 (pre-paid cellular phone service voucher)				
Characteristics	Evaluation	Arguments	SDG Indicators	
<b>Ecological</b>				
Energy Saving	+	"inbuilt hardware and software called 'Sun Boast' makes it possible for the phone to charge under normal daylight" (Dhavale 2013); "The phone can support more than eight days of use on standby and four hours of talk time" ( <a href="https://www.zdnet.com/article/vodafone-debuts-32-solar-powered-mobile-phone-for-rural-india/">https://www.zdnet.com/article/vodafone-debuts-32-solar-powered-mobile-phone-for-rural-india/</a> );	7, 9, 12; 10; 7, 8,16; 17	
Material Efficient	+	"Vodafone encouraged customers to return their unwanted handsets and accessories to them for reuse (whenever possible) and recycling." "offers a buyback proactive procedure, which aims to increase the number of handsets collected for recycling. (Manivannan 2016);		
Climate Neutral	-	"the manufacture of a mobile phone produces about 60 kg of CO2 and using a mobile phone for a year produces about 122 kg of CO2e." "mobile phones contain a large number of hazardous substances, including antimony, arsenic, beryllium, cadmium, copper, lead, nickel, zinc " (Manivannan 2016)		
<b>Social</b>				
Fulfillment of Basic Necessities	+	creating access to affordable, reliable, sustainable and modern energy for all; the possibility of communication		
Improves Health and Education	-	"Using mobile phones can harm the brain, and excessive use of mobile phones has been associated with dizziness." (Manivannan 2016)		
Promotes Inclusion and Equality	+	for people residing in areas where electric supply is unstable, so that consumers can rely on solar charging to remain connected		
<b>Economic</b>				
Time Saving	0	Indirect impact (people communicate faster than through brief communication)		
Increases Income or Saves Money	+	Affordable price enable more people in rural India to go mobile; selling pre-paid cellular phone service vouchers for as low as Rs.10.(\$0.2)(Dhavale 2013); by using solar charging do not need to spend money on electricity		
Creates New Jobs	0	N/A		

Appendix 20: Framework Vodafone Solar Powered Mobile VF 247

Aravind Eye Care Hospital				
Characteristics	Evaluation	Arguments	Promotion of SDC	
<b>Ecological</b>				
Energy Saving	0	N/A	3, 8, 9, 10, 12, 16	
Material Efficient	+	".. had perfected its own version of manual sutureless cataract surgery instead of the usual surgery done with suture or with the use of expensive equipment and instrumentation. The productivity of the doctors was also increased as each surgeon worked on two operation tables alternately"; " The equipments used for eye care were of high quality but rooms were utilitarian"		
Climate Neutral	0	N/A		
<b>Social</b>				
Fulfillment of Basic Necessities	+	"By empowering the blind people with the precious gift of eyesight, their quality of life improves."		
Improves Health and Education	+	"For an estimated 45 million people worldwide, and 9 million in India, have needless blindness. Eradication of needless blindness contributes to human well-being". "... a focus on the professional growth of all the doctors"		
Promotes Inclusion and Equality	+	Both rich and poor people receive the treatment.		
<b>Economic</b>				
Time Saving	+	"The comparison of surgeon productivity indicated that it was 6 times compared to the surgeons elsewhere. In Aravind an ophthalmologist performed in-between 6 to 8 Intraocular Lens surgeries per hour while it was one or two surgeries in the rest of the world".		
Increases Income or Saves Money	+	"Poor patients who come to the "free section" were not charged any consultation fee or for many of the surgical procedures not involving any expensive supplies."		
Creates New Jobs	+	The construction of the Hospital in Tirupati; Infrastructure expansion in Chennai and Coimbatore.		

Appendix 21: Framework Aravind Eye Care Hospital



Narayana Hrudayalaya				
Characteristics	Evaluation	Arguments	Promotion of SDGs	
<b>Ecological</b>				
Energy Saving	0	N/A	3, 8, 9, 10, 12, 16	
Material Efficient	+	"It did not purchase much medical equipment, opting instead to lease; NH paid only for the reagents needed for the equipment."; "...makes proper utilization of its resources, whether financial, material or human resources. The high physician productivity is achieved through their concentration of core jobs"		
Climate Neutral	0	N/A		
<b>Social</b>				
Fulfillment of Basic Necessities	+	By allowing access to the best health care, even to those who cannot afford it, NH improves quality of life.		
Improves Health and Education	+	"Offering world class cardiac care at radically low cost promotes human well-being by all means"; provides wide range of trainings; " Training programs were developed to try to retain nurses"		
Promotes Inclusion and Equality	+	"Both rich and poor receive this treatment. Poor patients who otherwise cannot dream of highly expensive surgeries, such as those performed in the US, receive it free of charge in India."		
<b>Economic</b>				
Time Saving	+	"Surgeons are measured on the time they take for an operation, the number of stitches and units of blood used... NH to cut costs radically is limiting surgeons' involvement in surgery to only the very highly complex elements of the heart operation, with other tasks like preparation and paperwork being reallocated to less expensive staff"		
Increases Income or Saves Money	+	"providing around 60 free operations a week to poor patients"		
Creates New Jobs	+	"plans to build 300-bed secondary-care hospitals in smaller cities across India, with a goal to operate 30,000 beds in seven years"		

Appendix 22: Framework Narayana Hrudayalaya Hospital

Jaipur Foot				
Characteristics	Evaluation	Arguments	Promotion of SDGs	
<b>Ecological</b>				
Energy Saving	0	N/A	1, 3, 9, 10, 12	
Material Efficient	+	"Below-knee as well as above-knee prosthetic products are indigenously designed and fabricated from locally available and durable high-density polyethylene pipes and a Jaipur Foot. These are rapid-fit limbs with low fabrication times. Fitting and fabrication times vary from one hour for below knee prostheses to about five to six hours for above-knee prostheses"; "has laid down extremely simple procedures for reception, admission, measurement taking, manufacturing, fitting, and discharge of patients. Unlike in medical centers all over the world, patients are admitted as they arrive without regard to the time of day."		
Climate Neutral	-	Produced from polyurethane. There is no information that the producer of Jaipur foot provides any instructions on how to dispose of the product at the end of its service life, for instance, where it can be sent for reuse.		
<b>Social</b>				
Fulfillment of Basic Necessities	+	Amputees who receive Jaipur Foot have a better quality of life. People have better employment prospects to therefore support their families.		
Improves Health and Education	+	"Empowering the poor by allowing them to take control of their lives"; "A Jaipur Foot artisan is a craftsman with several years of experience who is further trained for several more years to mold, sculpt, and form the Jaipur Foot."		
Promotes Inclusion and Equality	+	Rich and poor alike receive this treatment. Poor people, who have no means to afford expensive prosthetics, can still receive the Jaipur Foot free of charge. Promotes solidarity by helping poor sections of society.		
<b>Economic</b>				
Time Saving	+	By simplifying procedures and using easy and fast manufacturing and fitting processes, customers can walk within a few hours; "A mobile initiative called 'Jaipur Foot on Wheels'...to reach out to those who are unable to travel"		
Increases Income or Saves Money	+	Ability to walk on two legs enables people to have better employment prospects, therefore support their families and increased their incomes;" Jaipur Foot costs \$45 to manufacture but is given free of cost to the poor"; "Artisans and technicians, who are more experienced artisans, operate in a supervisory capacity and are paid by the hour plus overtime. A typical artisan earns 5,000 Rupees per month, or roughly US\$100 including benefits. The estimated US\$1,200 annual income of an artisan is approximately twice that of the per-capita income in India"		
Creates New Jobs	+	"Number of paid staff: 200; Affordable prostheses and fast adjustment allow enables amputees to work, thereby contributing to the creation of jobs,"... an amputee can work in wet and muddy fields."		

Appendix 23: Framework Jaipur Foot

GE Handheld Electrocardiogram (Mac 400)				
Characteristics	Evaluation	Arguments	Promotion of SDGs	
<b>Ecological</b>				
Energy Saving	+	"It has rechargeable batteries that could be charged in three hours and allowed over 100 ECGs or a week of use between charges"	3, 7, 8, 9, 10, 12, 16	
Material Efficient	+	Reduction of size leads to reduction of raw materials. 1)"The multiple buttons on conventional ECGs have been reduced to just four" (The Economist 2010) "simple one touch operation; 2) "the weight is 1,3 kg instead of 7 kg of conventional models"		
Climate Neutral	+	"The product described in this guide must not be disposed as unsorted municipal waste and must be collected separately. Please contact an authorized representative of the manufacturer for information concerning the decommissioning of your equipment."		
<b>Social</b>				
Fulfillment of Basic Necessities	+	"developed for use in rural Chinese areas"		
Improves Health and Education	+	"allows for the examinations to be carried out at the home of the patients. Previously, patients had to travel to distant hospitals or medical centers to receive treatment"		
Promotes Inclusion and Equality	+	Both rural and urban Chinese people have access to quick diagnostics.		
<b>Economic</b>				
Time Saving	+	"allows for the examinations to be carried out at the home of the patients. Previously, patients had to travel to distant hospitals or medical centers to receive treatment"		
Increases Income or Saves Money	+	"...provides no-interest loans for rural doctors", thereby allowing doctors not to invest additional funds; "The company generated a few million dollars in revenues within the first two years."; "...sells for \$800 instead of \$2,000 for a conventional ECG and has reduced the cost of an ECG test to just \$1 per patient."		
Creates New Jobs	0	N/A		

Appendix 24: Framework GE Handled Electrocardiogram (MAC 400)

GE Portable Ultrasound				
Characteristics	Evaluation	Arguments	Promotion of SDGs	
<b>Ecological</b>				
Energy Saving	0	N/A	3, 8, 9, 10,12, 16	
Material Efficient	+	"Instead of a large box full of custom hardware, sophisticated technology were involved."		
Climate Neutral	+	"The ultrasound unit uses RF energy only for its internal function. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment. The device must not be destroyed by incineration. Please return the device to your local GE representative for disposal."		
<b>Social</b>				
Fulfillment of Basic Necessities	+	Quick and easy access to health check-in		
Improves Health and Education	+	"More than 90% of China's population relied on poorly funded, low-tech hospitals or basic clinics in rural villages. These facilities had no sophisticated imaging centers, and transportation to urban hospitals was difficult, especially for the sick. Patients couldn't come to the ultrasound machines; the ultrasound machines, therefore, had to go to the patients."		
Promotes Inclusion and Equality	+	Rural clinics in China can afford the device and provide service to people from rural area		
<b>Economic</b>				
Time Saving	+	The device can be used at accident sites thus don't need to transfer a patient to hospital in order to diagnose problems.		
Increases Income or Saves Money	+	"By 2007 its number of engineers had grown from 13 to 70 and it total payroll from 132 to 339 "; "sold for as low as \$15,000 less than 15% of the cost of GE's high-end ultrasound machine"		
Creates New Jobs	+	GE created a new independent team within the company in Wuxi, China "recruiting locally"; "By 2007 its number of engineers had grown from 13 to 70"		

Appendix 25: Framework GE Portable Ultrasound (Vscan)

Embrace Baby Warmer				
Characte ristics	Evaluation	Argumets	Promotion of SDGs	
<b>Ecological</b>				
Energy Saving	+	"...is an easy-to-use, portable infant warmer that does not need continuous power supply."	3, 7, 8, 9, 10, 11, 12	
Material Efficient	+	"The entire sleeping bag can be sanitized in boiling water. It is far more intuitive to use than traditional incubators, and fits well into the recommended practice of "Kangaroo Care," where a mother holds her baby against her skin. 2) "... were initially designed to separate premature babies from their mothers; ...allow babies and mothers to be closer." (Westcott 2015)		
Climate Neutral	+	No energy is required for operation		
<b>Social</b>				
Fulfillment of Basic Necessities	+	Fulfillment of basic needs such as life and the opportunity to be parents. Reduces babies mortality in developing countries where incubators are extremely rare. Most hospitals and clinics in developing countries don't have enough incubators to meet the tremendous needs, since they are extremely expensive.		
Improves Health and Education	+	Helps to save the life of premature babies by providing thermal support.		
Promotes Inclusion and Equality	+	The incubator promotes equality between prematures from both poor and rich parents, since it has an affordable price and can be used outside of hospitals. "... is intuitive enough to be used by a healthcare worker or a mother."		
<b>Economic</b>				
Time Saving	+	The Embrace Incubator is small and light, making it easy and inexpensive to transport to rural villages.		
Increases Income or Saves Money	+	" while a conventional incubator can cost as much as ₹10 lakh (\$20,000), the Embrace warmer costs ₹15,000 (\$25) on average."		
Creates New Jobs	+	Local recruitment. "The Embrace team consists of 35 people, primarily located in Bangalore, India"		

Appendix 26: Framework Embrace Baby Warmer

GE Lullaby Baby Warmer				
Characteristics	Evaluation	Arguments	Promotion of SDGs	
<b>Ecological</b>				
Energy Saving	+	1) "Whereas conventional warmers consume around 600 to 700 kilowatts, this GE warmer consumes 158 watts and can thus work with solar energy, convenient for hospitals in remote settings." 2) Patient's skin temperature can be maintained at a low heater output. Innovative Calrod heater design: Faster heating than ceramic	3, 7, 9, 10, 16	
Material Efficient	+	Allows for infection control: Easy to clean and disinfect surface. Minimal risk of rupture.		
Climate Neutral	+	1) Reduced output results in lower insensible water loss; 2) "60% less power consumed on start-up and 20% less power consumed over 24 hours."		
<b>Social</b>				
Fulfillment of Basic Necessities	+	Provides delicate warmth to prematures and emulate the mother's womb. increase access to affordable technologies; contributes to the reduction of child mortality; Fulfillment of basic needs such as life and the opportunity to be parents.		
Improves Health and Education	+	"In a world where too many women don't survive childbirth and too many newborns don't survive their first month, ensuring the health of every mother and infant is more than a social concern". "GE Healthcare designed the Lullaby Warmer with both the newborn and caregiver in mind. Our goal is to ensure maximum safety for the most delicate patient in the world."		
Promotes Inclusion and Equality	+	"We need new cost-effective and reliable solutions to bridge the huge gap of unmet healthcare needs in India. Addressing this need will help us grow as well."		
<b>Economic</b>				
Time Saving	+	Designed for staff efficiency and comfort: Intuitive and designed for ease of use; The features, which includes manual temperature management modes, well-positioned lighting, convenient APGAR timer and rapid prewarming setting, allow doctors easy access to infants and their examination.		
Increases Income or Saves Money	+	1) The Lullaby Warmer follows all the safety standards prescribed by the International Electro-technical Commission (IEC) for such life saving equipment and still its price is 70% less than the imported baby warmers of the same class; 2) " With the new products, it hopes to expand this market in India and increase its market share by 10 per cent."; "The products made in India are also already exported to markets in Africa and Latin America."		
Creates New Jobs	-	N/A		

Appendix 27: Framework GE Lullaby Baby Warmer

Tata Swach				
Characteristics	Evaluation	Arguments	Promotion of SDGs	
<b>Ecological</b>				
Energy Saving	+	"No electricity required"	2, 3, 6, 7, 9, 10, 11, 12,15	
Material Efficient	+	1) "Built around a bulb-like water purifier made of natural elements like rice husk ash" ; 2) "One of the longest lifespan in the category, enough for a family of four for a year";		
Climate Neutral	+	In comparison with boiling water, especially with solid fuels, that results in carbon emissions, the filters are more climat neutral.		
<b>Social</b>				
Fulfillment of Basic Necessities	+	Access to safe and healthy drinking water		
Improves Health and Education	+	1) "The water purifier uses the advanced Silver Nano-Technology to remove 100 crore bacteria and 1 crore viruses from 1 litre water to get assured safe drinking water"; 2) Idirect impact on education.		
Promotes Inclusion and Equality	+	1) Affordable drinking water access for the rural poor, no running water needed; 2) " was based on launching Swach at a very low price of USD\$22."		
<b>Economic</b>				
Time Saving	+	Easy to clean and easy to assemble.		
Increases Income or Saves Money	+	Half the price of comparable water purifiers at it's launching in 2009.		
Creates New Jobs	0	N/A		

*Appendix 28: Framework Tata Swach*

Unilever Pureit Water Filter				
Characteristics	Evaluation	Arguments	Promotion of SDGs	
<b>Ecological</b>				
Energy Saving	+	"... the unit was designed to operate without electricity or other power and without a piped-in water supply."	2, 3, 6, 7, 9, 11, 12, 15, 17	
Material Efficient	+	"Made of strong plastic to ensure the purifier has a long life; Multi-stage purification process; Removes 1 crore virus of water; remove harmful pesticides to make water safe for consumption"		
Climate Neutral	+	1) In comparison with boiling water, especially with solid fuels, that results in carbon emissions, the filters are more climat neutral. 2)"carbon footprint is at least 80% smaller than boiled or bottled water."		
<b>Social</b>				
Fulfillment of Basic Necessities	+	Access to safe and healthy drinking water.		
Improves Health and Education	+	1)"The geometric mean reductions met the requirements for a microbial water purifier prescribed by the EPA protocol." "6-log reduction of bacteria, 4-log reduction of viruses, and 3-log reduction of protozoan cysts"; 2)" Initially, HUL focused on educating consumers, for which the company built an expansive DTH network, and also focused on building awareness amongst doctors."		
Promotes Inclusion and Equality	-	"cheaper than the more established, higher end filters, but at \$40 is still too expensive for most of the base-of-the-pyramid consumers, and cannot be assembled locally".		
<b>Economic</b>				
Time Saving	+	"release time for the users as the systems purify the water "on their own". Thus, time is not wasted in collecting fuel for boiling or keeping an eye on the boiling."		
Increases Income or Saves Money	+	"less expensive than"ultraviolet water purifiers which can cost more than INR5,000 (US\$102), that is far beyond the means of most rural dwellers. Many devices also require running water and electricity"		
Creates New Jobs	0	N/A		

Appendix 29: Framework Unilever Pureit Water Filter



Godrej ChotuKool				
Characteristics	Evaluation	Arguments	Promotion of SDGs	
<b>Ecological</b>				
Energy Saving	+	"Consumes just 62W, thus lowering the running costs. It goes into sleep mode; cuts off electricity after achieving inside cooling temperature of 10°C.; Stays cool up to 3 hours without electricity."	2, 3, 7, 9, 10, 11, 12	
Material Efficient	+	"The portable unit has 45 liters of volume inside a plastic body of less than 10 pounds. Instead of traditional compressors, ChotuKool is based on a thermoelectric chip that maintains a cool temperature on a 12-volt DC current—and can plug into a car battery or be left unplugged for hours."		
Climate Neutral	0	N/A		
<b>Social</b>				
Fulfillment of Basic Necessities	+	Chutokool is an affordable cooling solution for Indian households in rural areas with no other possibility to keep food fresh even with a bad energy supply		
Improves Health and Education	+	Keep vegetables and milk fresh		
Promotes Inclusion and Equality	+	The standard of living increases for households in rural India.		
<b>Economic</b>				
Time Saving	+	Perishable foods could be stored and do not need to be purchased daily.		
Increases Income or Saves Money	+	Cheaper than a conventional refrigerator, energy efficient and low maintenance. "ChotuKool carries a price-tag between Rs. 3,500 and Rs. 3,800 At launch, ChotuKool was about 50 percent cheaper than the next entry-level fridge available in the market costing about Rs. 7,000 "		
Creates New Jobs	+	ChutoKool is of great value for kiosks and small businesses to serve cold drinks, snacks and flowers; "Distributed by villagers (and other social entrepreneurs) who have been trained as salespersons. They earn a commission of roughly \$3 per fridge sold"		

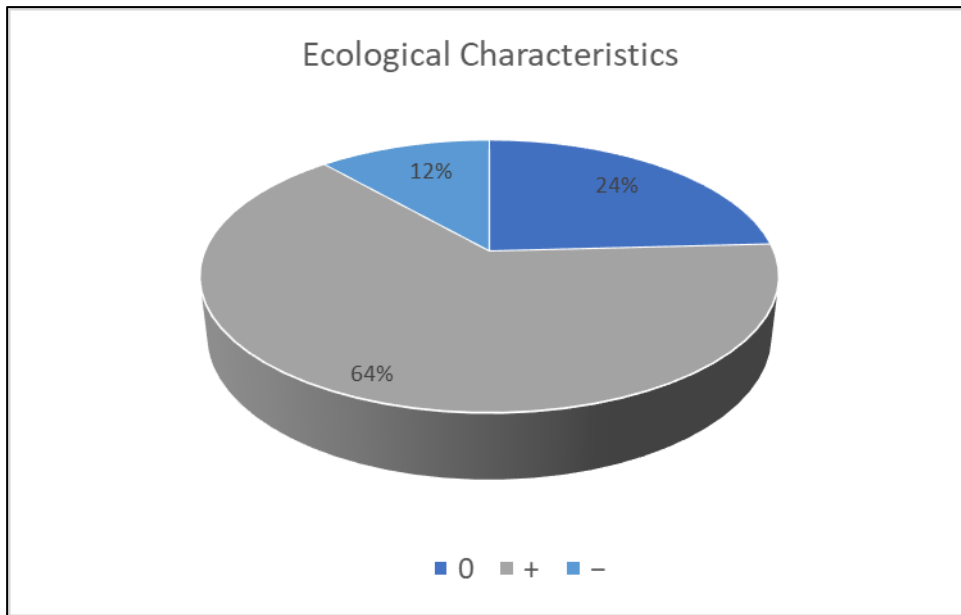
Appendix 30: Framework Godrej ChotuKool

Mitticool				
Characteristics	Evaluation	Arguments	Promotion of SDGs	
<b>Ecological</b>				
energy saving	+	"...provides natural coolness to the stored material without requiring any electricity or any other artificial form of energy"	2, 3, 7, 9, 10, 11, 12	
material efficient	+	"...made entirely from clay"		
climate neutral	+	"...does not emit any carbon gases that are harmful to health and environment"		
<b>Social</b>				
fulfillment of basic necessities	+	"...improve both quality of life and sustainable practices.."; 44% of the Indian population lack electricity -> Mitticool improves quality of life		
improves health and education	+	"Mitticool can keep the fruits and vegetables fresh for five days" and therefore allows a healthy diet		
promotes inclusion and equality	+	"The price of one Mitticool refrigerator is INR 3400, which is highly affordable for rural people"; "is simple, sustainable (durable and easy to use and maintain) and highly affordable"		
<b>Economic</b>				
time saving	+	"...it will take 12 hours to get cooling effect for the first use" + refill with water		
increases income or saves money	+	Half as expensive as a comparable conventional refrigerator + "...without requiring any electricity or any other artificial form of energy"		
creates new jobs	0	N/A		

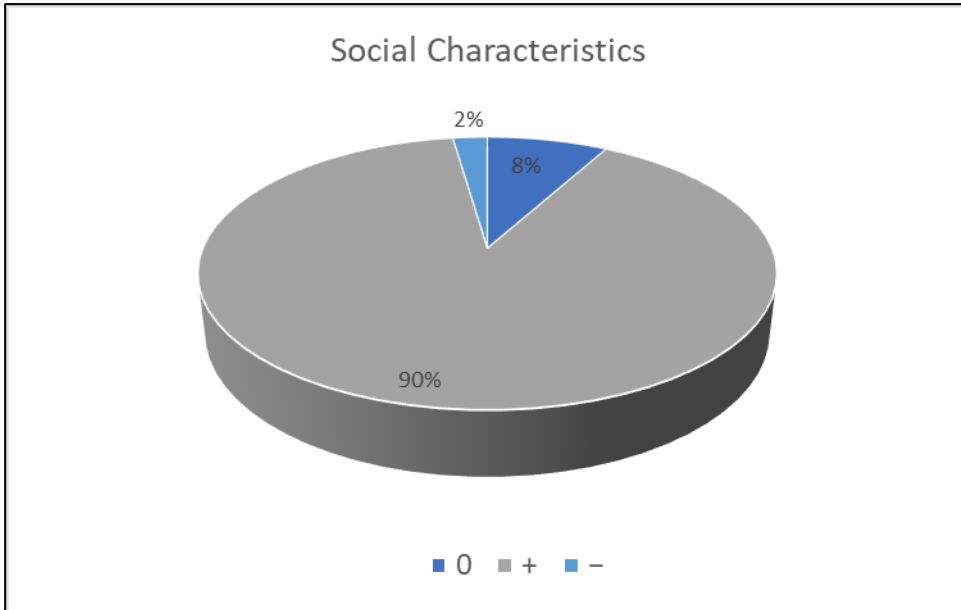
*Appendix 31: Framework Mitticool*

Haier Washing Machine "Mini Magical Child"				
Characteristics	Evaluation	Arguments	Promotion of SDGs	
<b>Ecological</b>				
Energy Saving	+	"The Mini Magical Child used concentric washing technology to operate with high efficiency and low noise, saving water, electricity, weight, and space compared to conventional washers."	5, 7, 8, 9, 10	
Material Efficient	+	"...operate with high efficiency and low noise, saving water, electricity, weight, and space compared to conventional washers."		
Climate Neutral	0	N/A		
<b>Social</b>				
Fulfillment of Basic Necessities	+	Access to washing machines. "Reduction of time consuming job instead of washing by hand"		
Improves Health and Education	+	"Access to washing machines will allow women to have the time to educate themselves and their children, and to work in gainful employment."		
Promotes Inclusion and Equality	+	"The access to washing machines will allow women to have the time to educate themselves and being equal with men"		
<b>Economic</b>				
Time Saving	+	Washing machine helps to wash clothes faster in comparison with washing by hands.		
Increases Income or Saves Money	+	"a real alternative to large, expensive washing machines"		
Creates New Jobs	0	N/A		

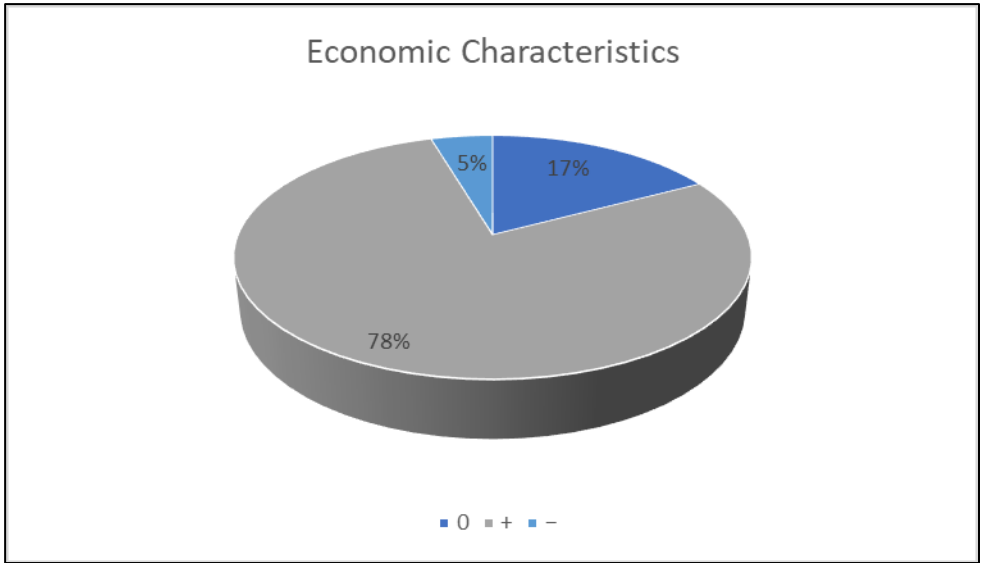
Appendix 32: Framework Haier Washing Machine "Mini Magical Child"



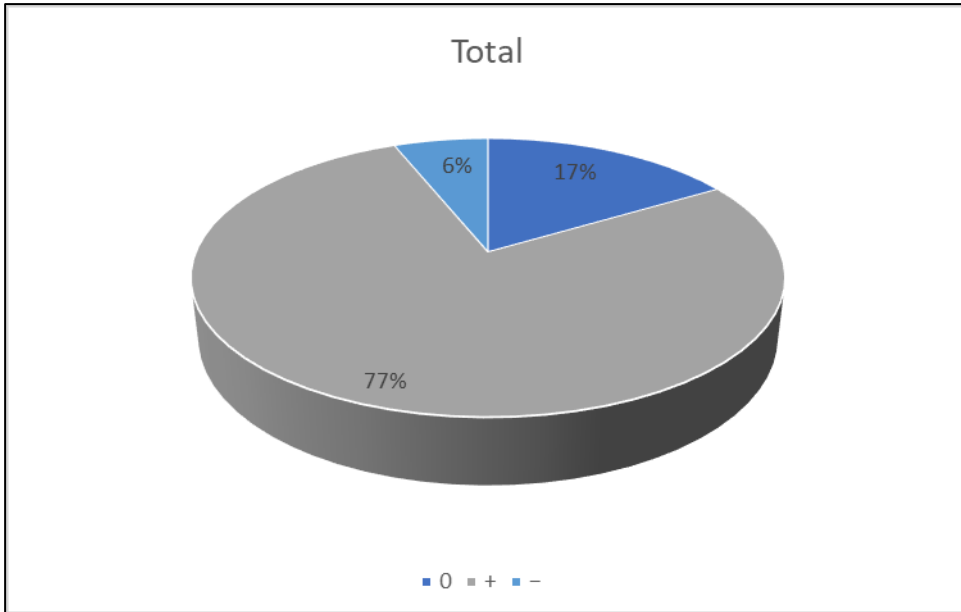
*Appendix 33: Ecological Characteristics Total*



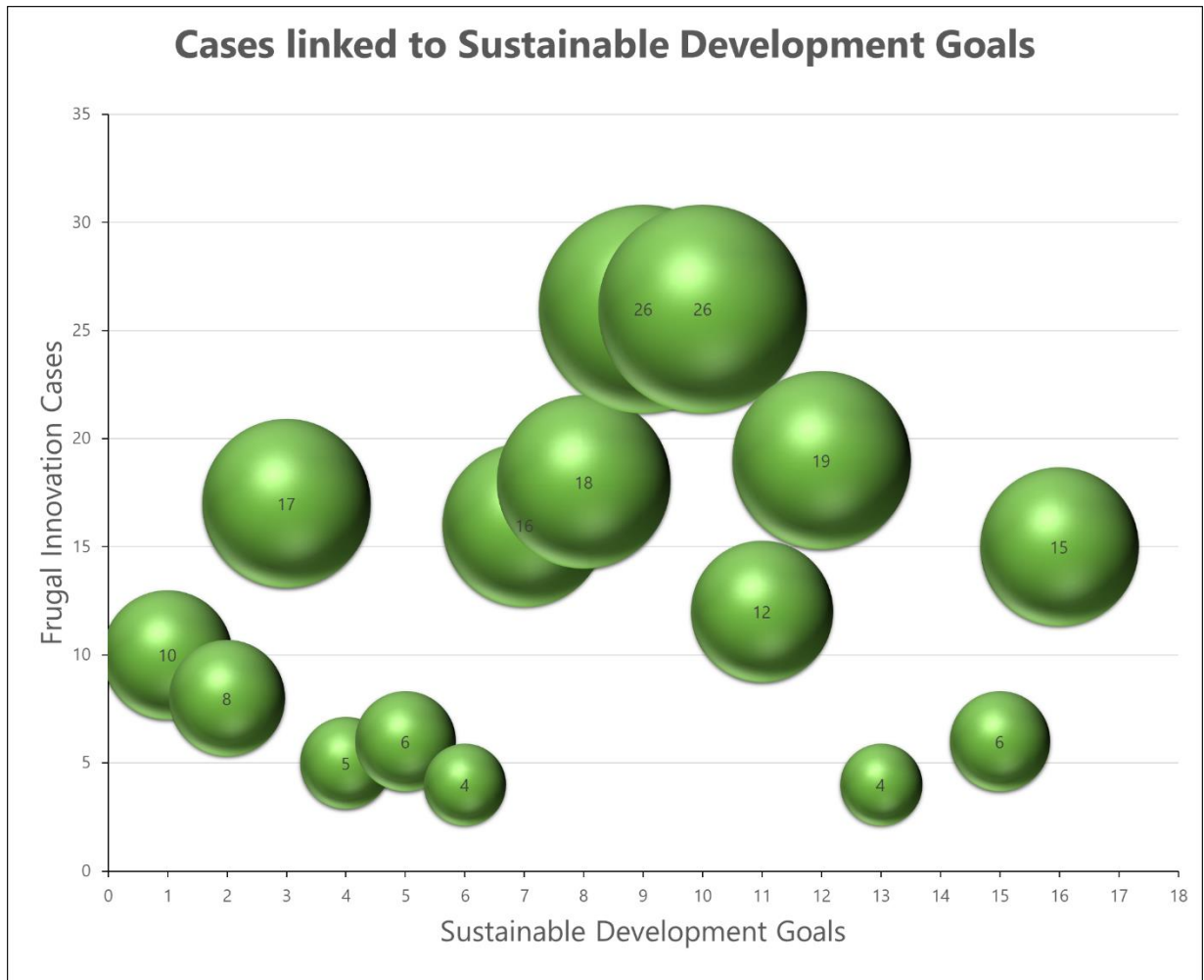
Appendix 34: Social Characteristics Total



*Appendix 35: Economic Characteristics Total*



*Appendix 36: Summary of all cases and characteristics*



*Appendix 37: Cases linked to Sustainable Development Goals*



#	Sector	Cases	Sustainable Development Goals																	
			GSD 1	GSD 2	GSD 3	GSD 4	GSD 5	GSD 6	GSD 7	GSD 8	GSD 9	GSD 10	GSD 11	GSD 12	GSD 13	GSD 14	GSD 15	GSD 16	SDG 17	
1	Appliances	Chinool		X	X							X	X							
2	Appliances	MittCool		X	X							X	X							
3	Appliances	Haier's washing machine						X				X								
4	Bank	M-Pesa	X			X		X				X	X					X		
5	Bank	Vortex ATMs	X		X							X	X							
6	Bank	Gramen Bank's microfinance						X				X	X					X		
7	Bank	Easy Paisa	X		X							X	X							
8	Bank	Rickshaw Bank in India	X	X	X	X						X	X							
9	Bank	EKO mobile phone banking	X	X				X				X								
10	Energy	Husk Power Systems	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11	Energy	SELCO			X	X	X					X						X		
12	Healthcare	GE's ECG machine			X							X								
13	Healthcare	GE's Ultrasound machine			X							X								
14	Healthcare	Aravind Eye Care			X							X						X		
15	Healthcare	Narayana Hospital			X							X						X		
16	Healthcare	GE's Lullaby baby warmer			X							X								
17	Healthcare	Japir foot	X		X							X	X							
18	Healthcare	Embrace			X							X	X							
19	ICT	Aakash	X				X	X				X					X			
20	ICT	Bharti Airtel										X	X					X		
21	ICT	Nokia 1100										X	X					X		
22	ICT	Micromax's mobile phone (India)										X	X					X	X	X
23	ICT	Vodafone Rs.10 pre-paid cellular phone										X	X					X	X	X
24	Transport	Tata Nano										X	X							
25	Transport	Mahindra & Mahindra's small tractors	X	X	X							X	X					X	X	X
26	Transport	Sono Motors Sion										X	X					X	X	
27	Transport	Tata Ace										X	X							
28	Water	Tata Swach		X	X							X	X					X		
29	Water	Unilever's Pureit		X	X							X	X					X		X

Appendix 38: Overview of Sustainable Developments Goals and Cases