Introduction to a Sustainability Evaluation Framework based on the Sustainable Development Goals applied to Four Cases of South African Frugal Innovation

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1 INTRODUCTION

Within the next 15 years, the world population will increase by more than 1 billion people, reaching 8.5 billion in 2030. For 2050, the United Nations (UN, 2017) estimate a population size of even 9.7 billion people. More than half of the growth is expected to occur in Africa, even if the level of fertility decreases in the short run. This development leads to an increased demand for space as well as natural resources, especially (drinking) water and food, further challenging natural resources. Meeting the demand of the growing world population, providing equal living standards and preserving the environment simultaneously are competing objectives that require a commitment to a more sustainable behavior (Rogall, 2012).

In September 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development Goals (SDGs) including 17 goals and 169 targets for sustainability. The goals intend to build on the Millennium Development Goals (MDGs) from 2000 and take aim at eliminating poverty and inequality and tackling climate change (UN, 2015). Sachs (2012) pointed out that objectives of sustainability differ globally within and between societies. The SDGs offer a universal set of objectives to be implemented by all countries, aiming for global welfare for the current and future generations.

Achieving sustainability means rethinking economic growth completely. That is where the concept of frugal innovations comes to mind as it is commonly associated with emerging and developing countries as well as sustainability (Brem & Ivens, 2013; Khan, 2016; Levänen et al., 2016). According to Wohlfahrt, Bünger, Lang-Koetz, and Wagner (2016), these innovations focus on core functionalities of products and services and are affordable for price-sensitive customer groups. Therefore, especially emerging countries like the BRICS are expected to provide basic contextual factors for frugal innovations. Frugal innovations are based on essential features exploiting a minimum amount of resources. Ideally, resources are locally available (Rao, 2013). That supports the assumption that frugal innovations contribute to sustainability. If frugal innovations can at least be called more sustainable than other innovative solutions, they could have a great impact on the economic future.

The evaluation of sustainability requires a transparent approach that can cope with the varying definitions of sustainability at best. The SDGs seem to be a suitable basis because they established a holistic perspective that is widely recognized. Therefore, this paper presents a framework for the evaluation of sustainability, a transparent...
and adaptable approach based on a review of existing frameworks for the evaluation of sustainability. Furthermore, four frugal innovations from the South African context were assessed. Especially in Africa, the high rate of population growth connected with the demand for sustainable economic development and equity promotes further research regarding frugal innovations.

In the next section, the theoretical framework of the study is presented, addressing sustainability, frugal innovations, and the South African context. This is followed by a description of the methodological approach including the sampling of the cases, and subsequently, the sustainability evaluation framework is introduced. Afterward, this framework is used to evaluate four cases of frugal innovation, an overall comparison follows resulting in a conclusion and future research implications.

2 | THEORETICAL BACKGROUND AND RESEARCH CONTEXT

2.1 | Sustainability

The concept of sustainability itself is multifaceted. Most cited sources for sustainability in scientific papers are the Brundtland Report (UN, 1987) and the Agenda 21 from the UN Conference on Environment and Development (UN, 1992) that called for intragenerational and intergenerational equity. The Brundtland Report established the conjunction and interaction between economic, ecological, and social sustainability.

In order to promote a more sustainable future, sustainability assessment has become an important topic in a wide range of areas (Bond & Morrison-Saunders, 2011; Pintér, Hardi, Martinuzzi, & Hall, 2012). Looking at sustainability from a rather political perspective, contributions of the UN come to the fore. The United Nations Development Programme (UNDP) initially introduced the MDGs intending to eliminate poverty and improve health and equity (UNDP, 2018). In 2015, the UNDP developed the MDGs into the SDGs in order to make a difference between the MDGs for developing countries and the SDGs for every country. The SDGs also combine economic, environmental, and social issues (Kercher & Mahler, 2015; Sachs, 2012). They are more broad and universal and intend to establish interrelations between single goals (Le Blanc, 2015). Although not legally binding, governments are expected to establish approaches and frameworks fostering the SDGs (UN, n.d.). The Bertelsmann Stiftung and the Sustainable Development Solutions Network (2017) set up the SDG Index and Dashboard report comprising 99 indicators used to evaluate and compare the achievement of the SDGs in 157 UN member states.

2.2 | Defining frugal innovation and linking sustainability

The concept of frugal innovations is shaped by various definitions and shows similarities to other approaches (Hossain, 2017; Pisoni, Michelini, & Martignoni, 2017). Pisoni et al. (2017) point out that the approach has its roots in emerging markets where these innovations intended to fulfill needs of consumers at the bottom of the pyramid (BOP). Originally, in 2005, Prahalad introduced 12 principles of innovation to address the BOP. Among others, he demanded not only lower prices but also new price performance to serve poorer population groups. He pointed out that the simple adaptation of Western products won’t be sufficient because functional requirements have to be considered comprehensively. Furthermore, he emphasized that product development has to consider infrastructural issues (Prahalad, 2010). These requirements resemble the key characteristics that frugal innovations display in their development and features, which is one reason why they are associated with the BOP (Khan, 2016; Pansera & Sarkar, 2016; Wohlfahrt et al., 2016). Illustrating the development of the definition of frugal innovation in the meantime, Pisoni et al. (2017) created a timeline showing the development of frugal innovation concepts. It starts with product-oriented definitions presenting product-based features. In the second generation, market-oriented and process-oriented foci expand the characterization. To enable a transfer from emerging market contexts to western industry contexts, the third group of definitions sets up criteria to define and distinguish frugal innovation in greater detail.

In this article, frugal innovations are defined following the criteria-oriented definition by Weyrauch and Herstatt (2016), who conducted a systematic literature review as well as interviews to create their classification. According to Weyrauch and Herstatt, the main characteristics of frugal innovations are substantial cost reduction, concentration on core functionalities, and optimized performance level. Although the term frugal innovation becomes more and more known, used and even associated with developing and industrial nations alike (Fraunhofer ISI and Nesta, 2016; Pisoni et al., 2017), this development towards a more general definition of frugal innovation seems detrimental. The concept would lose one of its key features and, in consequence, emphasize the similarities to other, already established concepts of innovation like low-end disruption (Christensen & Raynor, 2003). Thus, this paper focuses on frugal innovation projects in a developing country that provide products or services for low-income consumer groups.

Especially with the BOP as a target group, frugal innovations are often associated with sustainability. Their features are driven by affordability, simplicity, adaptability, and the use of local resources, which enables these innovations to foster sustainability (Basu, Banerjee, & Sweeny, 2013). According to a conceptual framework of Brem and Ivens (2013), frugal innovations support both sustainability and market performance by reducing input resources, value chain activities, and negative outcomes regarding sustainability.

Besides conceptual articles, the interrelation of frugal innovation and sustainability has meanwhile also been examined in case studies. For instance, Khan (2016) investigated several cases and emphasized the role of frugal innovation to support social sustainability. Contrarily to research strengthening the connection between frugal innovation and sustainability, Rosca, Arnold, and Bendul (2016) underlined that sustainability is no binding feature of frugal innovations. Hyvärinen, Keskinen, and Varis (2016) illustrated a frugal innovation example of the water sector and pointed out that sustainability evaluation should consider the whole value chain. These different approaches show the need to further investigate potential interrelations in order to identify possible conditions or key contextual factors.
2.3 The South African context

So far, the conceptualization of frugal innovation is empirically based on mainly Asian countries and their markets (Rao, 2013; Tiwari & Herstatt, 2012), which leaves other emerging regions like Africa and South America and their specific contexts as subjects for research. The authors’ focus on Africa follows expressed desiderata in recent articles (Hossain, 2017; Knorringa, Peña, Leliveld, & van Beers, 2016). As one of the BRICS, South Africa is assumed to have quite comparable context conditions as India and China for frugal innovations and will serve as the chosen setting for this investigation with the goal to contribute to closing the gap on frugal innovation research in the African context.

But it is not just about the potential role of frugal innovation in South Africa — rather, sustainability is of great importance for the country’s future development. Besides fostering economic growth, social issues like health and poverty as well as ecological topics like climate protection remain ongoing challenges (Federal Ministry for Economic Cooperation and Development, 2010). Considering the SDG Index of the Bertelsmann Stiftung and Sustainable Development Solutions Network (2017), South Africa holds a score of 61.2 points. Amongst 157 evaluated countries, it occupies position 108. The index illustrates that especially poverty and unemployment, health, hunger, poor education, inequality, a lack of energy and clean water, climate issues, and economic development are the main issues.

South Africa is aware of the need for more sustainable growth. Based on the requirements of the Brundtland Report, the nation wants to achieve economic development and social enhancement while regarding ecological sustainability as the most important dimension of sustainability. The Department of Environmental Affairs (DEA, 2011) sets up the National Strategy for sustainable development to improve systems for integrated planning and implementation, sustain South African ecosystems, use natural resources efficiently, promote the green economy, build sustainable communities, and tackle climate change.

Achieving sustainable growth is a huge challenge for every country. The SDGs can be seen as a guideline to be worked on (Bertelsmann Stiftung and Sustainable Development Solutions Network, 2017). A framework based on the SDGs was used to evaluate South African frugal innovations to gain insights regarding the manner in which these frugal innovations contribute to sustainability and help fulfill the South African requirements, which in turn may point towards ways to address these challenges in other contexts.

3 METHODOLOGY

The work on and with the introduced framework goes back to December 2015 and was completed, at least for the time being, in March 2018, as shown in more detail on Figure 1.

Initially two literature reviews (Adams, Khan, & Raeside, 2007) were conducted, at first an exploratory one seeking to get a broad insight into the research on frugal innovations and sustainability. The second, instrumental literature review focused on empirical approaches regarding the evaluation of the sustainability of frugal innovations, looking for their specific strengths, weaknesses, limitations, and hints at possible improvements of the frameworks.

To evaluate the sustainability of an innovation, a framework was developed based on a detailed analysis of the four studies gained from the literature review that evaluated the sustainability of frugal innovations.

Investigating innovative approaches in the South African context, 11 cases resembling frugal innovation were found (Bremmen, 2014; Innovation Prize for Africa, 2017; SEED, 2017a). Four cases were selected based on their theoretical fit, the availability of sufficient secondary data, and the access to the managers of the innovation projects to generate original primary data. A purposive sampling technique (Teddlie & Yu, 2007) was used because the number of cases documented, available, and accessible did not provide a sufficient basis for valid traditional probabilistic statistical inference (Godambe, 1982). Not using a randomized sampling technique, the results do not contribute much to external validity, but they can provide valid insights about the sustainability of the assessed cases as representations of frugal innovation activities in South Africa. This internal validity can provide insights that contribute to the theory (in this case of frugal innovation), to the understanding of frugal innovation in South Africa, and if repeated in other nations, they would be valid over a greater realm (Bernard, 2002).

The cases were investigated in a multi-case study (Yin, 2013). With the founder of every considered frugal innovation a topic-guided qualitative interview via Skype or a questionnaire with open-ended questions was conducted (Patton, 2002). Two interviews were guided within another research project; however, fitting parts were extracted and enhanced with further information (Albert et al., 2017). The interviews consider mainly the understanding of frugal innovations, the personal motivation of developing the innovation, impacts on sustainability, and South African context conditions. To triangulate (Denzin, 2006) the findings, collected secondary data from the official web presences of the considered frugal innovation projects, as well as articles and case studies on them, were gathered. The framework was

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**FIGURE 1** Timeline of the research project

![Timeline of the research project](Image)
tested on other frugal cases before and gone through three review and revision cycles that increased the reliability and improved the wording and procedure of the framework. The assessments of the cases presented in this article were tested and retested by the authors and rated by German as well as South African scholars from different disciplines (Bortz & Döring, 2006).

4 | DEVELOPING AN EVALUATION FRAMEWORK

A framework for the assessment of the sustainability of innovations needs to factor in the various aspects of sustainability. The three dimensions of social, economic, and ecological sustainability alone are multidisciplinary requiring a holistic approach (Sala, Ciuffo, & Nijkamp, 2015). Therefore, as a starting point for the evaluation of sustainability, we first analyzed and compared papers that focused on the evaluation of the sustainability of frugal innovations.

4.1 | Comparison of four approaches

Researching the specific conjunction between frugal innovations and sustainability evaluation, four scientific papers were found. Even though their approaches vary, they all include social, economic, and ecological aspects to a certain extent. Levänen et al. (2016), as well as Pansera and Sakar (2016), imply the SDGs in their method of evaluation. Table 1 illustrates the approaches of the considered papers.

The table shows that there is no standardized approach to evaluate sustainability. The articles even point out that it is a challenge to evaluate sustainability with a consistent method matching various examples. Looking at economic, ecological, and social circumstances seems to scratch the surface only. Contrarily, considering all 17 SDGs is precise, but the presented cases do not cover each goal. For instance, for one of the cases by Pansera and Sakar (2016), which is about a machine producing affordable sanitary pads, only seven SDGs can be considered properly. Levänen et al. (2016) evaluated sustainability by deriving questions from the SDGs fitting their examples, but these questions can hardly be adapted to other cases of frugal innovation. An approach is needed that is compatible with the various kinds of innovation.

Because the SDGs comprise social, economic, and ecological aspects and moreover try to interrelate them (Le Blanc, 2015), they are the most advanced as well as internationally recognized attempt of a holistic approach to sustainability. Therefore, the evaluation framework was created based on the SDGs in their entirety to allow a holistic assessment of their sustainability (when used ex post) or potential sustainability (when used ex ante or concomitant). To keep the complexity and holistic nature of the SDGs and at the same time make the framework accessible for the users and raters, it was split into three steps, inspired by the analytic hierarchy process (Saaty, 1982, 1994), going from a general assessment of the sustainability in Step I to an assessment of the fostered dimensions of sustainability in Step II. In addition, these dimensions are linked to specific features of the innovation in this step, followed by Step III, an assessment of the impact of these features on specific aspects of sustainability that were derived from the SDGs.

4.2 | Step I

The first step intends to consider all SDGs to meet the goal of a holistic approach. Previous approaches (e.g., Levänen et al., 2016; Pansera & Sakar, 2016) showed that the operationalization has been quite difficult because not every single SDG can be applied to every kind of

<table>
<thead>
<tr>
<th>Survey/Author</th>
<th>Methods of evaluating sustainability</th>
<th>Findings regarding sustainability</th>
<th>Interpretation and implications</th>
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</thead>
<tbody>
<tr>
<td>Corporate and Grassroot Frugal Innovation: A Comparison of Top-Down and Bottom-Up Strategies (Wohlfahrt et al., 2016)</td>
<td>Assessing economic, environmental, and social dimensions</td>
<td>Especially corporate innovators focus on economic sustainability and want to achieve high profitability Environmental sustainability seems to be a side-effect</td>
<td>Statements concerning economic, social and ecological aspects seem not to be sufficiently detailed.</td>
</tr>
<tr>
<td>Implications of Frugal Innovations on Sustainable Development: Evaluating Water and Energy Innovations (Levànen et al., 2016)</td>
<td>Regarding economic, ecological, and social aspects Consideration of SDGs Set of nine adapted indicators drawn from SDGs for evaluation</td>
<td>Cases are more efficient regarding energy production or water purification than existing solutions and are more climate neutral Socially-oriented entrepreneurs have a stronger focus on sustainability</td>
<td>SDGs are very detailed but had to be adjusted to use them to assess water and energy innovations.</td>
</tr>
<tr>
<td>Crafting Sustainable Development Solutions: Frugal Innovations of Grassroots Entrepreneurs (Pansera &amp; Sakar, 2016)</td>
<td>Consideration of SDGs for every case</td>
<td>Innovations reduce costs of production, enhance productivity and increase incomes Environmental impact evaluated as low More energy and material efficient solutions</td>
<td>SDGs are very detailed. However, it was not possible to evaluate every SDG for every case example.</td>
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<tr>
<td>Business models for sustainable innovation—an empirical analysis of frugal products and services (Rosca et al., 2016)</td>
<td>Regarding triple bottom line as the basis for evaluating sustainability impacts Considering sustainable business model archetypes (according to Bocken, Short, Rana, &amp; Evans, 2014)</td>
<td>Significant social impact Entrepreneurs and MNC create economic, ecological and social value Local manufacturing important for sustainability</td>
<td>Categorization of social, economic and ecological dimension provided a good outline but no details.</td>
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innovation. Therefore, the authors propose to consider all 17 SDGs from the viewpoint of being not infringed, providing a clear and comprehensible approach that is usable for various innovations. To assess the infringement, each target was transformed and formulated in the opposite way as shown in Table 2. This makes it possible to decide with a Yes or No whether the target has been violated.

The intention of Step I is to exclude frugal innovations harming the SDGs. As soon as one of the statements is answered with Yes, the innovation cannot be assessed as sustainable. As a result, innovations using resources inefficiently or noxiously can be sorted out immediately and regarded as unsustainable innovations, for example, from the perspective of a sustainability scholar. Or the specific drawback has to be exposed and improved or at least counterbalanced further, for example, from the perspective of an innovation project manager. Notes shall be filled in to explain the decision and the reason behind it. The innovations got to be evaluated in comparison with existing solutions or production patterns.

### 4.3 | Step II

The second step intends to check the impact on sustainability more detailed. Looking at the SDGs, it is difficult to differentiate selectively between the three distinct dimensions (social, ecological, and economic). For instance, SDG 2: *End hunger, achieve food security and improved nutrition and promote sustainable agriculture* can be seen from different perspectives. The main target could be improving social circumstances. However, *sustainable agriculture* concerns besides the ecological also the economic dimension. To overcome the issue of various perspectives that are comprised in all SDGs, eight answer categories were specified: Social; economic; ecological; social and economic; social and ecological; economic and ecological; social, economic, and ecological; and the option to answer with neutral.

The rater can choose the answer neutral if he estimates that the SDG was not infringed in Step I but does not perceive a positive impact on any of the three dimensions of sustainability. The notes and explanations from the first step facilitate the judgment in the second step. The rater also specifies which features of the innovation are the reason for the positive influence on sustainability.

Step II intends to assess qualitatively how the innovation contributes positively to sustainability. Therefore, the SDGs are evaluated in their original form. The second step enables to draw conclusions, for instance, on which dimension of sustainability the specific case is or is expected to contribute most. It also exposes how many SDGs have been left neutral meaning that they are not infringed, but the specific case does not or is expected to not contribute to these goals in a positive way.

### 4.4 | Step III

After gaining insights regarding the actual or expected impact on the three dimensions of sustainability in general, in Step III, the impact of the identified features on specific aspects of sustainability is assessed, focusing on direct effects and improvements compared with the status quo. As stated before, these aspects of sustainability were derived from the SDGs. Redundant aspects were combined to reduce their number and keep the assessment manageable. Table 3 shows the final aspects of Step III.

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1. Shown in detail in the Online Supporting Information.
2. Deduction shown in detail in the Online Supporting Information.


4.5 | Limitations

Each step was developed based on the SDGs to keep them as a key factor in evaluating sustainability. Several drawbacks of the goals regarding comprehension and usability were recognized. Some SDGs contain the term sustainable or sustainability itself. This hampers the development of more consistency in understanding the SDGs and sustainability because it does not contribute to more clarity regarding the concept of sustainability. Most of the SDGs comprise more than one dimension of sustainability, which impedes their usability in praxis. Depending on the context, the intention of the potential sustainable solution and the comparison with conventional ideas can lead to different perspectives and interpretations of single SDGs thereby. Furthermore, there is no hint regarding which level of contribution the SDGs tackle. Depending on the decision whether individual, group/community, societal, or even national levels are addressed the interpretations are diverse.

By regarding aspects of sustainability derived from the SDGs, a more detailed assessment can be achieved. The close connection to the SDGs ensures their consideration as best as possible; however, it does not guarantee that all possible aspects of sustainability are considered. To evaluate the degree of sustainability and the possible impact further, additional elements could be added to the framework, like an assessment of the ecological footprint.

5 | INTRODUCING THE FRUGAL CASES

To develop and test the usability of the framework, a multiple-case study was conducted, and the four investigated cases of South African frugal innovation were evaluated: Moladi building systems, 5 Star Stoves, Mellowcabs, and SavvyLoo.

Hennie Botes founded the Moladi building systems in 1986 (Botes, 2017; Moladi, 2016). It offers a service to build affordable houses using plastic forms and a special mortar-mix, called MoladiCHEM. The plastic panels are clipped together, their cavities are fitted with steel reinforcements, and the mortar is filled in. Once the walls are dry, the plastic forms are removed and can be used again. There are no restrictions concerning the size or type of the constructed buildings (Coetzer, 2010).

5 Star Stove is based in Cape Town and creates a local bioenergy supply chain. The enterprise buys waste biomass from regional harvesters at a fixed price and processes it into pellets. The pellets are sold to stove users facilitated by a local payment provider. The stoves are assembled in the community and distributed locally by a franchise model (Marlhebe, 2016; SEED, 2017b).

Mellowcabs are three-wheeled electric vehicles designed for transportation in urban areas. According to founder Du Preez (2017), 80% of urban taxi rides are less than 4 km. Mellowcabs aims to provide an affordable, safe, and environmentally friendly solution for short-distance rides with the intention to improve mobility (Court, 2015; Mellowcabs, 2014; Du Preez, 2017).

SavvyLoo is a pilot model of a waterless sanitation system for rural areas and temporary settlements founded by Dr. Dudley Jackson. The desiccating toilet provides an alternative to waterborne or chemical toilets or pit latrines. Furthermore, the system works with a conical disc separating liquids from solids, and organic waste is dried to biomass (Jackson, 2017; SEED, n.d.).

6 | FINDINGS

Regarding Step I of the sustainability evaluation system, none of the cases infringes any of the SDGs. As seen in Table 4, Step II revealed that all four cases have or are expected to have a positive impact on social, economic, and ecological sustainability.³

All cases intend to improve social circumstances by providing solutions for housing, cooking, transport, and sanitation. They consider ecological issues to develop sustainable products and processes like emission-free transport or desiccating sanitation. All of them integrate people locally as employees or franchisees into their value chain or strive to do so.

The extent to which the cases contribute positively to sustainability varies. As can be seen in Figures 2a–d, about half of the SDGs were left on neutral, meaning that these goals were not infringed, but there is no positive impact on the innovation associated with specific SDGs. Especially for Mellowcabs, it seems that the innovation only has a small positive impact on sustainability compared with other cases. Looking at Mellowcabs and SavvyLoo, it gets obvious that the ecological and social influences are the most important ones, and economic aspects fade into the background. Contrarily, moladi building systems and 5 Star Stoves seem to develop a more holistic solution when it comes to sustainability. They tackle social, ecological, and economic aspects. Ecological sustainability is the most important aspect of 5 Star Stoves as well in comparison with the other cases as in comparison with the other dimensions of sustainability for the innovation itself.

³Results for Steps I and II shown in detail in the Online Supporting Information.

### TABLE 3 Aspects of sustainability

<table>
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<tr>
<th>Aspects of sustainability derived from the SDGs</th>
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<tbody>
<tr>
<td>• Wealth</td>
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<td>• Health</td>
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<tr>
<td>• Education</td>
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<tr>
<td>• Inclusion</td>
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<tr>
<td>• Equality (incl. justice)</td>
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<tr>
<td>• Working opportunities</td>
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<tr>
<td>• Sustained economic growth</td>
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<td>• Resilient infrastructure</td>
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<tr>
<td>• Foster innovation</td>
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<tr>
<td>• Combat climate change</td>
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<tr>
<td>• Sustainable use of resources (incl. conserving natural resources and sustainable energy supply)</td>
</tr>
<tr>
<td>• Sustainable industry patterns (incl. sustainable agriculture, sustainable economic growth and sustainable industry)</td>
</tr>
<tr>
<td>• Sustainable living (incl. sustainable cities and sustainable consumption)</td>
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</tbody>
</table>
Overall, social sustainability has shown to be the most distinctive dimension for the evaluated cases, but only by a small margin (as illustrated in Figure 2).

The results do not allow an interpretation regarding which single aspects of sustainable development drive the three dimensions. For example, moladi building systems and 5 Star Stoves contribute to social sustainability to the same extent (as illustrated in Figure 3). This does not mean that it is about the same kind of social sustainability that is fostered. Therefore, in Step III, the cases are analyzed in depth regarding their contribution to single aspects of sustainability. This enables a more differentiated consideration that aspects of sustainability are fulfilled for each case and a more profound comparison between the cases (as illustrated in Table 5). As shown in Table 5, all the assessed cases contribute positively to wealth, health, working opportunities, and sustainable use of resources.

### DISCUSSION

The regarded cases strongly support the view that frugal innovations are sustainable or at least more sustainable than conventional solutions. Examining whether SDGs are infringed resulted in about half of the goals being considered neutral in terms of influencing sustainability, meaning that even though not infringed, they are also not fostered by the cases. This supports the idea that it is challenging to evaluate every single SDG; however, to assess whether they infringe any of the SDGs in the first step has proven to be suitable. Step II intends to evaluate social, economic, and ecological aspects of sustainability in more detail. For the evaluated frugal innovations, the greatest impact is on the social dimension. This goes in line with the results of Khan (2016) and Rosca et al. (2016) who emphasized the importance of frugal innovations for social sustainability. Ecological
aspects are important as well, especially for 5 Star Stoves and SavvyLoo. The cases tackle economic aspects to a smaller extent. Having analyzed the cases in more detail in Step III, it became conspicuous that all four innovations foster wealth, health, working opportunities, and sustainable use of resources. Rosca et al. (2016) also stressed that frugal innovations often intend to improve wellbeing and health.

The design and approach of all four innovations showed that they consider specific challenges of the South African context. They implement solutions that are affordable for underprivileged parts of the society, try to improve the employment situation, enhance equality, and address ecological issues. A frugal design seems to be the proper way to implement an appropriate solution thereby. The innovations fulfill the requirements for sustainability of the DEA (2011) to some extent. All cases intend to use natural resources efficiently and promote more sustainable communities by improving living conditions in an ecologically friendly way. By using solar energy and turning waste into biofuel, Mellowcabs and 5 Star Stoves contribute to the objective of a green economy and have an indirect impact on combating climate change. SavvyLoo has that as well by turning waste into biomass.

8 | CONCLUSION

All four cases foster the social, economic, and ecological dimensions of sustainability, and specific aspects of sustainability are addressed by all four cases. The aspects of wealth, health, working opportunities, and sustainable use of resources tackle challenges of the South African context leading to the conclusion that frugal innovation can be a worthwhile approach to address the country’s problems. Interestingly, except for ecological aspects like the sustainable use of resources, these are not the sustainability objectives formulated by the country itself. Due to this, future research might attempt to ascertain why there is a gap between the sustainability understanding of the country and the sustainability features of the innovations tackling above all social challenges. According to the DEA (2011), by focusing on ecological aspects, they intend to foster growth and ensure social enhancement. It remains unclear whether it is sufficient to address social and economic aspects in a more indirect way through environment-friendly approaches.

The introduced framework was appropriate to evaluate the sustainability of the cases. It overcomes the drawbacks displayed in the mentioned previous published studies that utilized the SDGs, keeping their holistic nature regarding the representation of sustainability. Its flexibility also suggests that the framework could be used in a practical context, for example, by founders or companies wishing to evaluate the sustainability of their innovation and products. The framework enables to evaluate sustainability at different levels of detail. Incorporating even more raters with diverse geographical and cultural backgrounds in future research would create the opportunity to analyze the understanding of sustainability and the SDGs by focusing
on their statements in the three steps. This can help to improve the understanding of sustainability. Additional research should also concentrate on further contexts like countries or regions. For instance, evaluating distinctions and similarities between developing and developed countries would contribute to the understanding of the differing shapes and interpretations of sustainability. Long-term studies monitoring frugal ventures could provide deeper insights regarding how the coming into being, development, and growth of a frugal innovation influences its sustainability. The introduced evaluation framework to assess sustainability can be used to do so.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.