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The Frugal Innovation Pyramid: A Taxonomy of Innovation Phenomenon in the Frugal Product Design Field

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Abstract- This study repositions the emphasis on frugal innovation from a "Low-cost" and "Resource constraint" innovation to a "Design-Driven" innovation. It establishes a framework for illustrating the significance of design in creating frugal innovations that emphasize user requirements and market demands. Although the role of design in frugal innovation is becoming more widely recognized, it is still difficult to quantify and empirically validate. The study builds a qualitative taxonomy for categorizing design-driven frugal innovations using a phenomenological technique to address this. This resulted in the "Frugal Innovation Pyramid" that defined three key drivers: adaptability, simplicity, and resourcefulness, and six critical values: functional, user-friendly, robust growing, local, and affordable for design-driven frugal innovation. By highlighting the qualitative features of design, this study tries to bridge the gap between design and innovation, Providing an efficient tool that allows businesses to create user-centric, frugal innovations.

Keywords: Frugal product design, taxonomy, Design-driven frugal Innovation, Frugal innovation pyramid, Design Value.

1 Introduction

Rapid technological developments and rising consumer demands challenge traditional product design and innovation paradigms. Companies are increasingly offering high-quality and affordable products to diverse customers. This transition has led to the notion of frugal innovation (Rao,2017). Frugal innovation has become a promising product and service development model during rapid technical advancement and global concerns(D'Angelo and Magnusson, 2022). It is an approach to "meeting the requirements of a marginalized population by developing affordable, accessible, high quality and simple solutions (Prabhu, 2017)." The understanding of frugal innovation originated from multifaceted sources (Kotelnikov, 2011). Systemic innovation theories claim that "frugal innovation arises from the dynamic interaction and cooperation among heterogeneous individuals(Santos et al., 2020). However, the first perspective towards frugal innovation was limited to resource-constrained innovations for a long while. Most of the time, frugal innovation is still defined as "low-cost, improved technological innovation" that offers value to many people (Prabhu, 2017).

In the 2010s, the Total Quality Management (TQM) theory encouraged a second alternative perspective for frugal innovation (Wooldridge, 2010). This new perspective focuses on consumer satisfaction, which has emerged above the resource-constrained or low-cost concept. Consequently, a theory was established that new market demand could potentially give rise to frugal innovation(Zeschky et al., 2010).

A third perspective on frugal innovation recently surfaced is "design-driven innovation," which incorporates the growing emphasis on consumer requirements and needs. Lim and Fujimoto (2019)

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state that this type of innovation complements market and technology- innovations rather than competing with them (Lim and Fujimoto, 2019). Design-driven frugal innovation might emerge by incorporating new technologies (Robustness, quality, and resourcefulness) or fulfilling new market requirements for an existing product. Although there is an increasing amount of research and a few successful cases, more is needed to clearly show the role of design in the frugal innovation process (Hindocha et al., 2021). The authors begin by defining the term "design" to elucidate the root cause of this difficulty. Niroumand et al. (2021) state that design is the "Process of conceptualizing, organizing, and developing products, services, or interactions to solve a particular challenge or goal" (Niroumand et al., 2021). As declared by Kovac et al. (2020), design in frugal semantics means, "Design is a problem-solving method that blends creativity into production processes to maximize a product's functionality with the least resources and simplicity (Kovac et al., 2020)." As the expression states, "The best designs are simple to understand and use, requiring fewer resources (Shackel, 2009)." While simplicity and creativity are the key drivers for frugal innovation, the subject of design adaptation is intricate to navigate; it can be challenging to define, justify, regulate, and quantify (Tiwari and Herstatt, 2019). Because of this, it's hard to say precisely what the design adds to the frugal creation process.

Additionally, the complexity gets exacerbated by the reality that, in production processes where design is acknowledged as significant, frugal product innovation is usually overseen by different departments. The marketing department is primarily concerned with fulfilling market expectations, whereas the research and development department handles technological aspects. While design does consider technology and meeting market expectations, its impact is predominantly subjective, making it challenging to quantify and demonstrate(Krippendorff, 1989).

Assessing the value created by design innovation is difficult because quantifying the product's adaption and cultural dimensions is inherently complex (Liefner et al., 2020). Financially, a new design is only considered innovative if it effectively creates revenue for the company. However, the benefits of design-driven frugal innovation can not always be quantifiable in revenue. Indeed, in some cases, like with the Tata Nano, a product arising from design-driven frugal innovation has yielded substantial communicative value for the business, even without revenues (Hossain, M. (2017). Design-driven frugal innovation might allow an organization to test new ideas, explore unexplored markets or manufacturing opportunities, and better understand consumer needs. The challenge in demonstrating the value of design innovation stems from its predominantly qualitative nature, whereas non-design firms have traditionally favored quantitative metrics. Therefore, the research aims to establish enhanced methodologies for illustrating the significance of design in creating frugal products.

The research used a phenomenological approach to investigate frugal product innovation to overcome this difficulty. The study developed a system for meaningfully and shareably qualitatively taxonomically categorizing design-driven frugal innovations. Phenomenology uses real-time observations to deduce fundamental principles from data, providing a distinct qualitative perspective on knowledge formation(Moran, 2002). It provides a detailed and subtle understanding of how design impacts the development and adaptation of frugal innovations. Quantitative approaches typically disregarded these aspects. Phenomenology captures design's qualitative qualities, such as simplicity, adaption, and resourcefulness, better to understand their significance in frugal innovation than traditional metrics (Bertola, 2004).

In our research, thirty innovative products were chosen as the phenomena to be qualitatively observed. Below is a summary of the research process and results.

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2 Research Methodology

The research follows Archer's (1995) morphogenetic approach(Archer, 1995). This methodology initially involved collecting " Data derived from research" and subsequently collecting " the assessment of other scholars " regarding the research problem; Archer's definition categorizes these sources of information as "primary" and "secondary." A logical argument was undertaken to draw the final formulation of results (Archer, 1995), as shown in Figure 1.

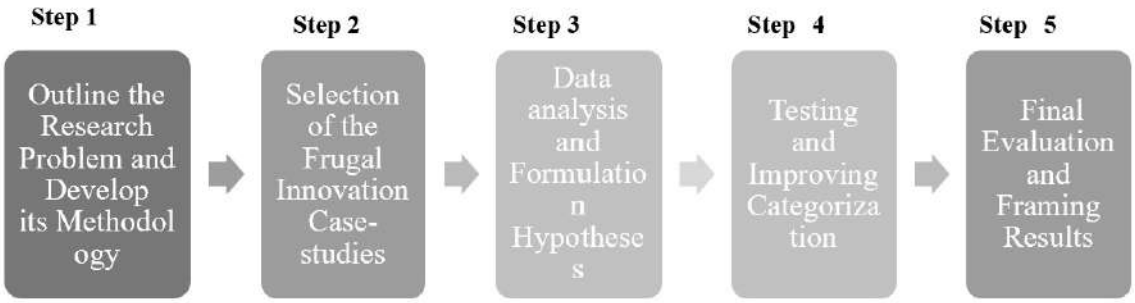

Fig. 1. Methodology of the Research

Step 1: Outline the Research Problem and Develop its Methodology.

The research team comprised twenty interdisciplinary experts, including six engineers, four management specialists, and ten design professionals. These experts were selected using a purposive sampling strategy based on their alignment with the research emphasis on design's contribution to frugal product innovation(Rai & Thapa, 2015). This ensured that the team had the requisite academic qualifications and practical experience in design and applicable innovation methodologies. The research dealt with a significant research problem in frugal innovation: The lack of a well-defined design role leads to a communication gap, and it is difficult for design experts to convince the stakeholders (like management and engineers) of the value of design when they may not prioritize design considerations. This research aims to fill this gap by systematically finding design's unique roles in developing frugal products. Ultimately, this research seeks to make frugal innovation projects more effective by using the power of design and improving communication. To tackle the research problem; the research employed a case research methodology. We have examined cases categorized as "frugal innovation phenomena." The qualitative data analysis employed an inductive approach, as outlined by (Lacey and Luff, 2001). Its initial objective was to suggest a hypothesis, which was later verified using qualitative and quantitative methods to achieve a consensus on their categorization.

Step 2: Selection of the Frugal Innovation Case Studies

The ten design experts employed a mixed-method approach, using primary and secondary data to identify representative cases of frugal design innovation. Primary data was collected through observations and field excursions, while secondary data was collected at the desk using videos, news stories, blogs, and company websites. These two sources enhanced the research's reliability and credibility(Hossain, M. (2017). The previous criteria for product selection were left unrestricted, allowing for the assessment of both historical and contemporary innovations. The designers compiled a shortlist of fifteen frugal products, emphasizing design-driven sectors such as transportation, healthcare, and housewares. To communicate the examples effectively, the final ten were chosen with a preference for dependable and well-established cases, such as the renowned Jaipur foot(See Appendix A).

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One or two images were selected from online sources for each of the ten frugal products that made the shortlist. The design experts explained each product's innovative variables, which were presented to the remaining ten research team members. This team comprised four management experts and six engineers whose inquiries actively contested the viewpoints of the design experts.

Step 3: Data analysis and formulation of Hypothesis

All members of the research team gathered for a plenary session. Two junior design researchers filmed and transcribed the conversations about the ten shortlisted frugal design products throughout this session. The main objective of this session was to identify critical variables that can be utilized to define the fundamental framework of design-driven frugal innovation. The focus on language analysis in this context is consistent with the typical methodology employed in phenomenological studies(Bertola, 2004), which involves gaining insights by examining individuals' lived experiences and interpretations (please refer to the appropriate citation on phenomenology in research methodologies). Under the guidance of six of the ten design specialists, the two young researchers attempted to organize data. To find all key innovation variables, important phrases describing the same innovative attribute were grouped (i.e., "it is functional" and "it performs its intended function"). There were four steps in this data-grouping procedure, as shown in Figure 2. This method corresponds to the approach delineated by Eppinger and Ulrich(1995, Ch. 4) to ascertain customer requirements. Both methodologies emphasize collecting and analyzing qualitative data to gain insight into a phenomenon(Eppinger and Ulrich,1995). Additionally, the research is influenced by Halldorsdottir's (2000) "12 Basic Steps of the Vancouver School of Doing Phenomenology." The phenomenological methodology employed in this research is consistent with its objective of comprehending the practical experience of design in frugal innovation utilizing research team deliberations and interpretations(Willis et al., 1996).

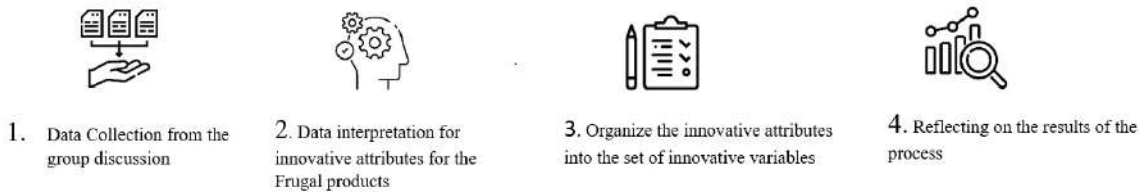

Fig. 2. Data Groping Process

The preliminary analysis of the transcribed discussions identified three critical variables related to design-driven frugal innovation. The initial two variables were easily anticipated to require resourcefulness (material, energy, information, and space) and simplicity. However, an unexpected factor that surfaced as a third variable was adaptability. Moreover, the data analysis emphasized the necessity of distinguishing between the ultimate design result and the methods utilized by the designer to accomplish it. The research team acknowledged the significance of this differentiation. It developed a research hypothesis: *A design-driven frugal innovation process can be characterized by a limited set of drivers and values*. Metaphorically, the notion "driver" signifies the designer's impact on the product under consideration. The designer functions as a pivotal factor, analogous to pulling a lever, whereas the design functions as a force. This metaphor underscores the designer's autonomy in the innovation process. Three drivers (Resourcefulness, adaptability, and simplicity and four values (Functional, robust, user-friendly, and Affordable) of frugal innovation are initially suggested.

Step 4: Testing and Improving Categorization

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The research team increased the sample size to test and improve the emergent research hypothesis regarding design drivers and value. Twenty frugal innovative products were compiled to consider Five design-specialized doctoral(PhD) candidates from Delhi universities. A well-defined set of criteria was implemented to determine which twenty innovative products would be included. The selection of these products was predicated on their presence in the reputable databases listed below: Chinese Patent Database, National Innovation Foundation for Indian Case Studies (NIF) or Frugal Thesaurus of US Patents (Search for patents, 2024).

For the final frugal product cases, the research team assessed the design of twenty new products in addition to the first ten. Each product was evaluated in independent design magazines, domestic design museums, and worldwide exhibitions. The design expert aided in evaluating each product's innovative content based on its cultural resonance among the design community. The four management professors provided noteworthy contributions throughout the second step of the research. On the other hand, management professors emphasized determining each product's importance to its producer's financial performance. This discrepancy highlights the essential differences between the business discipline, concerned with economic implications and quantitative value, and the design profession, which prioritizes qualitative and cultural aspects. Following operationalizing design success in frugal innovation, the research team designed a questionnaire to assess the proposed framework of three drivers and four innovation values. The questionnaire included a picture and a brief description of each of the thirty products. Before developing the questionnaire, the research team discussed each product's drivers (simplicity, adaptability, and resourcefulness) and creative values (Functional, robust, user-friendly, and affordable).

The questionnaire aimed to confirm the research team's frugal product driver-value pairings with the five PhD design candidates. It did so by asking yes/no questions in two sections: one on the three innovation drivers and one on the four innovation values, as shown in Appendix B.

The PhD candidates were also allowed to offer remarks without any restrictions. The outcomes of their attempt were: Eight products were identified for exhibiting function innovation, four as robust innovation, six as user-friendly innovation, and ten were considered affordable due to their endeavor. Four respondents found it challenging to classify the Logitech mouse and Unilever-Pureit products as functional or affordable frugal innovations. They added two new taxonomies, "growing innovation" and "local innovation," to address this categorization problem, allowing for a fifth and sixth frugal innovation results. We included this new potential result for frugal innovations in the questionnaire to investigate what would happen. The same five respondents completed the updated questionnaire, yielding fresh findings: Six products were identified as having innovative functions, four as robust, six as user-friendly, eight as having affordable, three growing, and three locally frugal innovation outputs. The six taxonomies were found to be adequate to characterize all thirty products included, and no additional taxonomizing issues occurred.

A refined comprehension of design-driven frugal innovation had been attained at this research point. This culminated in a formal hypothesis: *"Every design-driven frugal innovation process can be characterized by six values: functional, user-friendly, affordable, robust, growing, and local; and by three drivers: resourcefulness, Adaptability, and simplicity."* As mentioned, this hypothesis and the meticulously chosen product prototypes established the taxonomical categorized framework.

Step 5: Final Evaluation and Framing Results

According to Archer (1995),the research followed conventional humanities ideas. Logical argumentation, exemplification, and citation validate or reject the hypothesis in this manner. The research team questioned the taxonomic categorization structure from the four phases by consulting other design-driven frugal innovation academics. Critique of current literature and possible consultation

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with scholars (design experts) were required. After this approach, the "frugal innovation pyramid" provides a refined and scholarly-validated framework for design-driven frugal innovation.
Furthermore, a classroom experiment was conducted in which twenty-five master's degree students were given established innovation variables and prompted to suggest examples of frugal innovation aligned with these variables. This research aims to test the applicability of the taxonomic categorization structure of frugal product innovation. The student-generated examples were then analyzed and added to the initial sample of thirty products. Recognizing the limitations of a small sample size for statistical significance, fifty examples were incorporated (twenty from students and thirty from the literature review)(See Appendix A). Including a final sample of fifty products strengthened the validation of the "three drivers and six values" hypothesis. Below is the final result of this research method.

3 Design-Driven Frugal Innovation Process

A critical issue emerged during the stage of hypothesis formulation (step three): whether design-driven frugal innovation ought to be conceptualized as a process. The discourse about the preliminary ten product analyses underscored the necessity of distinguishing the ultimate design result from the instruments utilized in its construction. The research team embraced a universally recognized definition of innovation that underscores its procedural nature: “Combining creativity and successful implementation leads to innovation”(Von Stamm, 2008). Figure 3 presents the hypothesis resulting from our research methodology: Three drivers and six values can be used to characterize each design-driven frugal innovation process.

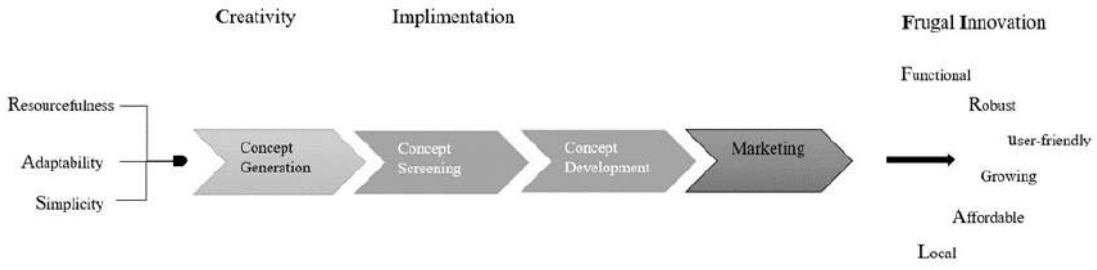

Fig. 3. Drivers and Values of Design-Driven Frugal Innovation

3.1 Drivers of the Design-driven Frugal Innovation Process

Three drivers can lead to design-driven frugal innovation. The research defines the three drivers: resourcefulness, adaptability, and simplicity, and employs appropriate examples to demonstrate their implementation. The analysis examines the degree to which each example represents its assigned driver.

- Resourcefulness: Resourcefulness can achieve innovative design solutions while working with restricted resources (materials, energy, information, and space)(Agarwal and Brem, 2017). The process employs creativity, generosity, and a systematic methodology to surmount limitations and generate impactful, streamlined products. Resourcefulness involves taking advantage of existing resources in unconventional manners. It is based on a rational evaluation of available materials, tools, and expertise. It is objective since it involves physical resources and traditional methods(Agarwal et al., 2021).

  MittiCool refrigerator, designed by Mansukh Bhai Raghav ji bhai Prajapati, illustrates a design that prioritizes resourcefulness (material, energy, information, and space). MittiCool exemplifies resourcefulness by using locally abundant clay as its primary material, decreasing

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environmental impact while promoting local craftspeople. The product's open-source architecture encourages knowledge exchange and permits local modification. The modular and compact design occupies little space. MittiCool effectively meets cooling needs in a resourceful manner (Rao, 2013).

- Adaptability: It refers to the ability of any product or service to fit different situations, environments, or user needs. It's about making ideas adaptable and simple to change or use in various situations. Adaptability is somewhere in between objectivity and subjectivity. It means adapting existing solutions or resources to new scenarios or obstacles. Adaptability relies somewhat on creativity and interpretation, but it still heavily relies on the objective characteristics of the resources and the new environment(Soni and Krishnan, 2014).

  Awaaz. De: Voice Message Board for Education is a prime instance of an adaptability driver for frugal innovation. The software platform gathers, processes, and routes voice messages using inexpensive mobile phones and Internet connectivity, adapting to the limitations of technology many societies confront. Awaaz. De, designed by Tapan Parikh and Neil Patel, offers services beyond literacy and language problems while disseminating information via speech content. Offers services like data collecting, surveys, polls, peer-to-peer information resources, mobile social network access, and interactive voice response voting. A further reason to characterize this frugal innovation as adaptable is the nearly infinite applications of such a service (Neil, 2012).
- Simplicity: A design theory that emphasizes clarity, ease of use, and basic functionality is called "simplicity." It's about making products that are simple, clear, and focused on functions. This driver focuses on eliminating complexity and developing simple solutions to comprehend and use. Simplicity requires a subjective assessment of what is "unnecessary" and "easy to use (Andersson et al., 2011)."

TATA Chemical: Rice Husk Water Filter is an example of design innovation focusing on simplicity and core functions. R. Gopalakrishnan develops it. Tata Chemical purifies drinking water without electricity, allowing households without access to electricity to enjoy safe, clean water (Singh, 2011).

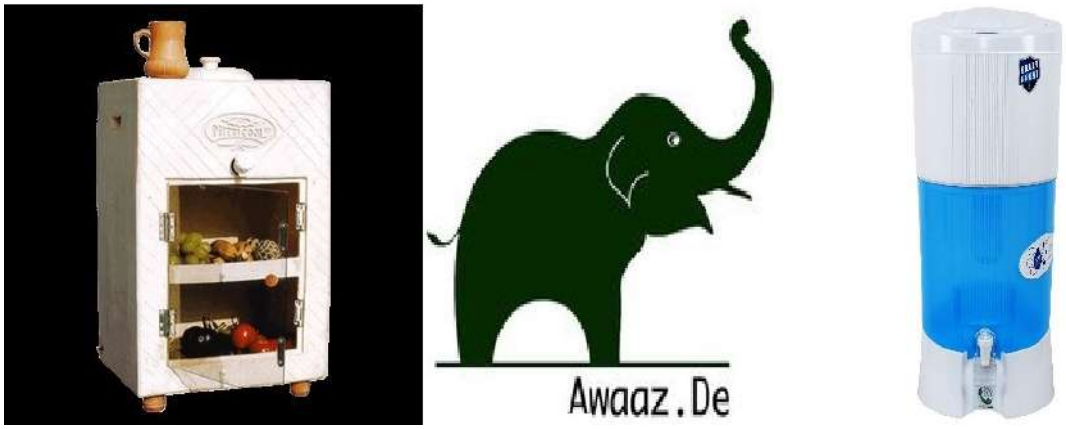

Fig. 4. Mitticool(Rao, 2013) b) Awaaz. De (Neil, 2012) c) Tata Chemical: water purifier(Singh, 2011).

In the design discipline, simplicity is undoubtedly the most distinctive characteristic. Still, it is also the most difficult to master, as it varies greatly depending on the target users, technical expertise, and cultural context (Goswami and Tiwari, 2015).

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From the perspective of the examples of these three drivers, as shown in Figure 4, we can observe that they align along an axis ranging from objectivity to subjectivity, from resourcefulness to simplicity.

3.2 Values Creation by Design-Driven Frugal Innovation Process

The research identified six possible innovation values from the Design-driven Frugal Innovation methodology. These frugal innovation values were developed through the procedure's phenomenological assessment. Figure 5 illustrates examples of frugal innovation values.

- Functional - Functional innovation refers to a product's primary purpose or what it is meant to perform. i.e., how successfully the product performs its intended function to meet the user's needs. It deals with the capabilities and features of the product (Breeding, 2015). The authors (Goswami and Tiwari, 2015) and (Stone et al., 2005) emphasize product functionality as a critical factor in driving successful innovation. They underline that product functionality innovation entails improving a product's essential functions and usability to fulfill changing customer needs and differentiate itself in the market. Organizations that provide novel significance to products, design culture, and sensibility can address latent requirements and establish new markets, resulting in breakout items fundamentally different from present solutions (Anderson et al., 2017). The Vortex Gram teller ATM illustrates functional frugal innovation by showcasing an efficient and need-based strategy for providing essential banking services in remote areas. The company's creative strategy entails creating solar-powered ATMs that use only 100 watts of electricity, making them appropriate for areas with inconsistent power supplies. Vortex ATM not only meets the distinctive needs of the community but also has a substantial social impact, giving millions of people in rural India access to essential financial services and the ability to open self-banking accounts. Both design and technical application areas can drive functional innovation (Agarwal and Brem, 2017).
- Robust - Creating innovative products that are robust, long-lasting, and able to survive various environmental challenges or changes is known as robust innovation. To achieve robustness in design, designers need to prioritize elements like durability, adaptability, and user-centered design. Innovations can endure various environmental conditions and usage scenarios by foreseeing possible hazards and implementing solid procedures (Roth, 2009). ToughStuff: Durable Solar Panel Charging System is an example of robust innovation. ToughStuff created a solar panel charging system to run radios, cellphones, and LED lights. The system reduces the cost and time spent traveling to recharge stations for crucial gadgets that sustain livelihoods. The technology is highly durable and can charge at night using energy stored throughout the day. It can tolerate extreme temperatures and has been tested under harsh situations (Marlow, 2009). The system's capacity to operate in harsh settings depends on its design and materials. The product's thin amorphous silicon sheet generates electricity from sunlight, making it both durable and user-friendly (The Trickle Out Project(2012).
- User-friendly - User-friendly innovation refers to how much a product improves or modifies its usability and intuitiveness; it may also include new features or change its design to other products already in the market. Therefore, it addresses user satisfaction, accessibility, and ease of use to improve the relationship between people and the product (Krippendorff, 2008). However, designers also need to consider how easy a device is to install, repair, and maintain in addition to considering the product during usage. Keeping maintainability and usability together enhances the user experience overall. According to Rampino (2004), the relationship between users and products in a particular environment determines the usage quality. It includes the product's features, how to use it, safety, and dependability (Rampino, 2004). Nandi: Jerry Can is a good instance of a user-friendly, frugal innovation that emphasizes the usability, accessibility, and overall user experience of their products, allowing the villagers to regularly

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drink clean water and use it in rural areas of India (Matthews, 2008). They can accomplish this by including features that are user-friendly, intuitive, and closely aligned with end users' requirements and expectations. To improve user satisfaction, Jerry- can clearly explain complicated procedures, offer concise directions, and create intuitive user interfaces. It is a user-friendly solution that connects with its customers and drives business success by adopting a user-centric strategy (Kartz, 2009).

- Growing - Growing innovation describes the capacity for scalability and adaptation. This could entail expanding into new markets, increasing production levels, or stimulating additional cycles of innovation that improve upon the original idea (Zeschky et al., 2014). By prioritizing growth, designers aim to reach more consumers with their solutions, which could help more people and solve the same problem more broadly (Pisoni et al., 2018). The ultrasound devices made by GE Healthcare are an example of growing frugal innovation. It is seeing growth and scalability through new advances. Initially, it develops items in developing economies such as China and India before marketing them globally. GE Healthcare is establishing itself in a position to take advantage of new market opportunities and lead value categories in developed nations. Their goals are to lower costs significantly, improve accessibility, and raise the quality of medical equipment. GE Healthcare can satisfy the needs of a wide range of markets and adjust to the shifting global health perception (Arshad et al., 2018).
- Affordable - Affordable innovation is defined as developing products and services within the means of a broad spectrum of consumers, especially those living in low-income or resource-constrained situations. Designers prioritize affordability as it addresses fundamental societal concerns, such as inequality in access to critical solutions (Mazumdar-Shaw,2018). Frugal innovation improves social justice, marginalized people's well-being, and economic growth. Furthermore, it can help organizations reach new markets and prospects while contributing to sustainable development. Considering affordability in innovation allows designers to produce meaningful and practical solutions that benefit society (Ernst et al., 2015). The Jaipur Foot is an example of affordable innovation. In 1968, Ram Chander created the Jaipur Foot. The Jaipur Foot is a rubber prosthetic limb for people with below-the-knee amputations (Sharma, 2011). Mr. D. R. Mehta founded BMVSS in early 1975 (Diaz, 2012). The Jaipur Foot's primary consideration is affordability, which provides the best value-to-cost ratio at a reasonable price. The Jaipur foot is lighter to facilitate travel and movement, mimics a standard foot and leg, and can be completely submerged in water. By contrast, a prosthetic foot in the United States costs $8,000 and takes up to a year to recover; the Jaipur foot costs $30 and requires rehabilitation lasting three to six months (Chopra, 2004).
- Local - Local innovation refers to sourcing materials, products, or services from nearby suppliers or manufacturers, focusing on local and community relationships. It provides many benefits that improve the design process's effectiveness, caliber, and sustainability (Svetina and Prodan, 2008). Many researchers focus on local sourcing as it benefits the local economy, builds community ties, decreases environmental impact by shortening transportation distances, boosts brand reputation by demonstrating a commitment to sustainability and community support, and builds a more robust and linked supply chain ecosystem (Jha and Krishnan, 2013)

Huk Power Systems (HPS) is a prime example of local innovation. It created a method using rice husks, a local waste, to produce electricity that is safe, clean, and efficient. The system encourages economic development and microenterprise while lengthening children's research sessions by extending village activities beyond daylight hours. With 3,000 plants constructed, HPS hopes to supply electricity to 10 million people in over 10,000 towns by 2017. The company also expects to support 2,500 small

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businesses and create over 7,000 jobs in the communities it serves. Using existing local resources is affordable and provides a comprehensive approach to the company product cycle (Greene, 2011).

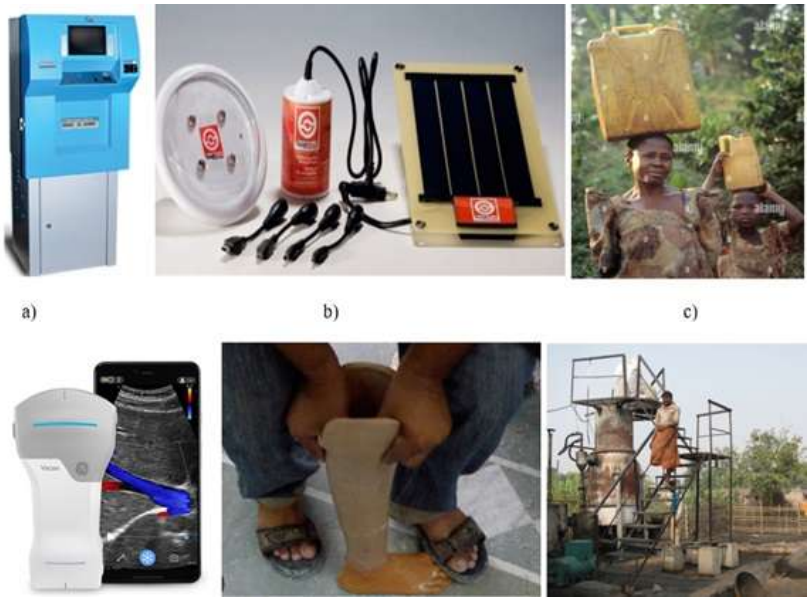

Fig. 5. a) Vortex ATM(Agarwal and Brem, 2017) b) ToughStuff: Durable Solar Panel Charging System(Marlow, October 16, 2009) c) Nani jerry can(William Davidson Institute, December 2009) d) GE ultrasound devices(Arshad et al., 2018) e) Jaipur Foot(Chopra, 2004) f) Huk Power Systems (HPS)(Greene,2011).

4 Frugal Innovation Pyramid

The six types of innovation value derived from the design-driven frugal innovation described can be distinguished based on their novelty level. Function, robustness, and Growing innovations are incremental, while user-friendly, affordable innovation is disruptive. Local innovation is both incremental and disruptive.

Incremental innovation includes many innovations focused on functionality, robustness, and growth, according to Dell'Era and Verganti (2007) (Dell'Era and Verganti, 2007). These developments enhance current products without fundamentally altering them. They frequently stick to a recognizable design that complements well-established product categories. Incremental innovations are simple to understand and only need a little cognitive effort to be implemented because they do not deviate from what people already know. Users regard them as reliable and predictable, resulting in favorable sensations of familiarity and a sense of knowing what to expect. Clayton Christensen defines disruptive innovation as introducing a new product and service that disrupts an existing market and displaces established firms or organizations (Terry, 2020). User-friendly and affordable innovation falls under the category of disruptive innovation. By developing affordable and easy-to-use solutions, these innovations can attract new users who were previously excluded owing to high costs or complexity.

As previously mentioned, the thirty product taxonomies yielded the following results: six functional innovations, four robust innovations, six user-friendly innovations, three expanding, eight affordable, and three local innovations. After adding twenty more products, a sample of fifty products was obtained. The findings included ten functional innovations, six robust innovations, eight user-friendly innovations, nine growing, twelve affordable, and five local innovations. The following charts demonstrate how the hypothesis was constant.

Table 1 Relationship between divers and values.

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	Thirty Frugal Products						Fifty Frugal Products					
Drivers Applied	**Functional**	**Robust**	**User-friendly**	**Growing**	**Affordable**	**Local**	**Functional**	**Robust**	**User-friendly**	**Growing**	**Affordable**	**Local**
Resourcefulness	0	0	0	0	3	2	0	0	0	0	5	4
Res. + Adaptability	0	1	0	0	2	1	0	1	0	0	2	1
Sim +Adaptability	2	1	1	2	1	0	4	1	2	3	1	0
Simplicity	4	2	5	1	2	0	6	4	6	6	4	0

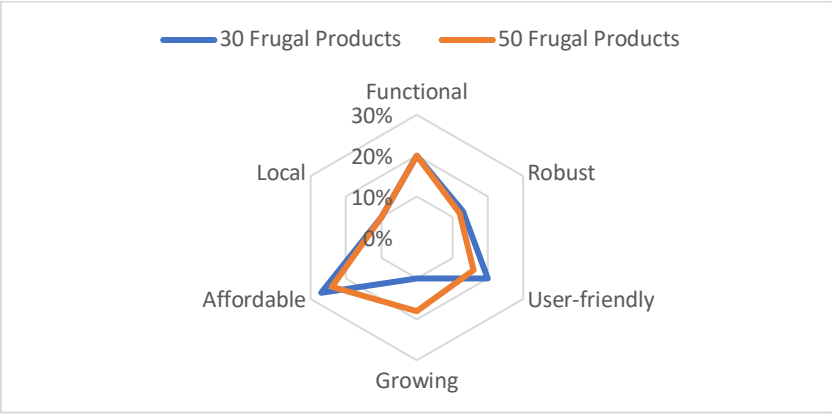

Fig. 6. Distribution of six types of frugal innovation value over thirty and fifty frugal product

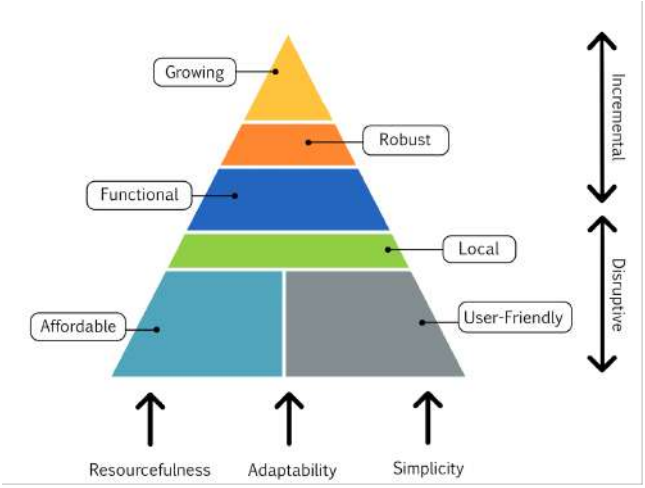

Fig. 7. Design-driven Frugal Innovation Pyramid

Considering the displayed percentages, systematizing frugal innovation led to a pyramid where incremental innovations (robust, growing, and functional) occupied the top, disruptive innovations (affordable and user-friendly) at the bottom, and local innovations disruptive and incremental were at the center, shown in Figure 7. When initial drivers and values are analyzed, it becomes clear that

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affordability and local immediately correlate with resourcefulness and that functional, robustness, user-friendliness, and growth are directly associated with simplicity. Some Designers also apply the adaptability driver. Table 1 displays the findings for the 30-product and 50-product analyses, and Figure 6 shows the distribution of the three drivers and six types of innovation values into frugal products.

5 Discussion

The research developed the Fugal Innovation Pyramid," a noble framework that taxonomically categorizes the design-driven frugal innovations into three drivers and six values. Following are the substantial implications of the research

5.1 Theoretical Implications

- The "frugal innovation pyramid" is an innovative framework that is proposed in this research as a means of categorization frugal innovations that are driven by design principles. Three fundamental drivers, adaptability, simplicity, resourcefulness, and six potential values, are identified: functional, user-friendly, robust,growing, local, and affordable. Researchers may be able to better comprehend and evaluate the design aspects of frugal innovation with the aid of this framework.
- This research emphasizes the shift of frugal innovation from a solely resource-limited strategy to one that considers both user and market requirements. It highlights the increasing significance of design in promoting frugal innovation beyond simply reducing costs, an aspect that has not been sufficiently explored in prior academic conversations. This change highlights the importance of design in improving the functionality and aesthetics of frugal products, making them more competitive and valued in the market.
- The research recognizes the challenge of measuring the value of design in conventional innovation procedures and aims to bridge the gap between the two. A qualitative methodology (phenomenology) investigates methods for connecting and highlighting the distinct value of design in the context of frugal innovation.

5.2 Practical Implications

- The proposed framework offers a significant tool for firms to enhance the integration of design concepts into their frugal innovation processes. Companies may create cost-effective products that are both economical and possess qualities such as functionality, user-friendliness, and adaptability by prioritizing the drivers and values of design-driven frugal innovation.
- Design-driven frugal innovation prioritizes user requirements and market demands and enables organizations to uncover new market opportunities. This approach is convenient in resource-constrained situations or for underserved populations.
- The pyramid facilitates cross-disciplinary communication among design, engineering, and management teams. It creates a shared vocabulary for discussing and assessing design contributions to frugal product development.
- The research advises organizations to value design-driven frugal innovation beyond financial indicators. It also includes communicating value, improving brand reputation, and seeking new markets or manufacturing opportunities. Focusing on these elements helps organizations use design to generate more meaningful and sustainable solutions.
- Frugal innovations lacking design may have difficulty adjusting to evolving user requirements or market expectations. Their long-term viability may be limited due to a lack of flexibility and modularity required for future development or improvements. Failure to prioritize design concerns puts these innovations in danger of becoming outmoded or ineffectual in dynamic situations.
- Inadequate design thought might lead to frugal breakthroughs that are challenging to use, maintain, or repair. This might result in user annoyance and discontent, undermining the cost-effectiveness advantages. Efficient design guarantees affordable products are usable, adaptable, accessible, and easily reachable, enhancing user experience.

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6 Conclusion

According to Kubler's 1972 book "The Shape of Time," humans can only fully comprehend the universe by simplifying it and rearranging the infinite stream of distinct events into a finite system of identity (Kubler, 1972). This concept is highly relevant to current research. Our research presents the "Frugal Innovation Pyramid," an innovative model for taxonomic categorization design-driven frugal innovations. The pyramid delineates three key drivers: resourcefulness, adaptability, and simplicity, as well as six potential values: functional, user-friendly, robust, growing, local, and affordable. This framework offers researchers and practitioners a significant instrument to enhance their understanding and analysis of the role of design in attaining successful frugal innovation. The research emphasizes a substantial change in the comprehension of frugal innovation, transitioning from a solely limited-resource strategy to one that incorporates user requirements and market expectations. The "frugal innovation pyramid" presents pragmatic benefits for businesses. Companies can produce affordable and versatile products that are also desirable by concentrating on the drivers and values. This approach has the potential to facilitate entry into untapped markets, enhance cross-disciplinary communication, and foster a more comprehensive appreciation for the value of design that extends beyond mere cost reduction. This research aims to connect design and traditional innovation processes by emphasizing a qualitative approach(phenomenology) to highlight the distinct contributions of design to frugal innovation.

However, the research also recognizes the natural conflict when categorizing something as fluid and ever-changing as creativity. According to Kubler, using flexible taxonomies can enhance the potential for innovative solutions (Kubler, 1972). Future research could focus on strengthening the pyramid to ensure its effectiveness in adapting to the dynamic world of design-driven frugal innovation. Furthermore, additional research could explore the wider-reaching effects of design-driven frugal innovation beyond the product itself. One aspect to consider is the exploration of economic and social implications, such as the potential for job creation, efficient resource utilization, and market development, especially in environments with limited resources.

Competing Interest - The authors declare that they have no competing interests.

Appendix

A. Selection of the Frugal Products

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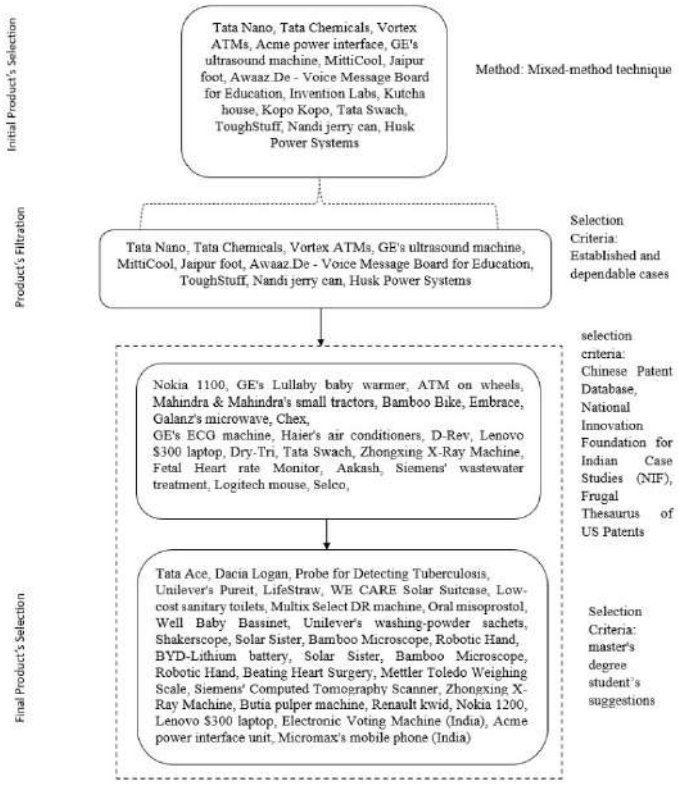

Fig. 8. Selection of frugal products

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B. *Questionnaire to assess the proposed framework*

Questionnaire Survey on Frugal Product Driver and Value

Aim:

The main aim of the survey is to understand and test the Frugal product's driver and value.

Introduction:

To identify the most relevant drivers and values of design-driven frugal innovation products, we must improve our understan critical role design plays in their success. This analysis will identify the essential drivers and value provided by design in the frugal innovation.

Frugal Design and innovation refer to reducing the complexity and cost of a good and its production, but they can also in product durability and using unconventional distribution methods.

Note: Participants must match the values and drivers created by each of the products in the above image, and their answers n format: **YES** ☐ **NO** ☐

Drivers

Resourcefulness

1. Does the product employ materials in a distinct or inventive manner to optimize efficiency?
2. Does the product have a design that aims to reduce waste during manufacture and usage?
3. Does the product use less energy or resources than comparable ones?

Adaptability

1. Does the product adapt well to varied uses or environments?
2. Does the product's feature set allow users to tailor it to their needs?
3. Is the product made to work well in various environmental factors, such as humidity and temperature?

Simplicity

1. Does the product have a simple, uncluttered design devoid of extraneous elements?
2. Does the product come with clear instructions that are easy to understand?
3. Is it easy for users to navigate the product's interface?
4. Is the product easy to assemble and ready for use in a short amount of time?

Values

Function

1. Is the product capable of consistently fulfilling its primary function?
2. Does the product fulfill the requirements of its target market?
3. Is it simple to use the product?

Robust

1. To what extent does the product manage normal wear and tear?
2. Does the product exhibit consistent performance under different conditions?
3. Does the product operate reliably without frequent errors or failures?

User-friendly

1. How simple was it to install the product
2. Is the product layout intuitive
3. Can a new user understand the product quickly?

Growing

1. Is the product suitable for developing and developed markets?
2. Is the product affordable for low- and high-income consumers?

Affordable

1. Is the product priced below or on par with comparable products?
2. Is the product affordable for many consumers, especially low-income ones?
3. Does the product provide a satisfactory level of value with the amount of money paid?
4. Can the product sustain its affordability while maintaining its quality over an extended period?

Local

1. Is it mostly built from local materials?
2. Is the product made by local entrepreneurs or businesses?
3. Does the product's manufacture contribute to the local community's economic growth and well-being?

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