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I am an Industrial Designer with extensive experience in collaborative innovation and sustainable product design. Presently, I hold the position of Assistant Professor in the Department of Design at the Indian Institute of Technology Guwahati. My doctoral research explored Design for Sustainability, specifically focusing on the development of scale-appropriate agricultural equipment. My academic journey began with a Bachelor's degree in Industrial Design from IIT Guwahati, followed by a Master's degree in Integrated Product Design from the Technical University of Delft, Netherlands, culminating in a PhD from IIT Guwahati.

I co-founded the Sustainability and Social Innovation Lab at the Department of Design, IIT Guwahati, which aims to redefine systems for sustainable human consumption and production. Our design interventions strive for a profound transformation of the consumption structure. The lab is an active participant in the

Learning and Education Network in Sustainability (LeNS), a global consortium of over 150 universities dedicated to sustainability. A significant portion of our work focuses on sustainable product-service development projects within the agricultural sector.

My expertise lies in Design for Sustainability, emphasizing the integration of environmental considerations into the design process. This includes Agricultural Product Design, aiming to improve the efficiency and sustainability of farming tools and equipment. I'm deeply involved in Lifecycle Assessment to measure the environmental impacts of products throughout their lifecycle. My work in Sustainable Product-Service System Design seeks to create innovative solutions that blend products and services for better sustainability. Additionally, my efforts extend to Medical Product Design, prioritizing user safety and environmental considerations. My strong foundation in User Experience Design and Human-Centered Design ensures that our products are not only sustainable but also user-friendly and responsive to human needs.

At IIT Guwahati, I teach various courses including System Design for Sustainability, Usability Engineering, User Research Techniques, Product Detailing, Interaction Design, Design Management, and Plastics and Composites. I have also developed a MOOC course on System Design for Sustainability for the SWAYAM platform, sponsored by MHRD.

Over the past few years, my professional journey has taken me across India, Bangladesh, and the Netherlands, collaborating with organizations such as ABB, Philips, Infosys, MIDCO, VU Medical University Amsterdam, Conpax Verpakking, Beat Belly, Botanische Tuin Delft, ACC Ltd, and numerous educational institutes and NGOs worldwide.

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Embracing Femininity in Design: A Pathway to Caring, Collaboration, Well-being and Sustainability

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1.1. Introduction

One fine hot and humid day in the farms of Bangladesh, while talking to a group of farmers, I realized how deeply feminine qualities like care, collaboration, and a focus on well-being are needed in our approach to design for anything and everything. The machine that I was testing to start a redesign exercise was generating a lot of soil dust on the face of the operator (Banerjee, 2015; Banerjee & Punekar, 2020). I mentioned that we will consider this aspect in the redesign. However, all the farmers jumped in and said, "We are farmers—men of the soil. We are hard. Machines are for the hard. We can take the dust." This interaction made me question the narrow definition of masculinity that we have developed in life and design and how it has alienated the feminine qualities that are so crucial for meaningful and impactful design outcomes and a good quality of life. On the one hand, the farmers said they constantly fell sick after operating the machine and had to take sick leave the next day. However, on the other hand, they needed to portray a masculine image of being 'tough' and 'able to handle it.'

As explored in this article, femininity refers to qualities and approaches often associated with women, such as caring, collaboration, and a focus on well-being and how it should become

the core of all Design exercises. These so-called femininity traits are not limited to women but have been historically undervalued in our society and design practices. Design practices have primarily focused on the so-called masculine norms. Traditionally, masculine norms, tenets, or principles (we have used these terms interchangeably in the article) have often dominated design, emphasizing efficiency, functionality, and technical prowess. However, by incorporating feminist perspectives, designers can reframe the design process to prioritize empathy, inclusivity, and holistic considerations (Mellor, 1992) for human and environmental well-being (Dijkstra & van der Bijl, 2016). Embracing femininity for design thinking shift is not about excluding masculine qualities but embracing the complementary strengths that both perspectives bring to the design process.

1.2. Defining Femininity in Design

Femininity in design is not solely about catering to women; instead, it is a broader approach that values characteristics often associated with the feminine, such as nurturing, cooperation, and a focus on emotional and social needs (Mellor, 1992). These qualities can benefit all users, regardless of gender, by creating design solutions that are more responsive to human-centered concerns (d'Ignazio & Klein, 2016). Let us look at some aspects that define femininity in Design and showcase how we at the Sustainability and Social Innovation Lab try to use the strengths of both masculinity and femininity principles.

1.3. Caring, Collaboration, and Well-being Orientation

Feminist scholars have long argued that traditionally feminine traits like empathy, care, and collaboration are essential for addressing complex social and environmental challenges (d'Ignazio & Klein, 2016). Another key aspect of femininity in

design is focusing on holistic well-being rather than narrow performance metrics (Hadi et al., 2020). These qualities are crucial in design, where the goal should be to create solutions that genuinely meet the needs of diverse users and communities while uplifting the overall quality of life of every stakeholder involved.

For example, while designing the game *Sahakarya*, a game which teaches people how to prepare for an impending flood and build resilience for themselves and how to work collaboratively with the community when the flood has hit, our design team focused on incorporating care, cooperation, and community-building as core game mechanics. The game demonstrates a sophisticated integration of feminine and masculine design principles, creating a nuanced learning environment for disaster preparedness. The feminine design principles manifest through:

1. ***collaborative core mechanics emphasizing community survival,***
2. ***care-based elements utilizing kindness points and support for vulnerable non-player characters,***
3. ***holistic problem-solving approaches acknowledging diverse strengths (knowledge, kindness, alertness, etc.),***
4. ***relationship-building mechanisms promoting knowledge sharing and trust, and***
5. ***nurturing elements focused on community resilience and prevention.***

These principles are complemented by masculine design elements, including

1. ***strategic resource management requiring optimization and efficiency,***

2. ***competitive frameworks with distinct winning conditions and achievement metrics,***
3. ***clear objective structures with defined progression systems,***
4. ***individual agency through character selection and autonomous decision-making, and***
5. ***systematic risk management approaches.***

The integration of these principles occurs through several game mechanics:

1. ***balanced motivations combining individual success with community well-being,***
2. ***complementary mechanics where strategic decisions influence social outcomes,***
3. ***hybrid victory conditions (highest knowledge points, highest kindness points, and highest combined points) valuing both achievement and community support,***
4. ***dual-focus design balancing personal survival with social responsibility and***
5. ***multifaceted learning incorporating both technical knowledge and emotional intelligence.***

This careful integration creates a rich pedagogical tool that effectively teaches players practical disaster preparedness skills and social responsibility principles, reflecting the complex realities of community disaster response through a balanced application of gender-archetypal design approaches.

The game demonstrates how traditionally feminine principles of care, collaboration, and community well-being can be effectively synthesized with masculine tenets of strategy, competition, and individual achievement to create a more comprehensive and engaging learning experience. This integration suggests a model

for how gender-inclusive design principles can enhance serious games and educational tools, particularly in contexts requiring individual competence and community cooperation.

1.4. Challenges of the Caring, Collaboration, and Well-being Orientation

Now, going back to the agricultural machine story that we started the article with. What were my customers demanding? They wanted an efficient machine that breaks down less, costs less to operate, is easy to transport from village to village, and is less hectic for the operator. Soil dust is fine. It causes huge fatigue to the operator, so if that can be reduced a bit else, they will manage by tying a sandbag in the front of the machine like how they are doing it now. The engineers and agricultural scientists involved in the project were looking for a robust machine that is efficient (in terms of technical requirements like seed-to-seed distance, errors, and turning radius), breaks down less, and is lightweight but cheap. Despite receiving these customer demands, we felt the story was incomplete. As designers, we grew up to engage in "Design Thinking". Brown (2008) says that design thinking is "a discipline that is built on a designer's approach to understanding the customer's demands very sensitively with what is scientifically possible and assisting in the conversion of customer value into an opportunity to be successful in the marketplace."

So, we decided to talk to some women about the machine. A group of them mentioned that due to some unrest, the police arrested all the men in the village, and it was thanks to this machine that they could complete the sowing activity in time. They wish it was ergonomically suited to their physical dimensions and the kind of clothing they wear. Another woman said that the operator can't operate the machine alone as they need someone to constantly drop seeds into it. So, the operator takes his sister or wife along for

this job. Now, this accompanying lady is not paid anything, and the money that the operator makes is basically one person's wage. A village elder told us that earlier, when we looked for a husband for our daughter, we would see how many cattle one had, and now, it was how many agricultural machines there were. So, a young man added, "This machine looks bad and reduces our reputation in the marriage talks. We want tractor-like machines." Then, the next bystander added, "We don't aspire to own this machine. It breaks down all the time. It makes me feel that I am poor, and hence, I have no other option. The sandbag that I tie in the front of the machine is like a bag that I tie around my neck." The manufacturer, who was also the reverse engineer behind the machine, was the pride of his village and nearby areas. The machine was a symbol of being made in Bangladesh and the ingenuity of the local people. It represented their collective spirit and the capability to engineer and make something out of the resources available. The manufacturer employed a lot of local youth, trained them in sheet metal fabrication, and had a lot of agricultural machinery in his kitty. These young men, ones trained, would usually leave for greener pastures, making him again rely on untrained people whom he would have to patiently train. Despite these challenges, he had succeeded in growing constantly and delivering.

So how, as a designer, should I approach this problem? The narrow customer-demand-driven, technical and efficiency-focused, market-driven approach or the feminine approach focusing on human-centered well-being, considering the holistic impact of a solution on a user's physical, mental, emotional, and social needs. Taking the broad feminine approach, in this case, is desirable. However, will smaller or economically weaker companies be willing to take this approach when they are unsure how to map the economic benefits to the resource investment? Taking the feminine approach involves actively seeking out diverse user perspectives,

deeply understanding their lived experiences, and crafting solutions that improve overall quality of life rather than merely functional optimization. By centralizing well-being as a key design principle, we can create solutions that nurture the whole person and community rather than treating users as isolated, one-dimensional consumers.

However, a well-being-oriented approach seems many a times untenable in low-resource settings for designers and their sponsors or the people who would ultimately manufacture and sell the designed solutions. Similar were the challenges we faced here. The NGO was interested in a well-being-oriented approach, while the scientific institution was more focused on the technical and efficiency-focused, market-driven approach. Other limitations came from the support institutions that need the volume of production to be able to agree to produce high-quality components for the machine or hoist spare parts or financial inclusion schemes. As designers, we took the well-being-oriented approach and designed an aspirable machine that looked like a tractor, fulfilled the technical, efficiency, and market requirements, was easier to operate and maneuver in the field, needed only one operator, and conceptualized product-service systems to operationalize the support ecosystem. However, it still depends on the sponsors and their resource availability if they can implement the caring, collaboration, and well-being-orientated approach or now in this low resource context.

1.5. Femininity's Role in Sustainability-oriented Design Thinking

Several researchers and design thinkers will point out how approaches like participatory design, design for well-being, and design considering a holistic approach where we see the world as a whole in terms of time, space, and quality of life are the key to

achieving sustainability on the triple bottom line: environmental, socio-ethical, and economic. These approaches are also grounded in the feminist approach to thinking. We will highlight one less spoken about that we are focusing on at our lab.

This approach is called the Design for Sustainable Distributed Economy. The term "Distributed economy" was coined by Johansson et al. (2005). Our lab is part of an international network of about 200 universities that call themselves the LeNS network, standing for Learning and Education Network for Sustainability. We published our collaborative research and development work in Design for Sustainable Distributed Economy as a Springer open-access book called Designing Sustainability for All (Vezzoli et al., 2021).

Distributed economy is an emerging concept that contrasts with centralized and decentralized economic models. It emphasizes local, small-scale, community-based economies (van den Dool et al., 2009) and is characterized by greater individual and community control over production and participation (Josh, 2018). Unlike centralized economies, distributed systems leverage peer-to-peer interactions and distributed technologies to integrate knowledge and resources more efficiently (Barile et al., 2017; Burger et al., 2019; Huberman & Hogg, 1995). In the energy sector, distributed energy resources (DERs) are transforming traditional centralized grids into more flexible, decentralized systems (Nadeem et al., 2023). This transition presents both opportunities and challenges, requiring new business models and regulatory frameworks (Hargroves et al., 2023). In computational systems, distributed approaches enable more efficient resource management and scheduling through economic models (Buyya et al., 2005; Jian et al., 2020). While distributed systems offer advantages in terms of flexibility and efficiency, they also introduce new complexities in coordination and control (Barile et al., 2017; Seidel, 2017).

Let's compare the traditional economic development model with the innovative sustainability-focused model of the distributed economy. The traditional model is based on individualism, growth, large-scale operations, competition, centralization, profit, tangible products, reduced ethics, and consumerism, while the distributed economy emphasizes solidarity, development, small-scale operations, cooperation, distribution, well-being, intangible services, ethical practices, and sharing (dos Santos et al., 2021). Very clearly, all feminine approaches! In this design for sustainability approach, we are looking to jointly promote the improvement of welfare, social cohesion, and social equity while significantly reducing environmental impact and resource depletion.

Let's look at some of our projects in this direction.

1.5.1. Case Study: The Baghara Cooperative - Feminine Design Principles in Action

The Baghara Traditional Dress-making Cooperative Society, located in Assam's Morigaon District, provides a compelling case study of how feminine design principles can be effectively integrated into sustainability-oriented practices. This cooperative, engaging 500 weavers primarily in weaving, sericulture, stitching, and embroidery, demonstrates the practical application of distributed economy concepts within a traditional craft sector. The cooperative's structure is a testament to key feminine design principles, emphasizing collaboration through its organization of 20 producer groups, each with 25 members, and the designation of secretaries and Cluster Development Executives. It integrates traditional knowledge with modern management, ensuring sustainable production methods by using locally sourced materials and adhering to cruelty-free and chemical-free practices. The cooperative also takes a care-centered approach, respecting

weavers' religious and cultural commitments, offering flexible scheduling, and incorporating family and community values into training. Decision-making is collaborative, involving group-based problem-solving, shared resource management, and collective knowledge transfer. Furthermore, the cooperative is well-being-oriented, focusing on skills development, economic empowerment, and cultural preservation.

Our study in this cluster and several other women-oriented clusters in Assam, time and again, revealed this distributed economy structure and NGOs or governmental organizations backing them with a care, collaboration, and well-being-oriented approach. They realize that women are balancing their weaving or tailoring jobs with their family responsibilities. Hence, they can only handle a certain number of hours per day, and variability from one day to another is unavoidable. They are formed into larger co-operatives or groups so that they can collectively complete orders. No bulk orders are taken as the women can't commit to the same. Hence, respect for human labor is inherent in the system design of these networked distributed economies. However, there are challenges, too. For example, we observed that the women did not keep a good record of their expenses and income. They don't price their products by comparing the price of similarly placed items or by valuing the time they have put into making the product. The business-oriented mindset is missing largely, and hence, conscious thinking into investing and expansion of their activities was absent. Handling these challenges while respecting their personal well-being (they don't overwork themselves or ignore the well-being of themselves and their families) is a difficult balance to achieve. Thus, when we designed our financial literacy program for these women, we made a conscious attempt not only to teach them a business mindset but also to tell them about the benefits of their current care, collaboration, and well-being-oriented approach to

their craft in line with the distributed economy's philosophy.

1.5.2. Janani Foundation's Eco-friendly, Reusable Cotton Menstrual Pads

The Janani Pads initiative, spearheaded by Aimoni Tumung and Uttam Teron through the Parijat Academy in Assam, presents a compelling case study of how feminine design principles can be effectively integrated into sustainable product development and community empowerment. This initiative exemplifies the distributed economy model while addressing critical intersections of environmental sustainability, social equity, and economic empowerment through a care-centered approach.

Figure 1 Aimoni and Uttam calls us to Bleed with Dignity through their Janani Pads intiative

The project demonstrates several key aspects of feminine design principles:

Care-Centered Product Development Unlike conventional market-driven approaches that prioritize profit maximization through

centralized mass production, Janani Pads embodies a care-centered design philosophy. The product development process began with addressing the fundamental needs of rural women, focusing on both menstrual hygiene management and economic independence. The two-part design of the reusable pads, which facilitates better sun-drying and hygiene, reflects deep consideration for users' practical needs and cultural contexts, moving beyond mere functional efficiency.

Collaborative Knowledge Systems The initiative exemplifies collaborative knowledge creation and transfer through its decentralized production model. Women are trained not just in manufacturing techniques but are empowered with comprehensive knowledge about menstrual health, sustainable practices, and entrepreneurship. This approach aligns with feminist design principles by validating and incorporating local knowledge systems while building collective capabilities.

Well-being Oriented Business Model The Janani Pads model demonstrates how well-being can be centralized in business design without compromising economic viability. Key features include:

- ***Decentralized production units enabling women to work from their communities***
- ***Flexible production targets that respect work-life balance (30 pads per day)***
- ***Income potential of up to ₹18,000 monthly while maintaining community ties***
- ***Pricing strategy (₹80-₹110 per unit) balancing accessibility with sustainability***

Environmental Sustainability Integration The initiative's approach to environmental sustainability reflects feminine design principles through its emphasis on:

- ***Long-term ecological impact consideration (3-year product lifecycle)***
- ***Waste reduction through reusable design***
- ***Local material sourcing and production***
- **Quality control through centralized material procurement**

Social Innovation Through Distributed Economy The Janani model exemplifies how distributed economy principles can be leveraged for social innovation:

1. **Decentralized Production: Small-scale, community-based manufacturing units**
2. **Local Value Creation: Skills development and economic opportunities within communities**
3. **Social Capital Building: Breaking menstruation taboos through community engagement**
4. **Sustainable Scale: Focus on optimal rather than maximum production**

This case study demonstrates how feminine design principles can be successfully integrated into sustainable product development while addressing complex social challenges. The initiative's success in creating both social and economic value while maintaining environmental responsibility provides valuable insights for designers working towards sustainability-oriented solutions.

The Janani Pads model also highlights how feminine design principles can help overcome the traditional tensions between profitability and social impact. By prioritizing care, collaboration, and well-being, the initiative has created a sustainable business model that generates meaningful employment while addressing

critical social and environmental challenges. This approach offers important lessons for designing sustainability solutions that can be effectively implemented in low-resource contexts while maintaining their commitment to holistic well-being.

1.6. Femininity's Role in our Design Processes

Through the case studies presented - the Sahakarya game, the agricultural machinery redesign, the Baghara Cooperative, and the Janani Pads initiative - we have demonstrated how feminine design principles can be effectively integrated into sustainable design processes. These examples offer crucial insights into both the opportunities and challenges of implementing care-centered, collaborative, and well-being-oriented design approaches, particularly in low-resource contexts.

1.6.1. Integration of Feminine and Masculine Design Principles

Our experiences reveal that the most effective design solutions emerge from a thoughtful integration of both feminine and masculine design principles. While masculine approaches prioritize efficiency, technical optimization, and market viability, feminine principles emphasize care, collaboration, and holistic well-being. This integration is exemplified in the Sahakarya game design, where competitive mechanics were balanced with collaborative elements to create an effective learning tool. Similarly, the agricultural machinery redesign demonstrated how technical requirements could be harmonized with broader social and emotional considerations.

1.6.2. Distributed Economy as a Framework for Sustainable Design

The distributed economy model, as demonstrated through the

Baghara Cooperative and Janani Pads initiatives, provides a practical framework for implementing feminine design principles at scale. Key insights from these cases include:

1. **Local Value Creation: Decentralized production systems enable communities to maintain control over resources while creating sustainable economic opportunities**
2. **Knowledge Integration: Collaborative knowledge systems that respect and incorporate local expertise while introducing new technical capabilities**
3. **Flexible Implementation: Adaptable systems that accommodate varying resource levels and cultural contexts**
4. **Social Innovation: Design solutions that address both practical needs and deeper social challenges**

1.6.3. Methodological Implications for Design Practice

Our experiences suggest several key considerations for incorporating feminine design principles into sustainable design processes:

1. Stakeholder Engagement

- ***Moving beyond traditional user research to deep community engagement***
- ***Validating and incorporating diverse knowledge systems***
- ***Building long-term relationships with communities***

2. Success Metrics

- ***Expanding beyond conventional performance metrics to include:***
- ***Social impact indicators***

- ***Well-being measures***
- ***Environmental sustainability metrics***
- ***Community empowerment indicators***

3. Implementation Strategies

- ***Developing flexible frameworks that can adapt to resource constraints***
- ***Building support systems for long-term sustainability***
- ***Creating balanced business models that prioritize both social and economic outcomes***

1.7. Challenges and Future Directions

Our case studies highlight the potential of feminine design principles, yet several challenges remain. One significant issue is resource constraints, as it is often difficult to balance comprehensive stakeholder engagement with practical limitations in low-resource settings. Additionally, there is the challenge of scale and sustainability; we need to develop models that can grow while still maintaining a care-centered approach. Another concern is business integration, where creating frameworks that assist organizations in incorporating feminine design principles must not compromise economic viability. Finally, we must establish robust methods for measurement and validation to effectively assess the impact of feminine design principles on project outcomes.

1.8. Future Research Directions

Based on our findings, we have identified several promising areas for future research. These include the development of practical tools and frameworks for implementing feminine design principles in various contexts, as well as an investigation into how these

principles can be effectively scaled while preserving their essential characteristics. Additionally, exploring new metrics and evaluation methods to capture the full impact of care-centered design approaches is vital. Finally, a study on how feminine design principles can be integrated into existing design and development processes is also crucial for advancing this field.

1.9. Conclusion

Our work demonstrates that feminine design principles offer a powerful approach for creating sustainable solutions that address complex social and environmental challenges. By embracing care, collaboration, and well-being as core design values, while thoughtfully integrating them with traditional design approaches, we can create more effective and sustainable solutions. The distributed economy model provides a practical framework for implementing these principles at scale, though challenges remain in terms of resource constraints and business integration.

The success of initiatives like the Janani Pads and Baghara Cooperative suggests that feminine design principles can be effectively implemented even in resource-constrained environments, creating sustainable solutions that generate both social and economic value. As we move forward, the challenge will be to develop more robust frameworks and tools that can help organizations implement these principles effectively while maintaining their essential care-centered nature.

1.10. In this Guest Editorial

In this Guest Editorial, we explore the integration of feminine design principles into sustainable development practices through multiple empirical case studies and theoretical frameworks. We present the design of a game, Sahakarya, which balances feminine and masculine traits. Next, we discuss the case of women gamers

and explore whether women gamers are the same as men. Is our gaming industry geared to explore the women's gaming market needs, and how big is it? From there on, we weave into the distributed economy, firstly in the Assamese weaving sector and then into the reusable menstrual product market.

Join us in this exciting journey!

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