



Invisible Sustainability: Gendered Circular Resource Practices and Household Climate Resilience in Rural Bangladesh

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Abstract: Households are not just sites of consumption but dynamic systems that constantly manage, reuse and recirculate resources through everyday practices. This study investigates the household activities of rural women through the lens of 'household circular resource systems' (HCRS) to demonstrate how the system generates and contributes to environmental sustainability and household resilience and survives in local resource circulation. This study used qualitative methods and collected data through 35 in-depth interviews, participant observation, and household activity mapping from 30 purposively selected rural households in six villages in Pabna and Sirajganj districts. The data were analysed thematically. The findings suggest that the cyclical use of food waste, water, and compost-based nutrients produces interrelated processes. These processes collectively contribute to environmental sustainability and household resilience through continuous resource regeneration, reduced household waste and expenses, and improved food security and water management. Moreover, the results show that the traditional HCRS is maintained through complex interactions among women's productive family resources, intergenerational ecological knowledge, and unpaid domestic labour. Rural women also perceive the circular system as a culturally embedded family custom. However, the level of circularity varies with the number of family-owned animals and arable land. Changing rural lifestyles, marked by greater reliance on commercial agricultural products and less control over property and livestock, are slowly undermining traditional circular techniques. This study advances sustainability and circular economy scholarship by conceptualising HCRS as a localised socio-ecological framework. It suggests that sustainable rural development policies should include family adaptability by acknowledging regional environmental practices, encouraging small-scale animal production, and giving residents greater access to fertile land to foster sustainability and resilience in rural society.

Keywords: Household Circular Resource Systems (HCRS); Invisible Sustainability; Household Climate Resilience; Gendered Everyday Practices; Rural Bangladesh.

Nomenclature:

IDIs: In-Depth Interviews

HIRH: High-intensity Reuse Households

MIRH: Moderate-intensity Reuse Households

LIRH: Low-intensity Reuse Households

HCRS: Household Circular Resource Systems

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I. INTRODUCTION

Increasingly, environmental sustainability is understood as a complex process that includes not only technological innovation, formal environmental governance and public policy, but also the everyday practices through which households manage and recirculate resources [1]. Everyday household decisions about food, water, organic materials, and other resources affect resource efficiency, environmental responsibility, and long-term resilience in social and ecological contexts. Foden et al. demonstrate the linkages between everyday practices of households and larger systems of resources [2]. Shahbaz et al. and Cheng et al. also further confirm that sustainable household consumption [3] and waste management contribute significantly to environmental sustainability [4]. Thus, sustainability scholarship increasingly recognizes households as important sites where everyday practices contribute to important environmental change, alongside formal institutional interventions [5].

Despite these advances, research has focused mostly on formal sustainability initiatives and individual pro-environmental behaviours, and less on how interconnected household resource management practices collectively sustain everyday systems of environmental sustainability. Households, however, are not simply places of consumption, but dynamic systems in which resources are actively managed, reused and recirculated through everyday practices with implications for environmental impacts and household resilience [6]. Godin and Langlois demonstrate that the sustainability of the household within these household systems is basically organised by gendered work and care [7]; the Food and Agriculture Organization of the United Nations, Mostari et al., and Bryan et al. show that rural women are key in the management of food and water [8], livestock resources [9], organic materials and other household assets [10]. These responsibilities shape women's roles in resource efficiency [11], household livelihoods, and environmental sustainability [12], making women's everyday practices vital to maintaining household resource systems and broader environmental outcomes [13]. Studies show that practices such as composting, recycling [14], water reuse, reducing food waste [15], and productive use of household by-products are important to resource efficiency and sustainable consumption [16]. Similarly, Mies and Gold imagine circularity as prolonging the productive life of resources through interconnected systems of reuse, repair, recycling, and regeneration [17].

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The environmental importance of household-level resource management is especially apparent in rural Bangladesh, where agriculture, livestock, and household livelihoods remain strongly connected [9]. Limited access to financial resources, market services, and formal waste management systems encourages households to optimise local resources through reuse, repair, recovery, and conservation [18]. In these contexts, women organise the everyday management of household resources through food preparation, water management [8], livestock care [9], use of organic residue, preserving reusable materials, and minimising waste [10]. These practices mainly support household livelihoods but also offer important environmental benefits by reducing waste, extending resource lifecycles, and promoting circular resource use [3].

However, mainstream sustainability discourse largely overlooks these routine practices. Formal environmental policies and institutional interventions remain privileged over routine domestic resource management [19]. Thus, identifying these practices extends normative understandings of environmental responsibility by situating sustainability in everyday household life [12]. Studies so far have mainly considered household sustainability in terms of waste management [4], the circular economy [17], and sustainable consumption and household environmental behaviour [20]. Relatively little attention has been paid to how multiple household resource-management practices collectively function as integrated household systems, especially in rural communities where resource circulation is closely linked to livelihoods, care work, and gendered responsibilities. To address these limitations, an analytical approach that unifies household resource management, everyday practices, gendered relations, and environmental sustainability into a coherent conceptual framework is needed.

To address this gap, this study presents the Household Circular Resource Systems (HCRS) framework to examine how rural women's everyday household resource management practices promote environmental sustainability in Bangladesh. The framework conceptualises domestic practices as interconnected, integrated systems that enable resource circulation, waste minimisation, adaptive resource use, household resilience, and broader environmental benefits. Drawing on insights from sustainability transitions, the circular economy, gender studies, and everyday household practices, the study develops a more socially grounded understanding of household sustainability. It shows how routine domestic activities accumulate environmental benefits that conventional sustainability research often overlooks. Specifically, the study aims to:

- A. Examine how women's everyday domestic practices create interconnected Household Circular Resource Systems (HCRS).
- B. Understand how these systems contribute to invisible sustainability and household resilience.

- C. Explore the role of gendered everyday practices and intergenerational knowledge in sustaining localised resource circulation.

II. METHODOLOGY

A. Research Design

This research used a qualitative multiple-case study approach with an anthropological perspective. The qualitative approach is appropriate for understanding people's daily behaviours, indigenous knowledge, and lived experience in depth. The ethnographic perspective allows the researcher to closely observe people's usual behaviours in a natural social setting. Furthermore, the multiple-case study approach, using homes from two districts, allowed contextual comparisons across different rural areas.

B. Study Area

The study was conducted in two rural districts of Bangladesh, Pabna and Sirajganj, purposively selected. These districts were chosen because rural livelihoods are primarily based on agriculture and livestock rearing, where women play a central role in managing household resources such as food preparation, water use, livestock care, and organic household waste. These livelihood systems provide an appropriate setting to explore how common domestic practices generate interconnected Household Circular Resource Systems (HCRS).

The study areas are located along the Padma River (Pabna) and Jamuna River (Sirajganj). They are characterised by dynamic riverine environments that push households to adapt continuously to resource constraints and environmental variability. Common local practices among rural families include reusing household by-products, feeding livestock with leftover food and crop residues, recycling organic waste, and maintaining integrated home-based farming systems. These everyday practices provided fertile ground for exploring invisible sustainability, household resilience, and the localised circulation of resources.

The long-established settlement patterns, socio-cultural traditions, and ongoing reliance on locally available resources also provided an appropriate ethnographic context for the study. Moreover, the accessibility from Dhaka and the researcher's familiarity with the local language and community allowed for a longer period of field engagement. The six purposively selected villages were Bakchidangi, Vadurdangi, and Gohailbari of Pabna, and Kachihara, Alampur, and Baraitala of Sirajganj.

C. Sampling Procedure and Sample Size

The study used purposive sampling to select 30 households from six villages in the two study districts (five households per village). The main participant in each household was the adult woman primarily responsible for household management, given her central role in everyday decision-making and resource management in the domestic sphere. Five elderly women from Households 3, 5, 14, 22



and 30 were also purposively selected to explore intergenerational transmission of household knowledge and practices about localized resource circulation.

D. Data Collection Methods

The study used various qualitative data collection methods including in-depth interviews (IDIs), participant observation and household activity mapping. These complementary methods enabled methodological triangulation by capturing participants' experiences, observed behaviours, and the spatial organisation of household resource circulation, enhancing the credibility and richness of the findings.

i. In-Depth Interviews (IDIs)

The selected participants were interviewed through in-depth interviews (IDIs) to explore their everyday household resource management practices, experiences and perceptions. Thirty-five participants were interviewed using a semi-structured guide with open-ended questions. The participants were one adult woman from each of the 30 households and five elderly women. The interview guide was developed in English and then translated into Bangla to ensure the participants understood. All the interviews were conducted in Bangla by the researcher and took approximately 30–45 minutes. All interviews were audio-recorded with the informed consent of the participants, and demographic data were collected.

ii. Participant Observation

Participant observation, non-intrusive in nature, was employed to record women's everyday resource management practices and routine household activities in their natural settings. During the fieldwork period, the researcher spent about 4–6 hours in each selected household observing traditional storage methods, resource-saving strategies, food preparation, livestock care and practices regarding resource reuse and informal waste management. A semi-structured observation checklist was used to ensure consistency, but also allowed for ethnographic flexibility. Field notes documenting observable behaviors, interactions between individuals and informal conversations were systematically recorded to complement and triangulate the findings from the interviews. This observation also enabled the detection of tacit knowledge and routine practices that participants might not verbalize during interviews.

iii. Household Activity Mapping

Household activity mapping was used to record and visualize the flow of household resources and the spatial organization of daily domestic activities. The circulation and reuse of food, water, organic waste and other household resources was emphasized instead of

their disposal. In each household, the arrangement of kitchens, courtyards, storage spaces, home gardens, livestock spaces and waste zones was observed for about 1-2 hours. Mapping data were collected via direct observations, informal discussions, sketch maps and detailed field notes. Mapping data provided a graphical representation of the localized circulation of household resources.

E. Data Analysis

The data were analyzed using thematic analysis to identify and interpret recurring patterns within interviews, observations and household activity maps. After the fieldwork was completed, the interview recordings and observation notes were systematically organized for analysis. The interviews were first transcribed in Bangla and then translated into English. Data were coded and analyzed using NVivo 14. The researcher coded the data as a way to maintain consistency within the analytical process. The final themes were generated through an iterative process of coding, comparing and refining themes. Emerging interpretations were continuously cross-checked with observation records and field notes to enhance the credibility and dependability of findings.

F. Ethical Considerations

The study followed the established ethical principles for research involving human participants. Before data collection, all participants were informed about the study's purpose and procedures, and the researcher obtained written informed consent before interviews and observations began. To maintain confidentiality and anonymity, the researcher assigned each household a unique identification code (e.g., HH1, HH2, HH3). Participation was voluntary, and participants were informed that they could withdraw from the study at any stage without consequence. During the research process, the researcher observed cultural sensitivity, and all collected data were used for academic purposes only.

G. Study Limitations

Several limitations should be considered when interpreting this study's findings. First, findings may not be generalisable to other contexts given the qualitative nature of the research and the inclusion of households from only two districts. Second, the limited time for ethnographic observation, constrained by available time and resources, may not have captured all aspects of households' everyday practices. Finally, as with all qualitative research, the research context and the researcher's positionality may have influenced the interpretations. However, the study maintained methodological rigour through triangulation and systematic analysis.

III. FINDINGS OF THE STUDY

A. Household Characteristics of the Participants

Table I: Household Demographic Information

Household ID	District	Respondent Age	Education Level	Livestock Ownership	Land Ownership
HH1	Pabna	38	Primary	Cow	Small to medium
HH2	Pabna	45	No formal education	Cow, chicken and duck	Medium to high
HH3	Pabna	32	Secondary	Poultry	Small to medium
HH4	Pabna	50	Primary	Cow, goat, chicken	Medium to high
HH5	Pabna	29	Secondary	None	Very limited
HH6	Pabna	41	Primary	Cow	Small to medium
HH7	Pabna	36	Secondary	Poultry	Small to medium
HH8	Pabna	55	No formal education	Cow, goat, duck	Medium to high
HH9	Pabna	33	Secondary	Poultry	Small to medium
HH10	Pabna	47	Primary	Cow	Small to medium
HH11	Pabna	39	Secondary	Cow	Small to medium
HH12	Pabna	44	Primary	Cow, poultry	Medium to high
HH13	Pabna	31	Secondary	None	Very limited
HH14	Pabna	52	No formal education	Cow, goat	Medium to high
HH15	Pabna	35	Primary	Cow	Small to medium
HH16	Sirajganj	28	Secondary	None	Very limited
HH17	Sirajganj	46	Primary	Cow	Small to medium
HH18	Sirajganj	40	Secondary	Cow, poultry	Small to medium
HH19	Sirajganj	53	No formal education	Cow, goat, poultry	Medium to high
HH20	Sirajganj	34	Secondary	None	Very limited
HH21	Sirajganj	37	Primary	Cow	Small to medium
HH22	Sirajganj	42	Secondary	Cow, poultry	Small to medium
HH23	Sirajganj	30	Secondary	Poultry	Small to medium
HH24	Sirajganj	49	Primary	Cow, goat, duck	Medium to high
HH25	Sirajganj	27	Secondary	None	Very limited
HH26	Sirajganj	38	Primary	Cow	Small to medium
HH27	Sirajganj	45	Secondary	Cow, poultry	Medium to high
HH28	Sirajganj	33	Secondary	Poultry	Small to medium
HH29	Sirajganj	51	No formal education	Cow, goat	Medium to high
HH30	Sirajganj	40	Primary	Cow	Small to medium

Source: Author Interview (2026)

Table 1 presents the demographic characteristics of the 30 households that participated in the study. The respondents were women mainly responsible for day-to-day household management in rural households in Pabna and Sirajganj. Participants were aged 27 to 55 years and had education ranging from no formal schooling to secondary school. Livestock ownership ranged from none to integrated systems with cattle, goats, poultry, and ducks, and landholdings ranged from very limited (1–10 decimals) to medium to high (above 50 decimals).

B. Women's Everyday Domestic Practices and the Formation of Household Circular Resource Systems (HCRS)

Findings show how rural women's everyday practices collectively form interconnected Household Circular Resource Systems (HCRS) that continually reuse and recirculate household resources. In both districts, women regarded these activities as routine responsibilities rather than environmental practices. Activity mapping showed interlinked cycles of food reuse, successive water use, composting, and the management of livestock by-products and organic materials through routine domestic practices.

i. Food Resource Circulation

Food resource circulation was integral to HCRS. Households did not consider kitchen residues as waste. Instead, they stored and reused vegetable peels,

cooking residues, leftover rice, and stale food as feed for cattle, goats, poultry, and ducks, thereby increasing productivity. In both districts, participants saw these practices as ordinary household chores, not as environmental actions. Domestic practices for collecting organic materials for cooking and feeding livestock were well established and passed down through routine household management. A couple of respondents from Pabna said that:

"During the cooking time we usually reserve a bowl to collect vegetable peels and remains of other organic products. The peels are later fed to goats and cows. Leftover rice is also fed to ducks and chickens. I think everything can be used somehow and I think that's a good thing. So, we don't like to waste food or other organic material."

(HH1, HH7, HH12: Rural women, Pabna District) Similarly, participants from Sirajganj reported similar practice:

"We take all the waste at the end of the cooking, and some is given to animals. We use the rest of the waste to make fertilizer, but we do not think that there is a need to throw away organic waste in our home."

(HH19, HH21, HH24, HH27: Rural women, Sirajganj District)

These accounts illustrate the interdependence of



food preparation, livestock feeding, and agricultural production through the continuous cycle of resources. Organic kitchen residues were left in the household system as livestock feed before being transformed into agricultural inputs.

Household activity mapping (Figure 1) further illustrates this circulation process. Vegetables entered the household food system from farms or local markets; people consumed the edible parts, and the organic residues fed livestock. The animal manure produced in this process was then composted and applied to homestead gardens and crop fields, creating a continuous cycle in which the outputs of one activity became the inputs to another.



[Fig.1: Food Waste Circulation Cycle]

Source: Household Activity Mapping by the Author (2026)

Participants' views on household resource use echoed this cyclical understanding. As one respondent said:

"In our house, there's nothing that's totally useless. The animals are fed vegetable waste, and the waste from animals goes back into the soil."

(HH14: Woman, rural, Pabna district)

Overall, the results suggest that the circulation of food resources was a key feature of HCRS and allowed women to maintain continuous resource flows, which in turn reduced organic waste and supported livestock management and agricultural production.

ii. Sequential Water Reuse

Another important HCRS component was sequential water reuse. Water used for washing vegetables, utensils, and clothes was diverted to clean the environment and water livestock shelters and trees in homesteads, increasing its productive value before it was discarded rather than used once and thrown away. Careful water management was seen as a normal household responsibility, not deliberate saving. This was especially important during seasonal water shortages, when access to tube-well water became increasingly limited. As one participant from Pabna explained:

"We try to use water very carefully. For example, we frequently use the same water to clean the yard or

water plants after washing vegetables or utensils. This is especially important during the summer season when managing water becomes very difficult."

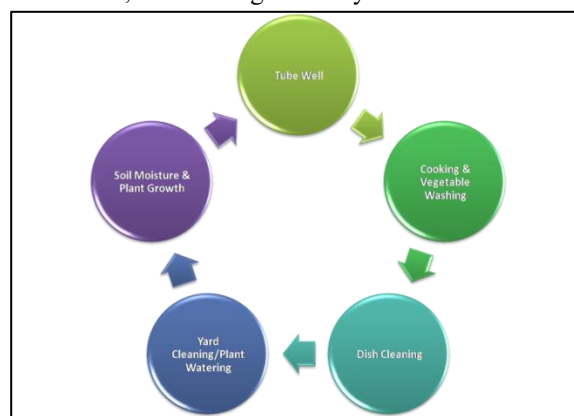
(HH3: Rural woman, Pabna District)

A similar trend was found in Sirajganj, where participants mentioned water reuse as an important strategy in the dry season.

"In the dry months, after washing vegetables, we don't throw away the water. We use it for the garden or for washing the cowshed because it is difficult to collect water several times a day."

(HH 29: Rural woman, Sirajganj District)

The mapping of household activities (Figure 2) further illustrates this circulation process. Water from the tube wells was first used for food preparation and washing, then reused for household cleaning, livestock management, and homestead gardening. Rather than following a linear pattern of consumption and disposal, water circulated through several interrelated domestic activities, maximising its utility within the household.



[Fig.2: Sequential Water Reuse Cycle]

Source: Household Activity Mapping by the Author, 2026

In summary, these findings show that sequential water reuse was an integral component of HCRS, linking several household activities through a continuous circulation of water, enhancing resource efficiency, and supporting daily household management amid seasonal water scarcity.

iii. Compost-Based Nutrient Circulation

Another HCRS element in the study households was compost-based nutrient circulation. Participants consistently described composting as an established household practice that converted food scraps, livestock manure, leaves, ash and other biodegradable materials into organic fertilizer, rather than discarding them. They then applied this compost to homestead gardens and crop fields, Enabling food production while reducing dependence on chemical fertilisers. A participant from Sirajganj said:

"We collect food scraps from behind the house, mix them with cow poo



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and leave them for a few months. After that, it's fertilizer and we use it for growing plants and crop production."

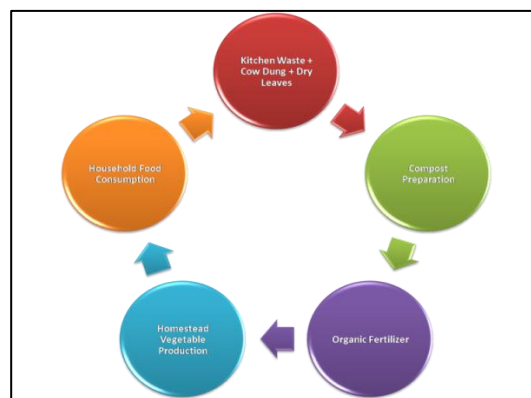
(HH29: Rural woman, Sirajganj District)

Participants also emphasised that they made the compost from a variety of organic materials.

"We also use goat dung, chicken and duck droppings and fish bones for this process. It boosts the soil fertility and reduces our dependence on chemical fertilizers and its cost to a large extent."

(HH2, HH18, HH28: Rural women, Pabna and Sirajganj Districts)

Household activity mapping (Figure 3) further illustrates the nutrient cycle, showing how organic residues from food preparation and livestock management were composted and returned to homestead gardens and agricultural land. Rather than being thrown away as household rubbish, these materials were continuously recycled as useful farm inputs.



[Fig.3: Compost and Gardening Cycle]

Source: Household Activity Mapping by the Author (2026)

Overall, compost-based nutrient circulation linked household consumption, livestock management, and crop production in a continuous nutrient cycle, strengthening HCRS by returning organic resources to productive use.

iv. Variations in Household Circularity According to Resource Endowments

All households studied practised circular resource management, but the intensity of these practices varied with livestock and land ownership. Ethnographic observation revealed three distinct patterns of household circularity, reflecting varying abilities to retain and reuse domestic resources (Table 2).

Table II: The Degree of Resource Circularity Based on Asset Ownership

Type of Household	Owned Assets	Zero-Waste Practices	Pattern of Resource Circulation	Specific Households
High-intensity Reuse Households (HIRH):	Own cattle, goats, chickens, and ducks; medium-to-high land ownership	Use vegetable waste as livestock food, prepare compost, reuse water, recycle manure via composting.	Minimal disposal of organic waste and high circularity	H2, H4, H8, H12, H14, H19, H24, H27, H29
Moderate-intensity Reuse Households (MIRH):	Limited livestock (poultry or cow only), small to medium land ownership	Feeding poultry, seasonal water reuse and partial composting, and small-scale organic recycling	Moderate circularity with some leakage of trash	H1, H3, H6, H7, H9, H10, H11, H15, H17, H18, H21, H22, H23, H26, H28, H30
Low-intensity Reuse Households (LIRH):	Not a single animal, very limited land access, heavy reliance on the market	Very little composting, irregular reuse of water, minimal ways of recycling	Higher waste disposal and low circularity	H5, H13, H16, H20, H25

Source: Author Interview(2026)

Households with integrated livestock systems and medium-to-high land ownership showed the highest level of circularity. Households routinely recycled organic residues as livestock feed, composted animal manure, reused water sequentially, and applied organic fertiliser to homestead gardens and crop fields. As a result, these households left behind only a small amount of biodegradable waste.

The households with limited livestock ownership and small landholdings showed moderate circularity. They practised livestock feeding, seasonal water reuse, and small-scale composting. Still, their resource flows were less integrated, resulting in greater dependence on external inputs and, at times, the disposal of organic materials.

Households with very small landholdings and no livestock had the lowest circularity levels. Limited composting and livestock-feeding opportunities reduced their ability to recycle household residues, increasing dependence on market inputs and waste disposal.

Participants also acknowledged the importance of productive assets in sustaining these resource flows. One respondent from Pabna stated that:

"If the house has cows and ducks, there is no waste. Small food waste can be used effectively too. But when there are no animals, it is difficult to manage waste."(HH4: Rural woman, Pabna District)

Overall, the findings suggest that HCRS intensity was shaped by household resource endowments, with greater access to livestock and productive land enabling more integrated and continuous resource circulation.

C. Household Circular Resource Systems, Invisible Sustainability and Climate Resilience

The results reveal that the HCRS identified in the previous parts generated environmental and livelihood benefits, although participants rarely recognised them as





sustainability practices. Rather, respondents saw such activities as routine household chores woven into everyday life. Sustainability outcomes were therefore largely invisible, emerging through mundane resource management rather than through deliberate environmental action. These practices helped to build climate resilience by lowering household expenditure, improving food security, minimizing waste, improving water management, and reducing reliance on external inputs.

i. Cost Reduction

One major outcome of HCRS was reduced daily household expenditure. Participants said that using kitchen residues for livestock feed reduced the cost of commercial feed purchases and that compost preparation reduced reliance on chemical fertilisers. These savings were especially important during times of drought, flood and financial difficulty. One respondent from Sirajganj explained:

We would have to spend a lot of money buying food for the cows every day. Kitchen waste helps us save money.

(HH23: Rural woman, Sirajganj District)

Another participant from Pabna illustrated how combining kitchen residues with conventional feed extended the use of purchased inputs.

"We usually feed our livestock with hay, chaff, and cooking waste... even extending its use saves us around 200–400 taka, which is a big amount for an agrarian family."

(HH8: Rural woman, Pabna District)

Participants also reported that homemade compost reduced fertilizer costs while maintaining crop production.

"In addition to being more affordable, homemade fertilizer benefits plants. Chemical fertilisers are not inexpensive at all."

(HH11: Rural woman, Pabna District)

One respondent from Sirajganj also pointed out the economic benefits of composting:

"We make organic fertiliser from cow dung and other waste from the home. It cuts our fertiliser costs by a lot and improves soil condition when we use it with urea."

(HH26: Rural woman, Sirajganj District)

In sum, HCRS delivered tangible economic benefits by reducing expenditure on animal feed and agricultural inputs, allowing households to manage scarce financial resources better.

ii. Food Security

HCRS also supported ongoing production of livestock products and homestead crops, thereby increasing household food security. Livestock fed recycled food residues provided milk, meat and eggs for household consumption, and extra income through market sales. Meanwhile, compost from household organics fed vegetable production in homestead gardens. Participants noted that these food sources were particularly critical during floods, droughts, crop failures and financial problems.

"In times of flood or crop damage, our family has a hard time when we get vegetables from our garden and milk from our cows."

(HH19: Rural woman, Sirajganj District)

Another respondent explained:

"We have cows, chickens and ducks that regularly provide us with milk and eggs. We eat them ourselves and sell them in the market. These products are our main source of food when we have financial problems or when floods or drought destroy our crops."

(HH27: Rural woman, Sirajganj District)

The results show that HCRS increased food availability by integrating food waste reuse, livestock production, composting and homestead cultivation into an integrated household system.

iii. Waste Minimization

Beyond the economic and food security advantages, HCRS greatly reduced organic waste production. Participants rarely threw away biodegradable materials, as they repeatedly said they redirected them to feed livestock, make compost, and support other productive household activities. Ethnographic observations confirmed these reports, showing that household disposal sites consisted mainly of plastics and other non-biodegradable materials and contained very little organic waste. One respondent explained:

"We try to use most of the organic waste which results in very less production of organic waste."

(HH5: Rural woman, Pabna District)

These findings show that the continuous use of biodegradable materials promoted effective resource rotation and decreased household waste.

iv. Water Security

Sequential water reuse also improved household water security, especially during seasonal water shortages. Participants said they reused water from food preparation and washing to clean household spaces, maintain livestock shelters, and water homestead plants. Households not only collected more water but also spread its use across several domestic activities. One respondent stated:

"We also do our very best to reuse water. That is very important especially during the dry season from March to May when the water in the tube wells goes down a lot and it becomes very difficult to pump water out of the tube wells."

(HH16: Rural woman, Pabna district).

Such practices were especially important from March to May, when falling groundwater levels made tube-well water increasingly hard to access. Under such conditions, sequential water reuse enabled households to manage limited water resources more efficiently and sustain essential domestic and agricultural activities.

v. Household Resilience

Collectively, these findings indicate that HCRS strengthened household resilience



through several interrelated pathways. These everyday practices helped reduce expenditure, support food production, avoid waste, and improve the management of locally available resources, thereby reducing dependency on external markets and agricultural inputs.

Participants did not frequently mention these activities as environmental or climate adaptation strategies, but they consistently described them as normal household duties. Yet these routine practices yielded significant environmental and livelihood benefits, increasing households' capacity to adapt to floods, droughts, rising agricultural input prices, and other socio-economic challenges. Together, the results reveal the dual role of women's routine resource management practices in generating both invisible sustainability and household climate resilience.

D. Gendered Everyday Practices and Intergenerational Knowledge in Sustaining Localized Resource Circulation

i. Learning Through Everyday Participation and Intergenerational Knowledge Transmission

The results indicate that women's circular resource practices were largely learned through intergenerational learning, embedded in daily household life. Knowledge of resource reuse, feeding livestock, preparing compost, and managing households was not formally taught; women learned it by observing and participating with older women in the family. Most respondents reported learning these practices from their mothers, grandmothers, or other older women in childhood and later repeating the mat home. Several respondents from Pabna explained:

"These things my mother taught me. When I was younger, I used to help her feed the animals and cook. Afterwards, I began doing the same in my own home." (HH6, HH9, HH15: Rural women, Pabna District)

A participant from Sirajganj similarly stated:

"These customs are a part of our daily life. Older women in the household educate younger girls on how to manage resources and waste at home effectively." (HH26: Rural woman, Sirajganj District)

These findings suggest that embedded intergenerational knowledge transfer in everyday domestic life sustained localised circular resource use practices.

ii. Women's Moral Responsibility

Participants perceived careful resource management as both practical and morally appropriate, linked to good household management. Participants regarded efficient resource use as a sign of responsibility, and wastefulness as neglect of household duties. Participants said that:

"Looking after resources helps everything in the house run smoothly. This is our own responsibility. And those who don't do this, I think, are indifferent to responsibility."

(HH7, HH10, HH18, HH23, HH30: Rural women, Pabna and Sirajganj Districts)

iii. Challenges from Rural Modernization

Participants also expressed concerns that ongoing socio-economic change was gradually eroding traditional circular practices. They cited challenges such as dwindling livestock ownership, less land per household, greater reliance on commercial agricultural inputs, and changing lifestyles. One of the participants from Sirajganj said:

"It was simpler to utilize garbage because every household had ample land and cows in the past. These days, lives are evolving, and a lot of youth have little interest in these customs."

(HH20: Rural woman, Sirajganj District)

Similarly, a participant from Pabna observed:

"Earlier, every house used to have a separate place for composting dung and garbage. While many houses still compost, the practice has declined because of limited space, lack of interest, and increasing dependence on chemical fertilizers."

(HH5: Rural woman, Pabna District)

iv. Continuity of Localized Circular Practices

Despite these difficulties, local circular practices remain vital to household management in the two districts studied. Women still control the flow of resources and pass on practical knowledge from one generation to the next, thus maintaining HCRS continuity. Together, the results show that these systems persist not only because of household resources but also because of gendered knowledge that enables localised circular practices to be learnt, adapted, and sustained over time.

IV. DISCUSSION

A. Household Circular Resource Systems as a Localized Model of Everyday Circularity

This study advances Household Circular Resource Systems (HCRS) as a socio-ecological framework at the household level through which women's everyday domestic practices generate localized circularity, environmental sustainability and household resilience. Food reuse, sequential water use, composting, livestock integration and household decision-making are interlinked processes rather than isolated resource-saving behaviours, where the output of one activity becomes the input of another. Sustainability thus emerges through the continuous interaction of practices that maintain, regenerate, and recirculate resources, shifting the focus from individual behaviours to the organisation of household life in resource-constrained rural settings.

One major contribution is the finding that these circular systems develop without being consciously recognized as environmental practices. Food reuse, composting, water conservation, and livestock management were perceived as mundane household chores that contribute to family well-being rather than as environmental protection. Yet these practices reduced waste, recycled nutrients, preserved resources, and maintained agricultural production. This challenges behaviour-centred accounts of sustainability linked to environmental awareness or intentionality,





suggesting that ecological outcomes may be unintended consequences of culturally embedded routines learned over generations.

Results show that rural households are dynamic socio-ecological systems supported by continuous resource regeneration. Food residues become livestock feed, manure becomes compost, compost improves soil fertility, and agricultural production supports the household food supply, with water reuse linking activities in sequence. These flows are interlinked, indicating that household circularity is based on regeneration rather than linear consumption and disposal. HCRS shows how hyper-localised knowledge and everyday organisation can support circular systems with existing household assets, rather than traditional circular economy models that focus on technology and formal recycling infrastructure, highlighting decentralised households as an under-explored opportunity for sustainable resource management. The study also repositions women's unpaid domestic labour as a form of environmental governance. Together, cooking, livestock care, composting, water management and resource allocation are referred to as household resource flows. They are environmentally important because they maintain an integrated system that consistently produces ecological benefits. This acknowledgement challenges sustainability narratives that privilege formal institutions, technology, and markets while overlooking the environmental value of unpaid domestic work.

An equally important finding is that household circularity is not homogeneous or equally feasible across rural households. All households recirculated resources to some degree, but the intensity of this practice depended on resource endowments, particularly livestock ownership and the amount of land available for cultivation. Households with higher productive assets maintained more integrated cycles. In contrast, households with limited land or no livestock had fragmented flows, as opportunities for composting, livestock feeding and nutrient regeneration were structurally constrained. Circularity is thus a continuum, not a dichotomy, reflecting productive capacity rather than environmental commitment. Hence women's resource-conserving practices are mediated by the material conditions within which they operate.

This relational view sees HCRS as arising from interactions among gendered labour, locally embedded knowledge, and productive household assets. Sustainability is not just behaviour-driven or material-resource-driven, but produced through the interplay of women's everyday resource management and structural conditions that enable or constrain circulation. This socio-material perspective explains variation in sustainability outcomes across households and positions HCRS as a systems-oriented framework in which interrelated practices create environmental sustainability, resource efficiency, and livelihood security beyond individual activities.

B. Invisible Sustainability as a Pathway to Household Resilience

The importance of HCRS goes far beyond resource efficiency. It shows how intertwined domestic practices support household resilience and climate adaptation through

the ongoing regeneration of resources. Transform food waste into feed, manure into compost and compost into soil nutrients to create regenerative loops that reduce dependence on outside inputs and preserve productive assets. These processes reduce costs, enhance food security and agricultural productivity, and minimize waste, demonstrating that sustainability, livelihood security, and resource efficiency reinforce one another. Thus, resilience comes from an ongoing stream of everyday resources, not from isolated conservation or technological interventions.

The most important insight, perhaps, is that significant sustainability outcomes are largely invisible to the women who make them. Participants framed their practices as responsibility, thrift and good household management rather than as environmental protection or climate adaptation. This implies that sustainability can be embedded in normalized domestic routines without formal environmental knowledge or deliberate pro-environmental attitudes. Women's unpaid domestic work is not only housekeeping, but a constant form of ecological management that organises, restructures, and reclaims resources in productive motion.

C. Intergenerational Knowledge and the Continuity of Household Circular Resource Systems

The results show that HCRS continuity depends not only on material resources but also on locally embedded ecological knowledge. Young women mainly learn practical abilities through intergenerational learning via observation and participation in daily household activities, rather than through formal environmental education. This experiential knowledge enables households to adjust resource management to seasonal conditions, available resources, household needs, and changes in agriculture, helping maintain resilient localised circular systems despite limited institutional support. Sustainability therefore involves sustaining resource flows and the social learning processes reproducing ecological knowledge.

But these systems are becoming more vulnerable to rural transformation. Declining livestock ownership, shrinking arable land, shifting livelihoods and greater dependence on purchased products reduce opportunities for integrated resource cycles. Another challenge to practical ecological skills is the erosion of intergenerational knowledge transmission. Because HCRS depends on productive assets, women's labour, and local knowledge, erosion in any dimension can undermine household resilience. Safeguarding sustainability thus depends on conserving natural resources and the social and material contexts that sustain localised circular systems.

D. Conceptual and Policy Implications

Overall, this study contributes to the broader understanding of rural household sustainability by presenting Household Circular Resource Systems (HCRS) as an integrated socio-ecological framework. Rather than treating food reuse, composting, livestock integration, water conservation, and resource management as separate practices, it shows that their interaction creates interconnected systems that support environmental sustainability, livelihood



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security, resource efficiency, and household resilience. Household circularity is a continuum defined by women's unpaid labour, productive assets and locally embedded ecological knowledge, moving beyond behaviour-centric explanations to position rural households as active sites of environmental governance.

The study also points to policy implications for the circular economy and climate resilience. Policies should build on existing household capacities by promoting small-scale livestock production, protecting productive land, promoting locally appropriate composting and recognizing women's ecological knowledge. Over-reliance on technology or externally designed interventions risks missing the point of existing household systems. Building on these mundane practices can help develop local capacity by showing how much of the contribution to sustainability comes from invisible, socially embedded routines that constantly regenerate resources and sustain rural livelihoods.

V. CONCLUSION

The paper introduces Household Circular Resource Systems (HCRS) as a localised form of circularity that draws on the everyday practices of rural women and yields circularity, environmental sustainability, and household resilience. Women's unpaid labour, productive assets, and ecological knowledge sustain these systems, yet they remain largely invisible in mainstream sustainability discourse. Supporting women's knowledge, household assets, and localised resource circulation can enhance climate resilience and promote inclusive, sustainable rural development.

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