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Innovative financing for a gender-equitable first-food system to mitigate greenhouse gas impacts of commercial milk formula: investing in breastfeeding as a carbon offset

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Women's contributions to food production and food security are often overlooked, thus perpetuating inequitable and unsustainable globalized commercial food systems. Women's role as producers in the first-food system, breastfeeding, is largely invisible and underfunded, encouraging the production and consumption of environmentally unsustainable commercial milk formula (CMF). This policy brief highlights opportunities for including and funding interventions enabling breastfeeding under carbon offset schemes such as the United Nations Clean Development Mechanism (CDM). A Green Feeding Tool is being developed to account for the national carbon and water footprints of CMF. The tool will help ensure that women's contributions to a sustainable first-food system are not ignored by the CDM and other mechanisms funding greenhouse gas emissions reductions.

KEYWORDS

breastfeeding, carbon offset schemes, commercial milk formula, first-food system, gender, greenhouse gases, innovation, sustainable development goals

1. Introduction—the problem

Climate change presents potentially catastrophic risks to human health and survival. One of the mitigating responses globally needs to be a reduction of greenhouse gas (GHG) emissions (WHO, 2022). There is an increasing awareness that the global food system is a major driver of environmental damage, including GHG emissions. Globally, one-third of GHGs result from food production, particularly by livestock industries. As a dairy product, CMF products, such as infant and follow-up formula, also have significant GHG emissions (Pope et al., 2021) which for China alone approximated the impact of 18 billion miles of car travel in 2019 (Smith, 2019).

1.1. Overlooking women in food systems

Recognizing and strengthening the self-determination of women¹ as food producers is an important lever for achieving sustainable food systems and development (UN Women, 2018). However, women's contributions to food production are poorly understood and defined, and substantially unrecognized, particularly their contribution via the first-food system, breastfeeding (Van Esterik, 1999; Smith, 2015; Van Esterik, 2018; Baker et al., 2021a,b). Even in the few instances where the connections between climate change, and children's diets are recognized in food system frameworks (Raza et al., 2020; Hollis et al., 2021; Agostoni et al., 2023), women's productivity through breastfeeding of infants and young children is only infrequently acknowledged. As concerns grow about the unsustainability of globalized industrial food systems, and amidst rising demands for food sovereignty from social movements (Friel et al., 2020), women risk being marginalized in the global food system transition by gender power systems and gender-biased perspectives on key players and funding priorities (UN Women, 2019, 2021).

1.2. Global policy context: commercial milk formula for infants and young children versus breastfeeding

It is well-recognized that breastfeeding is the biologically normal way to feed human infants and young children, and is important not only to children's health and development but also to women's health including through child spacing (Chowdhury et al., 2015; Victora et al., 2016; Finlay et al., 2018). The World Health Organization (WHO) recommends exclusively breastfeeding for the first 6 months of life, and continued breastfeeding to 2 years and beyond for optimal nutrition and child development and population health (WHO, UNICEF, 2022). The associated infant and maternal health outcomes

produce healthier populations that use fewer healthcare resources (Rollins, 2016; Victora et al., 2016; Walters et al., 2019). The WHO Global Nutrition Targets identify breastfeeding as a 'Double Duty Action', addressing both undernutrition and overnutrition, and underpinning the call for 50% of infants to be exclusively breastfed by 2025, and 70% by 2030.

A global syndemic of obesity, undernutrition, and climate change was identified by the Lancet Commission on Obesity in 2019, with a call for comprehensive, systemic food policy responses in a human rights framework (Swinburn et al., 2019).

Based on extensive evidence from multiple studies, the papers in the 2023 *Lancet Series on Breastfeeding* (Baker et al., 2023; Pérez-Escamilla et al., 2023; Rollins et al., 2023) identified the urgent need to address the cultural and structural barriers to breastfeeding and the corporate influence and power systems that interfere with women's intentions about breastfeeding. These include socio-cultural norms that ostracize breastfeeding in public, or breastfeeding beyond a certain age of infancy and the lack of appropriate, safe, and sanitary public facilities for women to use. These also include policy and fiscal priorities that result in insufficient investments in quality health and maternity care services, and deny many women adequate maternity leave to establish breastfeeding after childbirth, or the social or economic infrastructure and workplace supports needed to combine breastfeeding with employment. These power systems also facilitate the unregulated and egregious marketing of CMF targeting health professionals, women, and parents. Messaging frames CMF in terms of women's choice and empowerment (Baker et al., 2021a,b). Such factors, including feelings of guilt about supplementing or replacing their milk supply with CMF, can be highly detrimental to women's mental health and well-being.

Recognizing that some women may choose not to breastfeed, or may be prevented from doing so, breastfeeding women can be conceived uniquely as local producers in a globally distributed food production, nurture, and care system (Smith, 2015; UN Women, 2019; Baker et al., 2021a,b), providing the optimized food for infants and young children in all countries (Oshaug and Botten, 1994). This first-food system has a much lesser impact on a range of key environmental indicators than CMF (Linnecar et al., 2014; Pope et al., 2021; Andresen et al., 2022). Hence, improved protection, support and promotion of breastfeeding has been urged as a global priority in addressing current unhealthy and unsustainable food systems - a 'Triple Duty Action' (Dadhich et al., 2021).

As noted above, gendered power systems and institutions shape breastfeeding patterns and foster dependence on CMF (Baker et al., 2023), by limiting women's access to economic resources of time and money (UN Women, 2019, 2021). For example, breastfeeding is unpaid care work and time use studies show it has a high opportunity (time) cost to women if not enabled by suitable workforce arrangements and policies such as paid maternity leave and similar entitlements (Smith and Forrester, 2013; Holla-Bhar, 2015).

1.3. Feminist economic perspectives

A feminist economic perspective is particularly valid for this research study and to illustrate how gendered power systems and institutions shape breastfeeding patterns, and environmental outcomes. Feminist economics is the critical study of traditional

¹ Terminology in relation to sex, gender, and gender identity is contentious. The following definitions are used in this paper. The words 'women' and 'mothers' are used to mean female people and female parents and 'men' and 'fathers' to mean male people and male parents, respectively. We have chosen to use language that is based on the sex of individuals because female reproductive processes, rights and health are central to the issues under consideration, including for those with diverse gender identities. We use gender equality to express the idea that the sex of individuals should not limit rights, responsibilities, or opportunity and that the interests, needs and priorities of both women and men are considered. Sex equity is used to describe a 50:50 division between males and females. For further discussion see Gribble KD, Bewley S, Bartick MC, Mathisen R, Walker S, Gamble J, et al. Effective communication about pregnancy, birth, lactation, breastfeeding and newborn care: the importance of sexed language. *Front Glob Women's Health* (2022) 3. doi: 10.3389/fgwh.2022.818856.

Abbreviations: BFHI, Baby-friendly Hospital Initiative; CDM, United Nations Clean Development Mechanism; CERs, Certified Emission Reductions; CMF, commercial milk formula; EBF, exclusive breastfeeding; GHG, greenhouse gas; LMICs, low- and middle-income countries; UNFCCC, United Nations Framework Convention on Climate Change.

economics and draws attention to the social construction and gender bias in economics models, methods and assumptions.

Feminist economic scholars demand greater attention to neglected and undervalued areas such as women's traditional care work, and the interactions of the non-market sector of the economy and unpaid work, with the paid, or market sector (Benería et al., 2016). They also argue that this non-market economic activity, including the unpaid reproduction and care of children (Folbre and Wagman, 1993), underpins economic life, and should be better accounted for and measured in economic statistics and policies. The invisibility of the non-market sector has led to economic injustice and inequality in women's wages and economic development policies which have had less beneficial impacts on women than on men (Boserup, 1970).

The international system for measuring the economy, the system of national accounts, has been powerfully critiqued by feminist economists (Waring, 1999), especially for how women's unpaid work and the environment have been excluded from what counts as productive in the economy. Feminist economists also argue this invisibility gives rise to important synergies with ecological economics and green economics (Aslaksen et al., 2014), and can generate stronger political strategies for action, by integrating social provisioning in ecological sustainability models (Reksten and Floro, 2021).

Feminist economic scholarship has also illustrated that women's unpaid care work including breastfeeding (Smith, 2014), is rendered invisible in public policy by the global economic accounting systems which define and measure productivity such as Gross Domestic Product (GDP) (Smith and Folbre, 2020). Despite powerful calls for investment in breastfeeding policies and programs (Hansen, 2016), large financing gaps for implementing the key policies and programs persist (The United Nations Breastfeeding Advocacy Team, 2008; Holla-Bhar et al., 2015; Kakietek et al., 2017; Walters et al., 2017; Carroll et al., 2018; Siregar et al., 2019, 2021; Ulep et al., 2021; Sanghvi et al., 2022). Feminist economics also scrutinize power relations within the economy such as how male-dominated economic institutions place women at a disadvantage in the workplace (Power, 2004). A recent study of 185 countries globally estimated that 649 million women lack adequate maternity protections, yet the comprehensive provision of paid maternity leave and breastfeeding breaks was both feasible and affordable in all countries (International Labour Organization, 2022). In this report from ILO, paid maternity leave is a crucial policy for increasing exclusive breastfeeding, which is valued by the improved maternity leave policy in Canada in 2021 compared with 2011. All over the world, and especially in low- and middle-income countries, the contemporary context is marked by the precariousness of labor relations, with large contingents of women performing informal work (International Labour Organization, 2022). ILO standards require that adequate maternity benefits through non-contributory social assistance funds be provided to women who do not qualify for benefits out of social insurance, especially those in the informal economy. Successful experiences observed from Brazil, Ghana, The Philippines, Indonesia and Mexico suggest that comprehensive measures covering the informal sector are fiscally achievable in diverse country settings (Vilar-Compte et al., 2019, 2020; Siregar et al., 2021; Ulep et al., 2021; Carroll et al., 2022).

Despite the WHO recommendation noted above for exclusive breastfeeding and continued breastfeeding for 2 years and beyond (WHO, UNICEF, 2003), few countries are on track to meet the Global Nutrition Targets, and progress toward recommended IYCF practices

in recent decades has been slow (Bhattacharjee et al., 2021; WHO, UNICEF, 2022). While exclusive breastfeeding rates have increased to around 47%, continued breastfeeding rates are declining in low- and lower-middle-income countries, and in most global regions between 2000 and 2019 (Neves et al., 2021).

Meanwhile, the CMF industry is growing rapidly, driven by factors such as urbanization, the medicalization of childbirth, rising maternal labor force participation, and aggressive marketing (Baker et al., 2016, 2021a,b). Feminist economic analysis has highlighted that this growth in CMF sales is counted as increasing GDP and economic growth, while a decline in breastfeeding is unmeasured (Smith and Ingham, 2005). Two Nobel prize winners in economics who were commissioned to critically review the use of GDP for measuring economic progress have cited this example as archetypal of how the current system of measuring the economy is biased and misleads policymakers (Stiglitz et al., 2009).

Feminist approaches also seek to challenge power relations within agrifood systems, similarly highlighting the invisibility of women farmers in agroecology (Trevilla Espinal et al., 2021). For example, recent research in Kenya shows that gender dynamics shaped how the commercialization of dairy production impacted women's livelihoods resulting in gendered costs of commercialization (Tavener and Crane, 2018). Likewise, a study of dairy development through local cooperatives in Indonesia found that institutional and organizational dynamics and the social context for the initiative may have replicated or even entrenched inequalities. Traditional gender norms, and structuring by laws on land and property ownership and control and inheritance rights, meant that mainstreaming did not necessarily empower female dairy farmers, and formalization and professionalization tended to advance male dominance (Wijers, 2019). The disappointing experience of Nepal with gender mainstreaming in agriculture has led to calls for transformative approaches focused on empowerment through economic and political rights and entitlement to productive resources (Devkota et al., 2022).

Nevertheless, empowerment in particular domains such as paid work or accessing financial credit does not necessarily translate into women choosing to exercise agency, due to conflicting goals or loyalties such as family relationships and care work, or strategic pragmatism on priorities (Kabeer, 2008; Buisson et al., 2022).

Breastfeeding women's 'agency' as producers of valuable food for infants and young children cannot be taken for granted, and varies across cultures, history and country settings. Yet it is near universally practiced and culturally acceptable as food for infants and young children. While it is possible that conceptualizing women as milk producers could be resented as if classifying them as cattle, breastfeeding and milk production can also be a source of pride for women along with other unique reproductive capabilities (Almroth and Greiner, 1979).

1.4. The environmental impact of commercial milk formula sales

The environmental harms of food and agricultural production and the degradation of environmental assets have also been excluded from economic accounting systems and are invisible to policymakers (Stiglitz et al., 2009). Worldwide, livestock production contributes

approximately 18% of total GHG emissions, with dairy comprising approximately a quarter of that (Gerber et al., 2011).

Almost a decade ago, Linnecar recommended research to build the evidence base for breastfeeding advocacy around the environmental damage caused by CMF (Linnecar et al., 2014). A growing evidence base on the GHG impact of commercial milk formula (CMF) supports the importance of the breastfeeding work of women for food sustainability. CMF production and consumption involves multiple agricultural and industrial steps with its impact primarily via the carbon and water footprints of its production (Linnecar et al., 2014; Long et al., 2021; Pope et al., 2021; Andresen et al., 2022).

Empirical studies provide reliable estimates of the carbon footprint of CMF feeding, and the GHG emissions of CMF have been estimated at country (Joffe et al., 2019; Smith, 2019; Andresen et al., 2022), regional and global levels (Cadwell et al., 2020; Dadhich et al., 2021). The carbon footprint of CMF over the full product life cycle, including emissions from production, transport, and feeding equipment and sterilization, is estimated at 11–14 kg CO₂ per kilogram of CMF (Karlsson et al., 2019; Andresen et al., 2022). Thus, feeding an infant fully for 6 months with CMF instead of breastfeeding is estimated to generate between 226 and 288 kg of CO₂ (Pope et al., 2021).

In 2019, the prevalence of CMF consumption at age < 6 months was 11.6% globally, 36.0% in high-income countries, 12.8% in upper-middle income countries, and 5.2% in lower-income countries, while the corresponding prevalence of consumption of animal milk, other than CMF were 9.8, 7.6, 9.9, and 12.6% (Neves et al., 2021). Although the consumption of CMF increased slightly among children aged 6–23 months compared to those under 6 months, the prevalence of animal milk consumption reached about 33% globally and is similar across the national income levels (Neves et al., 2021). Life cycle analysis reveals that most of the CMF emissions (68–82%) come from the production of raw milk (Karlsson et al., 2019).

1.5. Greenwashing commercial milk formula

Food sustainability discussions give considerable attention to decarbonizing production processes. However, reducing demand for products with high carbon footprints may have a bigger impact on food sustainability. A recent critical analysis reflecting a gender and social justice perspective demonstrated that achieving the breastfeeding targets in the Global Nutrition Targets by reducing CMF consumption would far exceed the GHG reduction from decarbonizing the production process of CMF products, while simultaneously improving the health of infants, mothers and nations, and contributing to a just transition (Long et al., 2021). For example, emissions saved in Ireland from decarbonizing production for the Irish and Chinese infant formula markets is estimated at around 16 thousand tonnes of CO₂, compared to around 77 thousand tonnes of Global Nutrition Targets for exclusive breastfeeding under 6 months were met (Long et al., 2021). The study by Long and colleagues (Long et al., 2021) also highlighted that rather than reducing overall GHG emissions from CMF consumption, greenwashing of CMF marketing could lead to increased, “guilt-free” CMF consumption, hence greater GHG emissions.

2. Policy options and implications—the solutions

The invisibility of women in economic accounting systems and public policy is mirrored in GHG accounting. In this section, we consider what is needed to include interventions that enable breastfeeding in carbon funding mechanisms.

2.1. Global mitigation options: carbon accounting schemes and the United Nations clean development mechanism

Carbon or GHG accounting is the process of calculating and analyzing how much carbon dioxide an individual, organization, or country emits. It informs the methodologies upon which carbon markets are based (He et al., 2022). The concept underlying carbon accounting schemes is that of carbon pricing (UN Climate Change, 2022). Carbon pricing policies facilitate the development of carbon offset schemes, wherein GHG emitters are required to pay for the cost of offsetting their emissions by buying carbon credits to compensate for the GHGs that they emit. An example is the United Nations Carbon Offset Platform which enables the purchase of offsets called Certified Emission Reductions (CERs), and funds projects in low- and middle-income countries (LMICs) (UN Climate Change, 2022).

Methodologies and platforms are available for carbon accounting and carbon offsetting at personal, business, national, and international levels. Some carbon offset markets and programs, such as the European Union Emission Trading Scheme, are legally mandated, and compel companies and governments to buy carbon offsets to compensate for the carbon dioxide that they emit (KPMG, 2023), while other programs are voluntary (for example, allowing individuals to offset GHG emissions when flying). These programs are verified by certifying agencies such as Verra (2023) and Gold Standard (2023).

The CDM is a potential platform for reducing the harmful environmental impacts of the food system. Its implementation began in 2005 when the 1997 Kyoto Protocol came into effect. The CDM is the main source of finance for the Adaptation Fund which supports climate change adaptation projects in LMICs. CDM projects are required to demonstrate GHG emission reductions while contributing to sustainable development as defined by the host country (Sutter and Parreño, 2007). The CDM is currently the largest source of carbon emission mitigation funds.

At the COP26 climate conference in late 2021, WHO established the Alliance for Transformative Action on Climate and Health (ATACH), which committed to helping countries facilitate access to climate change funding for health (WHO, 2021, 2022). At COP 27 in 2022, parties agreed to establish a global reparation fund through which high GHG emitting countries would compensate LMICs for the historical environmental damage caused (Wyns, 2022). Since the producers and exporters of CMF are mostly based in high GHG emitting countries, such a fund is a promising source of finance for LMICs to mitigate the damage done to breastfeeding cultures in LMICs by the export and marketing of CMF (Berg, 1973; Jelliffe and Jelliffe, 1978). Ensuring that the reparation fund financed interventions that enable breastfeeding would simultaneously compensate for the damage to the environment and improve health and development in

a gender-just way. Both women and children could particularly benefit from improvements to food sovereignty and food security.

2.2. Food system or dietary interventions are underrepresented as carbon offsets under the CDM

The CDM websites identify the criteria by which projects are assessed as suitable for funding as carbon offsets. To date, the focus of the CDM has been technologies that increase energy efficiency; switch from high to low-carbon fuels or renewable energy sources; reduce emissions from agricultural and industrial processes or waste management; or provide carbon sinks through afforestation and reforestation (Curnow and Hodes, 2009).

The CDM funds agriculture projects to reduce GHG emissions, while assuming the same or increased productivity and demand. Low-carbon diets that reduce consumption of environmentally expensive products like meat and dairy, thereby avoiding the production of GHG emissions, are not considered under the CDM. However, there is no existing methodology for establishing a baseline and monitoring demand reduction for mitigating climate change in food-related projects as a carbon offset. This means that reducing GHG emissions through diets that reduce demand for meat and dairy are not considered under the CDM.

Nevertheless, there is a strong logic for funding demand-side project interventions in food systems that reduce the consumption of high-carbon foods, such as CMF. This is especially so where the same actions improve population health in LMICs. A demand-side measure (Long et al., 2021) could be applied to breastfeeding promotion interventions aimed at reducing CMF consumption.

2.3. Gender power systems and institutions: the CDM excludes food and women's non-market productivity

Our gender analysis of the CDM criteria suggests key gaps and gender inequities, arising from its market sector orientation, the CDM's general exclusion of small-scale food system interventions, and specifically from its overlooking of infant and young child feeding. These policies privilege commercial actors in the food system, while women's productivity and participation in the crucial first-food system, are unrecognized and underfunded. Lowering GHG emissions through reducing methane emissions or improving the energy efficiency of CMF manufacturing processes better fits CDM criteria than measures to reduce CMF sales and increase breastfeeding.

3. Actionable recommendations—funding policy and methodological innovation required for gender-inclusive climate change mitigation

Interventions that increase breastfeeding and decrease CMF consumption by infants and young children can have a demonstrated

substantial impact on GHG emissions, although the relationship is not exact because around a third of children 6–23 months consume animal milks only or in combination with CMF (Neves et al., 2021). The proportion of young children consuming CMF increases by country income category.

3.1. The impact of interventions that increase breastfeeding and decrease the production and use of CMF

Breastfeeding interventions have proven effective and feasible (Gavine et al., 2022), and can be replicated and scaled up to increase exclusive breastfeeding and decrease the use of CMF (Carroll et al., 2020). These interventions to enable breastfeeding include adequately funded policies and programs for:

- (a). Adopting and enforcing the International Code of Marketing of Breast-milk Substitutes and subsequent related resolutions (The Code) (World Health Organization, 2017),
- (b). Enacting paid family leave and workplace breastfeeding policies (ILO, 2022),
- (c). Establishing national and health facility-level policies that promote the Ten Steps to Successful Breastfeeding ('Ten Steps') (World Health Organization, 2018),
- (d). Providing more breastfeeding counseling to all mothers,
- (e). Encouraging community support for breastfeeding practices, and
- (f). Tracking data to measure progress on breastfeeding programs. (Bégin et al., 2019)

The results of key studies on the impacts of interventions to increase breastfeeding are summarized in Table 1.

3.2. Estimation of possible environmental impacts of breastfeeding interventions

Globally, only 44% of infants under 6 months of age are exclusively breastfed (UNICEF Division of Data, 2021). If exclusive breastfeeding until 6 months of age was scaled up to 90% (Bhutta et al., 2013), GHG emissions of CMF would be significantly reduced.

To illustrate the GHG emissions that could be avoided by enabling women to breastfeed, we present illustrative calculations of the carbon footprint implications of a hypothetical breastfeeding extinction scenario (Whittington, 2015), and a real-world intervention that increased exclusive breastfeeding.

These examples use the following data and assumptions:

- Exclusively CMF-fed infants require 21 kg of formula per six-month period (UNICEF, 2021).
- Each kilogram of infant formula sold generates 11–14 kg of CO₂ (Karlsson et al., 2019; Andresen et al., 2022; the calculations below use 14 kg).
- The scenarios assume that infants aged under 6 months are either exclusively breastfeeding or exclusively CMF feeding. They do not account for the GHG emissions resulting from mixed feeding or CMF sold for children beyond 6 months.

TABLE 1 Impact of breastfeeding promotion and protection interventions.

Intervention	Demonstrated impact
Ten steps or baby-friendly hospital initiative	Increases EBF under 6 months by 49% (Rollins, 2016)
Peer counseling	Increases EBF under 6 months by 48–90% (Haroon et al., 2013; Sinha et al., 2015; Rollins, 2016)
Paid maternity leave (any duration or level)	Increases 5.9 percentage points of EBF under 6 months corresponding to a monthly increase in paid maternity leave (Sinha et al., 2015; Rollins, 2016; Chai et al., 2018)
Workplace support (e.g., lactation rooms, breastfeeding breaks)	Increases any breastfeeding by up to six months by 25% (Rollins, 2016)
Media including social media	Increases early initiation of breastfeeding more than fivefold (Sinha et al., 2015; Rollins, 2016)

3.2.1. The extinction scenario

Exclusive breastfeeding prevalence among Nepali infants under 6 months is high (77%) (Ministry of Health, 2017). What would happen if exclusive breastfeeding were entirely displaced by CMF feeding, as approximates the situation in some countries, such as Ireland or Jordan? Were exclusive breastfeeding to be replaced by exclusive formula feeding, CMF feeding of Nepali infants in the first 6 months would have produced around 176 million kg of CO₂ eq. of GHG emissions in 2021 (Table 2).

It is a limitation of the analysis that this assumes exclusive breastfeeding is replaced by CMF, rather than animal milk, which can overestimate the GHG and water use relating to CMF production and use (Neves et al., 2021).

3.2.2. Lengthening paid maternity leave

Paid maternity leave has been demonstrated to improve breastfeeding and other maternal and child health outcomes (UNICEF, 2019). Conversely, reductions in paid maternity leave have been shown to lead to reduced breastfeeding initiation and duration (Chatterji and Frick, 2005) and exclusive breastfeeding (Jia et al., 2017). In 2008, Canada increased paid maternity leave from 25 to 50 weeks, with a resulting increase in exclusive breastfeeding of 7.7–9.1 percentage points, or 40% (Baker and Milligan, 2008). A simple calculation suggests that the paid maternity leave policy reduced Canada's GHG emissions by over 9 million CO₂ eq. kg simply by increasing exclusive breastfeeding (Table 3).

3.3. Innovative approaches to addressing gender inequity and injustices in food systems

Currently, a *Green Feeding Tool* is under development (Supplementary Tables S1, S2). The *Green Feeding Tool* is a Microsoft Excel-based offline and online digital tool that highlights the environmental importance of breastfeeding by

TABLE 2 Impact on GHG emissions of 'extinction scenario' of CMF feeding replacing all exclusive breastfeeding in Nepal in 2021.

Infants born (2021)	Amount of CMF consumed by infants under 6 months (21 kg/infant/6m)	CO ₂ emitted in 6 months (14 kg CO ₂ /kg CMF)
596,958	12,536,118 kg	175,505,652 kg CO ₂

calculating the carbon and water footprint of CMF at country and global levels. The estimation is based on available data on feeding practices of children under 6 months of age, and studies of the greenhouse gas and water impacts of commercial milk formula product production and use. Users can add their own data on infant feeding practices and assumptions about maternal dietary patterns.

It is based on a methodology that is a standard and replicable procedure of establishing a baseline, calculating and monitoring GHG emissions avoided by increasing exclusive breastfeeding and reducing CMF feeding as a result of breastfeeding promotion interventions. This provides a basis for developing a new CDM methodology that can be used for funding countries to implement such interventions. This adjustment to CDM funding criteria to include interventions that enable more women to breastfeed would go some way toward addressing women's invisibility to food policymakers and subsequent gender inequity and injustices in food systems and the CDM. It would also improve human and planetary health, and potentially increase gender and social equity, while also increasing the resilience of a highly vulnerable population—women, infants and young children - to climate change risks (Smith, 2019).

The developers of the tool will also advocate for its inclusion in other carbon offset schemes and footprint calculators which are used by individuals to evaluate the impact of their lifestyle choices on the environment. While providing a tool to aid governments and stakeholders to mitigate climate impacts, the *Green Feeding Tool* also supports improvements in global breastfeeding practices in line with the WHO targets.

The *Green Feeding Tool* complements the *Mothers' Milk Tool* (Smith et al., 2022). The *Mothers' Milk Tool* estimates the quantity and monetary value of human milk production globally and for over 140 countries, and was inspired by the example of Norway, which since the 1990s has counted mothers' milk as part of the country's food supply (Smith et al., 2022).

4. Conclusion

We propose the feasibility and utility of including proven country breastfeeding policies and programs as suitable projects for funding as carbon offsets in United Nations programs. In doing so, we answer *The Lancet Commission's* call to break the silos and collaborate to address the global syndemic created by the combined pandemics of undernutrition, overnutrition, and climate change.

TABLE 3 Impact of increased paid maternity leave in Canada in 2008 on exclusive breastfeeding and GHG emissions.

	Infants born (2008)	Prevalence of EBF under 6 months (%)	Number of infants under 6 months exclusively breastfed	Number of infants under 6 months exclusively formula fed	Amount of CMF consumed by infants under 6 months (21 kg)	CO ₂ emitted in 6 months (14 kg CO ₂ /kg CMF)
Before	377,900	23.1	86,917	290,983	6,110,643	85,549,002
After	377,900	31.5	119,039	258,862	5,436,092	76,105,281
Reduction						9,443,721

Breastfeeding is economically undervalued for its maternal and child health cost-saving impacts, and here we have shown that transformational change to the environment for breastfeeding is also unrecognized as a climate change policy response.

The CDM is an important mechanism for reducing GHG emissions and mitigating climate change. Strong evidence for the effectiveness of interventions to promote breastfeeding exists. Interventions to protect, support or promote breastfeeding and decreasing CMF feeding would fit the CDM criteria, by avoiding greenhouse gas emissions from CMF but these measures are presently not included as a category of CDM projects.

Our gender analysis of the first-food system highlights that the CDM focus and market orientation fails to recognize the importance of sustainability of women's contribution as efficient local producers in the first-food system. This distorts funding priorities and disempowers women as preferred providers of food for infants and young children. The high prevalence of CMF use generates significant GHG and environmental impacts. By contrast, breastfeeding substantially mitigates emissions from CMF emissions at the production and consumption stages.

The lack of recognition of such commercial food production and consumption as a source of GHG emissions is an unjustifiable oversight from the CDM and similar schemes, in light of evidence on the GHG emissions of the food system and its other contributions to environmental degradation.

The *Green Feeding Tool* will provide the methodology for including interventions aimed at increasing exclusive breastfeeding and reducing CMF feeding in carbon offset calculations.

The *Mothers' Milk* and *Green Feeding Tools* are essential pieces in recognizing the key role and productivity of women in a sustainable and healthy food system, demonstrating the importance of breastfeeding for human and planetary health, and coherently combining nutrition and environmental targets.

Author contributions

JS, BB, and RM: conceptualization. JS and AI: methodology. AI: software, formal analysis, and data curation. JS, BB, AI, TN, and RM: validation, investigation, and writing–review and editing. RM: resources and funding acquisition. JS and BB: writing–original draft preparation and visualization. JS: supervision. JS and RM: project administration. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fsufs.2023.1155279/full#supplementary-material>

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