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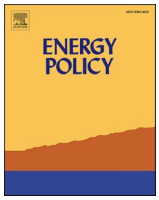

Green Remittances: A novel form of sustainability finance☆

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ABSTRACT

Lack of finance is a key barrier to sustainable development. Formal aid and private investment are insufficient and vulnerable to inefficient government-to-government interactions and fail to reach some populations. Remittances from 280 million migrant workers to families at home represent enormous complementary monetary inflows to low- and middle-income countries, and, at $600 billion globally, are three-times greater than "top-down" Official Development Assistance. While commonly intended to alleviate poverty, remittances are rarely targeted towards sustainable development, and can even lead to environmental degradation. There is significant potential to align remittances with sustainability goals, assisted by emerging technologies and digital-finance platforms. Proactive "green remittances" can take the form of cash, goods, or services. They can be targeted to households, transportation, agriculture, entrepreneurial purposes, or community-level infrastructure projects. Applications include renewable energy, energy-efficiency, and a range of climate change resilience and adaptation activities. The article provides a unique synthesis of the existing literature, highlighting the lack of focus on proactively directing remittances toward sustainability, and identifies and assesses early targeting efforts in eight countries. Key policy challenges include awareness-building among remittance providers and recipients, identifying and pooling applicable locally-available goods and services, assuring quality, reducing transaction costs, and scale-up.

1. Introduction

While most current global greenhouse-gas emissions originate from wealthier countries – the top 10% of the population emits almost half of the global total – the most acute needs for finance are in lower-income contexts (Chancel, 2022). Similarly, the value at risk from climate impacts is high among wealthy countries, but they also have less vulnerability and greater ability to finance adaptation domestically.

Enormous infusions of capital are needed if the world is to meet the UN's seventeen ambitious Sustainable Development Goals (SDGs) by the aspirational deadline of 2030. The current finance gap is estimated at $2.5 trillion per year (OECD, 2020). An analogous "adaptation gap" exists in fulfilling promises of North-to-South aid and investment for reducing vulnerability to climate change impacts (Musah-Surugu 2017). UNEP (2021) estimates a need of $155 billion to $330 billion per year for climate adaptation by 2030, yet today's "climate finance" to developing nations (adaptation plus mitigation) is just under $80 billion per year. Prospects for formal assistance have worsened as a result of the COVID pandemic, with an interagency task force, coordinated by the UN, warning of the potential for a lost decade (UN, 2021).

Identifying the appropriate methods of finance is a key challenge, and high first costs are a well-known barrier to investment in the household or small-business arenas, particularly in lower-income contexts. For example, of 24 barriers identified by Irfan et al. (2022) in India, affordability and finance ranked highly.

An encouraging trend is that the sources of development funds have evolved fundamentally, as have the methods by which funds can be transferred. In particular, remittances from emigrants and temporary migrants offer a rarely-tapped opportunity to bridge the gap created by insufficient top-down finance for climate change mitigation and adaptation.

It has been observed in multiple studies that energy use and greenhouse-gas emissions tend to increase in tandem with remittances (Neog and Anup Kumar, 2020), suggesting a need for energy and climate policy to focus more closely on their application. The literature has only recently begun to look rigorously at potential roles for remittances in managing energy demand (Das et al., 2021). Similarly, national entities and the United Nations have only just begun discussing the potential synergisms between remittances and sustainable development goals (Scott et al., 2018; IFAD, 2017), albeit only in general terms.

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The previous literature has focused more on quantifying remittances and understanding their broader socioeconomic and macroeconomic dynamics (Russell, 1986) than on their specific uses (Jessica and Siegel, 2007). Although interest has emerged in targeting their application in generalized terms (e.g., for consumption versus investment) (Zarate-Hoyos and German, 2004) and for promoting development in very loose terms (UNDP, 2011), policymakers have focused more on inducing the total flow of remittances than on directing and maximizing their application.

Beginning with a review of the current global remittance landscape, this article further develops the concept of sustainability-focused "green" remittances informed by modest precedents for the sustainable energy sector and for climate change resilience and adaptation. New concepts are introduced, such as remittances for services (as distinct from goods) and the development of a neutral global platform for scaling up the offerings. This article also provides a unique synthesis of previous largely tangential references to focusing remittances on sustainability capital needs, and assembles sparse case studies of efforts to operationalize the idea in Africa, Asia, and the Americas. The discussion enumerates market challenges and barriers to scaling up the practice, followed by recommendations for enhancing and expanding this promising approach for sustainability finance.

2. Global remittance landscape

While the broad concept of money has been in operation for millennia – and barter of goods for longer still – advances in communication technology were required before money could be exchanged electronically across long distances. Initially the domain of banks and large businesses, with the appearance of Western Union in the mid 1800s the opportunity to make transnational transfers became available to individuals at all income levels. With the advent of PayPal and cryptocurrencies, money could be moved online without bricks-and-mortar intermediaries, and with mobile money now even "unbanked" populations can access and move funds electronically, and at far lower cost (IFAD, 2019).

Meanwhile, with globalization came an increasingly large and far-flung diaspora of people migrating from their home countries for work and other reasons. Often earning more than the families left behind, these individuals have steadily come to remit hundreds of billions of dollars each year back to their home countries. The aforementioned technology innovations facilitated distribution and reduced transaction costs. As suggested in Fig. 1, these migrant remittances have become the largest source of foreign monetary inflows for many developing countries. Globally, migrant remittances are three-times greater than "top-down" offshore development assistance (ODA), and on a par with foreign direct investment (FDI) – and 50% greater than FDI when excluding China. Remittance flows are more stable, more widely and evenly distributed among and within countries, and are counter-cyclical and resilient even during economic downturns or other crises in countries where remittance-sending migrants live (Ratha, 2017; UNDP, 2011). During the 2019 to 2020 period of the global COVID pandemic, remittance flows to low- and middle-income countries declined by only 1.6%, compared with a 11% reduction in FDI (30% if excluding China) (Ratha et al., 2021). Private investment (so-called "portfolio flows") was also far more sensitive than remittances. Interesting dynamics exist with the world oil market. Price spikes are also associated with reduced remittances (Dagher et al., 2020), while increased interest rates (Urom et al., 2021) make remittances even more essential to recipients whose other option is borrowing. However, the converse is true for oil-exporting countries (Scott et al., 2018).

The overall global population of migrants stood at 281 million people in 2020 (about 4% of the world's population), about two-thirds of which send remittances to their home countries (Batalova, 2022). About 800 million people – one in nine globally – benefit from remittances, representing an average of $300 per month from each sender (15% of their income) (UN News, 2019). These remittances have become a core – but decentralized – pillar in the flow of funds into the developing world, and thus an integral, albeit informal, component of poverty alleviation and development finance (Lucas and Stark, 1985). Their contribution to recipient countries' GDP has increased steadily over time (World Bank, 2022). It is not surprising that migrant remittances have been shown to reduce poverty (Adams and Page, 2003, 2005; Gupta et al., 2009).

Major categories of remittances include those for households, entrepreneurial purposes, or aggregated at the community level for infrastructure projects. Community-level and entrepreneurial

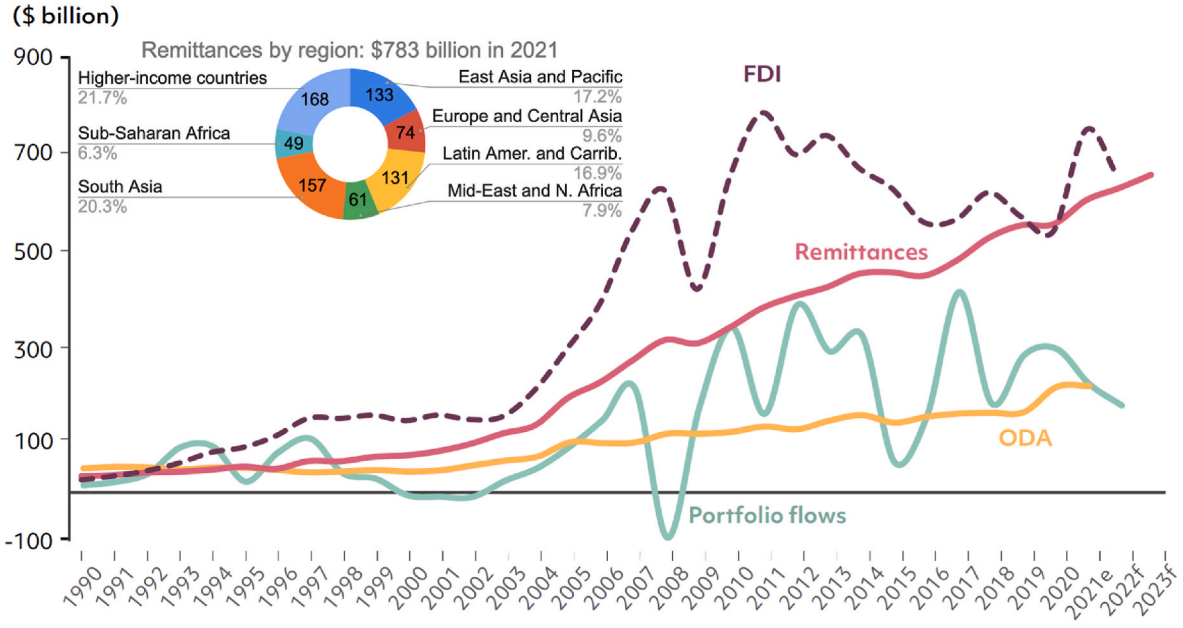

Fig. 1. Trends in major financial inflows to low-and middle-income countries (1990-2023est). Inset pie chart includes remittances to all countries. FDI = Foreign direct investment (private sector), ODA = Official development assistance (public sector, including multilateral entities such as the UN and World Bank – excludes military), Portfolio flows = bonds and equities. Source: Ratha et al. (2021, 2022).

remittances have been recognized since the 1990s or earlier (Goldring, 2004). Migration and the sending of remittances to families can be viewed as a form insurance and risk-spreading within families, motivated primarily by "tempered altruism" and "enlightened self-interest" on the part of the senders (Lucas and Stark, 1985), with decisions about their use typically left to the recipient. Intra-family remittances driven by self-interest can help a migrant prepare for a successful return to their home country. These funds are used for a wide variety of purposes, including food, housing, infrastructure, education, debt service, savings, disaster recovery, and other core elements of the development process. Once basic needs are met, there is further potential for remittances to be used to boost the standard of living, help start businesses, etc. In service of this latter use, there is already precedent for banks to provide financing based on future remittances as collateral (Ratha, 2017).

Community remittances are typically aggregated by migrant organizations. In Mexico, for example, $1.7 billion was generated by Hometown Associations in 2008 (75% of which was a federal match under the country's 3 × 1 program) (Duquette-Rury 2015).

Remittance inflows reached $781 billion (196 receiving countries) in 2021, of which $597 billion (76%) were sent to low- and middle-income countries (KNOMAD/World Bank, 2022). Importantly, these values include only those funds officially recorded in national balances of payments, while informal flows have been estimated to be 50% again as large (Ratha, 2017). Among the informal flows are what may be called "in-kind" remittances, i.e., the transfer of actual goods rather than money. In one example of this known as "barrel shipping," migrant workers send goods to their home country in barrels (Giick Schiller et al., 1995). In the Philippines, the common container is referred to as a "Balikbayan box". Visiting migrant workers often bring goods to their families.

Fig. 2a–c provides a global view of remittance flows, and their contribution to overall economic activity (GDP). For the year 2020, the leading sending country was the United States, with $69 billion remitted, followed by the United Arab Emirates at $43 billion. The leading recipient among low and middle-income countries was India at $83 billion per year, followed by China at $60 billion. The leader by share of GDP was Tonga at 39.3% of GDP, followed by the Kyrgyz Republic at 31.1%.

Fig. 3 shows the 30 countries with the greatest remittances as a share of GDP in 2022. The sum of incoming remittances for this group was $124 billion in that year, with an average contribution to GDP of 22% and national-average per-household inflows of just over $3100. The "outlier" case of Tonga (an archipelago nation of 172 islands) is illustrative of the often-significant role of remittances in national economies. In Tonga, one half of all adults work outside the country (IFC, 2020), sending remittances to 80% of all households (IFC, 2018) valued at an average of $13,500 per household in 2022. Tonga's dependence on remittances is estimated to have reached 50% of GDP in 2022 (KNOMAD/World Bank, 2022).

As seen in Fig. 1, the volume of remittances has been steadily increasing for decades (Ratha et al., 2022). Roughly a quarter of the remittances to low- and middle-income countries are sent to East Asia and the Pacific, Latin America and the Caribbean, and South Asia. Sub-Saharan Africa and the Middle East plus North Africa receive only 8% and 10% of the total, respectively.

3. Green remittances

The terms "green" and "sustainability" are often gratuitously coupled with "remittances", but it is usually a misnomer. With rare exceptions, the focus is usually placed on the broad socio-economic and development benefits that remittances can bring by virtue of increasing income (poverty alleviation, financial inclusion, education), rather than the environmental benefits achieved by investing those remittances strategically (World Bank, 2021; Olivie and Santillan O'Shea, 2022; Akanle et al., 2022). For example, several UNSDGs relate specifically to remittances. Indicator 17.3.2 seeks to increase the overall volume of remittances. SDG Indicator 10.c.1 seeks to reduce the associated fees and other costs. Similarly, in the case of climate resilience and adaptation, the existing literature points almost exclusively to the indirect benefits associated with increased disposable income, and in some cases disaster recovery, as distinct from proactively targeted investments in pre-event loss-prevention.

Remittances do not intrinsically and reliably support sustainable development; they must be deliberately directed in order to do so. There exists enormous potential for more tightly aligning remittances with sustainability goals and capital investment. The digitization of finance and money movement has made this easier than ever. Isolated examples can be found where remittances are used for sustainable energy products or to prevent weather and climate extremes. There is similar potential to do so with regards to climate change adaptation finance.

3.1. Remittances have both positive and negative implications for sustainability

Remittances intrinsically impact purchasing and consumption behaviour in ways that are consequential for sustainability. Among these, remittances are often used directly for the purchase of energy (an informal subsidy) or indirectly for activities that result in greater energy use or other activities that increase environmental degradation. Detailed breakdowns of how remittances are spent are rare, but some assessments find that poorer households spent up to 25% of theirs on energy (Akkari and Armacost, 2013; Arc Finance, 2014). Thus, remittances can correlate with increases in energy use and greenhouse-gas emissions (Scott et al., 2018; Rahman et al., 2019, 2020; Khan et al., 2020; Zaman et al., 2021; Das et al., 2021).

Others have found that remittances can passively result in decreased emissions due to the purchase of renewable energy systems (Sharma et al., 2019; Zafar et al., 2022; Das et al., 2021). Investment of remittances in energy efficiency or renewable energy equipment also defrays energy costs, thus contributing to poverty alleviation. Das et al. (2021) observed a causal relationship between remittance inflows and growth in the use of renewable energy by households in Bangladesh (the ninth largest remittance recipient, with $4.2 billion in remittances in 2021). Zafar et al. (2022) found similar relationships in 22 top remittance-receiving countries. However, these are second-order effects arising thanks to the presence in the market of technologies such as solar home systems and, at least in some cases, the presence of a favorable policy environment for such systems, rather than the result of any particular remittance-oriented policy to adopt the technology, suggesting a potential for far more uptake if information and incentives are aligned to increase this activity.

Similarly, while not the result of any particular top-down program or policy, Holder and Gregory (2011) determined that remittances to Guatemala have contributed to reducing unsustainable forestry practices. Reasons included the use of funds to convert from wood- to fuel-based cooking (again, not driven by policy), and for substitution of lumber with masonry in home construction, and that migrants tend to be younger males who would otherwise work in the forests and who often return to their home country with values and knowledge more aligned with careful forestry practices.

3.2. Focusing remittances on sustainable technologies and practices

When a cab driver in New York City remits $100 to their family in Senegal, there is no assurance that the funds will benefit the family in the ways hoped for by the giver. In some cases, givers may be concerned about how the funds are used (e.g., drinking or gambling as opposed to medicines or food). These perceptions gave rise to the idea of "in-kind" remittances such as the aforementioned "barrel" and "box" strategies through which goods rather than funds are remitted. The occasional preference for these alternatives to cash (typically on the part of sender),

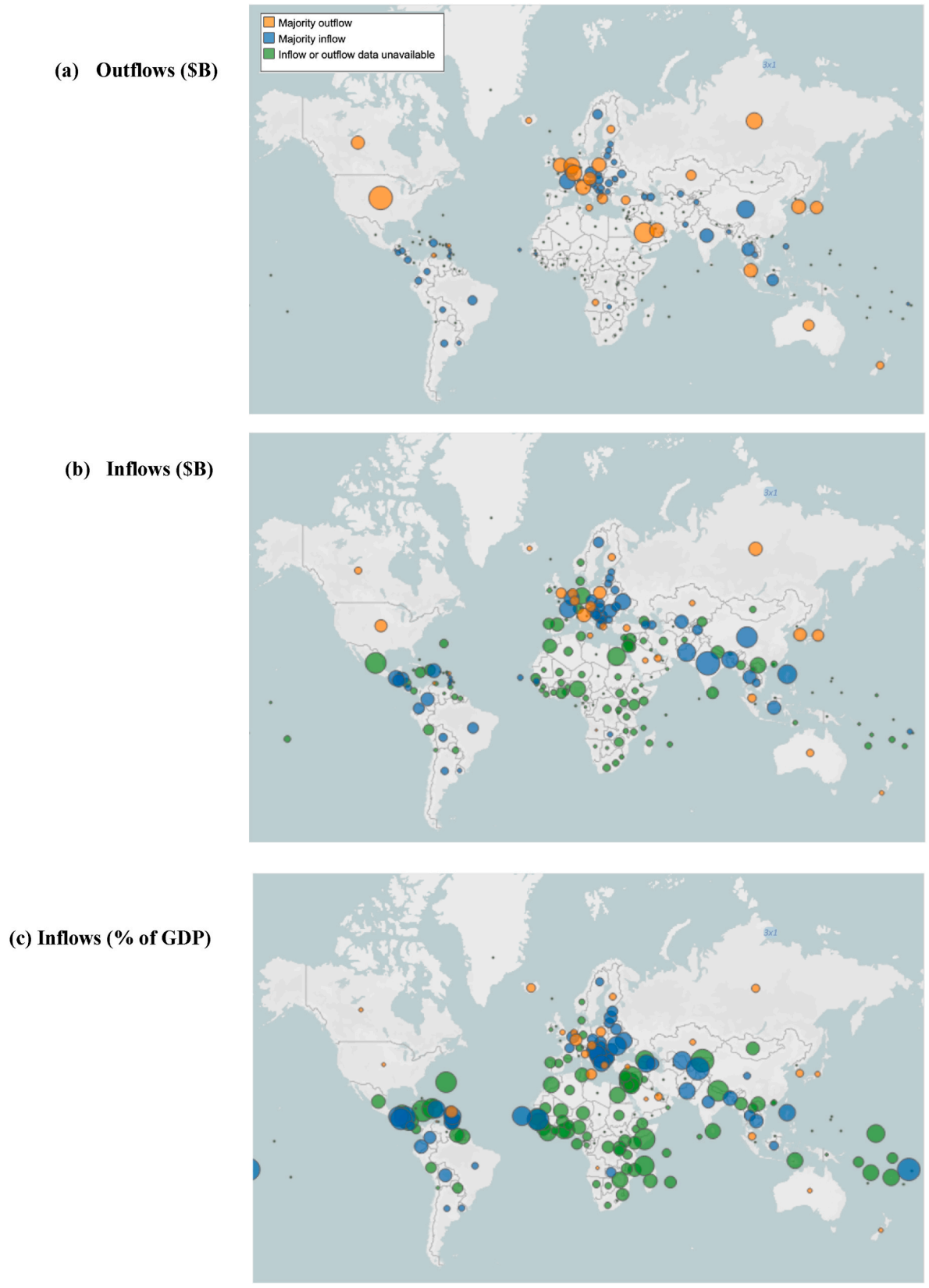

Fig. 2. a-c. Migrant remittance outflows (a), inflows (b), and inflows as a share of GDP (c), by country (2020 in current dollars). Orange indicates that the country is a net provider of remittances, blue indicates that the country is a net recipient, and green means that one value or the other is undocumented. For scale, the U.S. sent $69.9 billion in 2020 and received $7.2 billion. Tonga's inflows represented 39.3% of GDP (largest, easternmost bubble) and Mexico's inflows were 4.0% of GDP. Source: MPI (2022). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

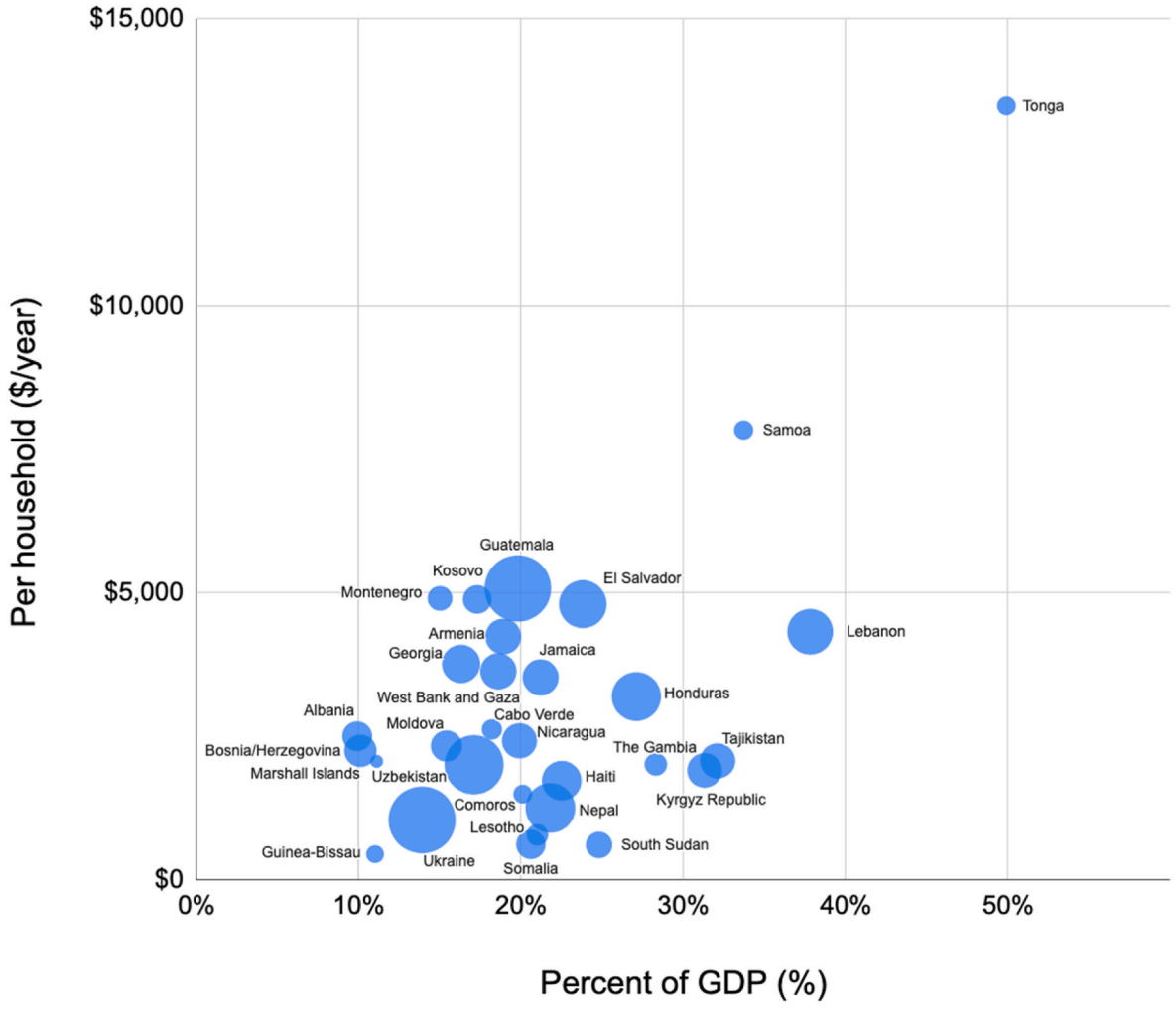

Fig. 3. Migrant remittances for the top-30 countries by percent of GDP (2022). The bubble size is proportional to total remittance inflow (in dollars), with the largest absolute recipients (Guatemala and Ukraine) each at $18 billion. Per-household values on the vertical scale are the average over all households, so actual receipts per receiving household are larger. Source: KNOMAD/World Bank (2022) and UN (2017) and country sources for household size data.

is aligned with the logic of sustainability remittances, i.e., the giver's desire to target remittances towards a particular goal for which there is an unappreciated or unmet need.

The United Nations has determined that targeted remittances could help support attainment of at least 12 of their 17 SDGs (IFAD, 2017). In addition to funding individual smaller projects directly, remittances could be pooled and used to fund collectively owned infrastructure, or capacity building, or to provide finance for larger community-scale projects. Such efforts have extensive precedent. An analysis of approximately 2500 such projects (albeit not sustainability-focused) in Mexico – wherein remittances were matched by public grants – found that two-thirds were public-works investments (Burgess, 2012; Duquette-Rury 2015).

The application of even a small fraction of global remittances to goods and services in support of sustainability goals could have significant impact. A wide variety of sustainability project types can be envisioned, spanning energy, water, health, agriculture/livestock, housing, education, energy, and climate-change resilience and adaptation measures. While one may imagine this as an opportunity only in the lowest-income rural settings, there are also many higher-income urban recipients of remittances who face barriers to implementing sustainable technologies and practices in their homes and businesses. Moreover, properly implemented, green remittances stand to enhance rather than disrupt local markets, whereas top-down approaches (including subsidies or charity favoring certain suppliers) can dislocate local providers (Mills and Jacobson, 2007).

In the energy domain, opportunities exist both for supply- and demand-side measures. Energy supply projects at decentralized scales would chiefly include solar-home systems or solar power for enterprises, clinics, schools, etc. Microgrids could also be remittance-financed for multiple end users. Improved energy-efficient technologies for households could include efficient cookstoves, integrated solar lighting and appliances, solar water heating, and building-envelope improvements. Examples suitable for micro-enterprises or collective uses include solar lights for poultry production or night fishing (Tracy and Mills, 2011; Mills et al., 2014a,b), solar-powered agro-processing mills, water pumps, crop dryers, oil expellers, shared cold storage, consultancy services (e.g. energy audits), and training. A collectively owned solar-photovoltaic-powered "micro laundry", for example, designed to serve 25 households could be funded through one-time remittance payments of as little as $40 per household (Craine, 2022).

3.3. *Digitization enables innovation*

As sustainable technologies become enabled with sensors and Internet-of-Things (IoT) capabilities, additional opportunities arise for green-remittance-based equipment finance, payment for services or training instead of equipment, as well as performance monitoring and enhancement. Remittances have yet to be focused on this opportunity in a material way.

Particularly germane to renewable energy equipment, embedded pay-as-you-go (PAYG) technology offers a new means of micro-financing, and enables market inclusion of the 1.7 billion people who are not part of the traditional banking system and instead use mobile money, prepaid accounts, or other forms of electronic wallets (Irkliewskij and Raia, 2018). The equipment itself is the collateral, with payments dynamically unlocking it for use. This technology tethers a cell phone or other networked device (or prepaid cards) to the equipment, allowing digital payments based on time in use. Networked monitoring and control of even the simplest devices enabled with PAYG can make it possible for distant migrants and/or equipment owners to ensure technologies are maintained and functioning properly, and to assist users with troubleshooting and diagnostics (Makanza, 2021).

PAYG has rapidly become a widespread strategy for solar energy technology, ranging from simple lanterns to full solar home systems (IRENA, 2020). In some applications, payments can be lower than the operating cost of incumbent fossil-fuel technologies, resulting in immediate positive cashflow for the user. As of 2018, the solar PAYG market had a presence in 37 countries and was projected to grow to annual sales of 20 million enabled products valued at $6 to $7 billion by 2022 (Irkliewskij and Raia, 2018). Other remittance-financed use cases could include non-household and potentially community owned solar-powered devices, grid-charging vehicle batteries (cars, bikes) or larger stationary ones, and services beyond the energy sphere such as water pumping, communications, and sanitation. Similarly, remittance flows could be implemented in emerging PAYG finance domains such as microinsurance to enhance economic resilience and disaster recovery.

While expanding social inclusion with first-time access to financing, PAYG has the ancillary benefit of helping individuals build a credit history, thus becoming eligible for other forms of credit. Moreover, microfinance providers sometimes offer remittance handling services, suggesting an opportunity to combine the two in the context of making green remittances more attractive.

3.4. Initial efforts to focus remittances on sustainable energy projects

There have been isolated efforts to focus remittances on sustainable energy in Bolivia, Ecuador, Haiti, Ivory Coast, Nigeria, Nepal, Sierra Leone, and Zimbabwe.

The earliest identified program involved the distribution of solar lanterns to households in Haiti, a technology well positioned to avoid significant global greenhouse gas emissions and address other adverse impacts associated with dependence on candles and kerosene lanterns (Mills, 2005). Only about 12.5% of Haitian households were electrified at program inception, a situation worsened by a major earthquake in 2010 that damaged energy infrastructure (Akkari and Armacost, 2013). Remittances flowing into the country (25% of GDP at the time) were already being used to fund fuel-based lighting (kerosene, LPG, candles, etc.), so the effort was seen as a substitution of remittance funds within the energy budget in a way that would reduce long-term costs as well as environmental impacts (Akkari and Armacost, 2013; Inter-American Development Bank, 2013). Seven business models were considered and an entire value chain was created involving the remittance agents in the US and Haiti, product manufacturers, and distribution partners (Fomin, 2009). Extensive pre-program market research was conducted, an informational campaign was mounted, and a variety of products were offered through a partnership with Sogexpress, a Haitian money-transfer agent, who had 57 local remittance locations across Haiti as well as a network of mobile agents. As these agents already had expanded their offerings to provide cell phone charging services, it was a relatively natural step to add rechargeable lighting products. More than 6000 lanterns were sold under the program during a twelve-month period between 2012 and 2013 (some devices also provided solar cell-phone charging). That number had risen to 10,000 lamps by 2014 (benefitting nearly 31,000 people), although an unspecified portion was purchased without remittance funds (Arc Finance, 2014). The program cited development-related co-benefits such as support for learning, reduced indoor air pollution, reduced greenhouse-gas emissions, and enhanced energy security and safety when the grid is down following natural disasters. Some recipients "commercialized" the phone-charging feature to supplement their incomes. A notable aspect of this program was the effort made to test multiple deployment strategies, and to actively engage the senders' participation, which was focused on the Haitian diaspora community in Miami, Florida. Interestingly, some products were remitted within Haiti, i.e., from urban centers to family members in outlying areas.

Several efforts have taken place in Africa. Under the Diaspora Initiative, a solar company (Amergy) facilitated remittance-based purchase of battery-supported solar electric systems by homes and businesses in Nigeria (Whitlock, 2021; Takouleu, 2019). Also in Nigeria, DiasporaPower deployed solar systems for homes and microgrids. In the Diaspora Energy initiative by the French utility EDF, remittances were used in the Ivory Coast to finance solar home kits, solar pumps for farms, and other renewable energy projects (Makanza, 2021; Takouleu, 2021). This utility-run effort leveraged existing products, supply chains, installation, and maintenance capabilities. Umilio Energy enabled diaspora in the UK (Kuhudzai 2021). A company called Easy Solar offered various types of solar lanterns, fans, televisions, radios, and efficient cookstoves for households in Sierra Leone, with a remittance-based payment option and distribution via twenty-one remittance agent locations across the country (Thomas, 2020).

In South America, the EcoBazar program engaged the diaspora in Spain to fund residential solar water heaters in Bolivia, raising US $200,000 and installing about 150 systems (a 50% market share) in the first year, benefitting 2000 individuals (NCF, 2015). The International Fund for Agricultural Development (IFAD) project also engaged diaspora in Spain, in this case for unspecified "sustainable energy" projects in Ecuador.

A novel approach has been taken in Nepal – the one project identified in Asia – where a private-equity group was formed to attract investment in a 5 MW centralized solar plant (as well as other projects not related to sustainability) to provide domestic renewable energy for households that can be purchased with remittances. One stated goal was to help build up a domestic industry. The $50M Dolma Impact Fund (closed as of early 2023) was not-for-profit and was invested in by international development agencies in Austria, Finland, the Netherlands, Sweden, UK, US, and the International Finance Corporation (Simon 2014 and dolmafund.org). There does not, however, appear to be a project component that actively cultivates the direction of remittances to solar power purchases once the plant becomes operational.

3.5. Applying remittances for climate resilience and adaptation

As efforts to curb emissions lag behind the need, climate-change resilience and adaptation is generally recognized as an increasingly necessary response to natural disasters or other impacts of climate change. While certain geographies are particularly underfunded through traditional mechanisms, these same areas can be particularly dependent on remittances. This is the case for Pacific Island nations, which receive less than 1% of global funding (OECD, 2021), while remittances make particularly large contributions to their GDP. The potential role of migrants to proactively help finance enhanced adaptation and resilience in their home countries has not been well-examined. That said, many vulnerable households receive no remittances.

Evidence exists that *untargeted* remittances can support recovery following natural disasters and other climate-change impacts (Mohapatra et al., 2012; De et al., 2015; Caven and Saratiel, 2017). In one example, families at risk of losing livestock and crops during drought in Botswana were observed to receive increased remittances during those periods (Lucas and Stark, 1985). Ferro (2021) observed that remittances increase in drought years. Maduekwe and Adesina (2020) examined the correlation between those exposed to specific climate hazards and the

Table 1
Summary of known instances of remittance-based financing of sustainable energy and climate change resilience.

	Diaspora Energy	Diaspora Initiative	Diaspora Power	Dolma Impact Fund	Easy Solar	EcoBazar	IFAD	Sogexpress	Umlilo
Prime implementing entity	Électricité de France [electricity provider]	Arnergy [product manufacturer]	Community Energy and Social Enterprise, LTD [entity type unknown]	Dolma Impact Fund [investor]	Easy Solar [distributor]	Gaia Consulting [consultancy]	International Fund for Agricultural Development [public agency]	Arc Finance [non-profit]	Umlilo Energy [installer]
Partners/sponsors	Unspecified	Flutter-wave	Unspecified	UK Department of International Development; development finance institutions–FMO, Finnfund, Austrian Development Bank-OeEB, International Development Finance Corporation, Swedfund, IFC	Africell/ Afrimoney (telecom); Aurora Foundation	Nordic Climate Facility, Harder Trust, Basel Agency for Sustainable Energy, Foundation, Banco FIE, Energética, Arc Finance, Fundación AMIBE CODEM/ ACOBE - Asociación de Cooperación Bolivia España	Unspecified	Inter-American Development Bank, Clinton Bush Haiti Fund, FOMIN, Basel Agency for Sustainable Energy, Sogexpress (money-transfer agent), Food Express (Miami remittance center), Micama Soley (appliance importer)	Unspecified
Receiving country	Ivory Coast	Nigeria	Nigeria	Nepal	Sierra Leone	Bolivia	Ecuador	Haiti	Zimbabwe
Diaspora country	Unspecified	Unspecified	Unspecified	Unspecified	Unspecified	Spain	Spain	United States (Miami)	UK
Start-up year	2021	2021	2019	2014	2020	2014	2009	2012	2019
Sector/Strategy									
Household	Solar home kits: PV panel, battery, radio, LED lights, phone charging port, optional television and fan	Solar systems	Solar home kits	none	Solar home systems, solar lanterns, solar fans, solar televisions, solar phone charging	Solar water heaters	"Clean energy" perhaps lighting	Solar Lanterns with phone-charging	Solar home systems
Transportation	none	none	none	none	none	none	none	none	none
Agriculture	none	none	none	none	none	none	none	none	none
Business	none	Solar systems	none	none	none	none	none	none	none
Community- scale	none	none	Small mini-grids	Central solar targeted at households	none	none	none	none	none
Climate adaptation	none	none	none	none	none	none	none	none	none
Digital payment			Mobile money		Mobile money; Pay-as-you-go				
Sources	Takouleu (2021)	Whitlock (2021)	Takouleu (2019)	Clark (2014); Nepal Energy Forum (2014);	Sierra Leone Telegraph (2020); Dumbuya (2022)	NCF (2015); BASE, 2022b	IFAD (2009)	Arc Finance (2014)	Kuhudazi (2022)

receipt of remittances (for any purpose) in Nigeria. They found a poor match, but significant potential.

Meanwhile, the efficacy of top-down climate aid is often diluted by "poor social and ecological contextualization, tokenism, lack of community consultation and participation, and corruption" and private finance often lacks appropriate targeting (Maduekwe, 2016). These are precisely the types of barriers that direct migrant remittances are positioned to overcome.

Analyses and examples of how pre-event remittances can proactively help address climate risks are more evident in the literature than in the case of sustainable energy, including Burkina Faso (Ferro, 2021), Ghana (Musah-Surugu et al. 2017), Nigeria (Maduekwe and Adesina (2020), and India (Banerjee et al., 2017). However, the presence of adaptive measures tends to be only incrementally greater among households receiving untargeted remittances over short periods of time, although it increases markedly for remittances maintained over long timeframes. Several governments and NGOs have experimented with giving smaller (but untargeted) "anticipatory" cash transfers immediately before extreme events occur (Samuel, 2023). Most of these focus on emergency preparedness and recovery as distinct from proactive adaptation, although one emphasized climate-resilient agricultural practices.

Many sources of top-down finance for adaptation focus on centralized, large-scale infrastructure (flood control, transportation corridors, etc.). To improve their value for enhancing adaptation and resilience, remittances could be proactively coordinated to finance distributed and smaller-scale measures such as more resilient home construction or retrofit, relocation to safer areas, and improved water storage and efficiency of use, supply and storage. Other categories of measures include projects addressing disease vectors (e.g. mosquito nets), drought-resistant agricultural practices and seed-banking, and early warning systems (which require possession of communication devices, e.g. radio or cell phone). Aside from capital measures, advisory services could support risk assessments and adaptation option identification and decision-making. Microinsurance (to help fund disaster recovery) is another vehicle that could be directly paid via remittances (Mills, 2013). Ferro (2021) cites examples of remittances used to finance training in agroecology in Burkina Faso in the context of enhancing climate resilience. Musah-Surugu et al., (2017) identified examples such as well-digging and creating water-storage in Ghana.

Lacking better education and direction, the observers noted above found that conventional remittances were unlikely to be directed toward proactive climate change preparedness without interventions.

4. Discussion

The aforementioned early efforts to link remittances to sustainable development have been creative, achieving uptake at varying levels in eight countries. All implementations (summarized in Table 1) focus on sustainable energy. No concrete examples have been identified for proactively focusing remittances on climate-change resilience and adaptation, but the issue has been studied in Burkina Faso (Ferro, 2021) and a feasibility study is underway for vulnerable communities in the Pacific (BASE, 2022a). That said, as noted above, the Sogexpress solar lantern program in Haiti cited disaster-resilience as a co-benefit to energy savings.

A wide diversity of entities operated the programs, including an electric utility (EDF), product manufacturers/distributors/installers (Arnergy, Easy Solar, and Umilio), investor groups (Dolma Impact Fund), consultants (EcoBazar), non-profit organizations (Arc Finance), and international agencies (IFAD, based at the UN). In no case did a traditional remittance-processing entity play the lead role, but in most cases were engaged. Each entity had its own institutional and commercial goals. Many involved public-private partnerships with entities including government agencies, NGOs, foundations, telecom companies, in-country market allies, and local financial institutions.

Funding and financing mechanisms were not always well documented, but it is clear that many were dependent on grants or large third-party investments to develop the process by which the senders of remittances could direct the desired offerings to the recipients. The Sogexpress effort credited a donor revolving fund with stabilizing the program. At least in one case, dependency on grants or other non-market financing caused inertia and delays in deployment (NCF, 2015). It does not appear that the earlier initiatives continued after founding grants expired, or that the newer ones will go on indefinitely. On the customer-facing side, a few of the projects employed advanced digital financing for the product recipients, while some appeared to be direct-sales without third-party participation. The Diaspora Power and Easy Power programs allowed incremental payments using a mobile-money platform, and Easy Power's products were also equipped with a built-in pay-as-you-go capability based on usage. Umilio offered conventional payment plans.

Most past efforts focused on linking single diaspora communities (i.e., in a given city or country) with a given recipient country or sub-community and a single or small set of sustainability measures, which were, in turn, available through a very finite number of distribution nodes. For example, the Haitian project targeted diaspora only in Miami, Florida, which represents only about 7% of the country's global diaspora, and of course only a portion of the Haitian diaspora within the United States. On average, diaspora in 50 different countries send remittances to their country of origin (KNOMAD/World Bank, 2022), suggesting great potential to diversify and scale deployment efforts.

The case studies and existing literature focused predominantly on opportunities at the individual household level and on a narrow set of technologies, typically solar energy for specific end uses. Moreover, several were driven by manufacturers or distributors representing a small number of products. Two projects (Dolma Impact Fund and Diaspora Power) sought to fund community-scale implementations. No examples have been identified for transportation, agriculture, or for services in any sector (i.e., as distinct from hardware). Only the Diaspora Initiative explicitly mentioned businesses as target participants, although other programs may have had a spillover effect. Only the Dolma Impact Fund explicitly sought to foster business formation.

Among the early efforts, there is limited evidence of efforts to educate and engage the remittance-sending diaspora community. The Sogexpress program documentation made specific reference to sender engagement and education. There are many migrant organizations through which this can occur, e.g. the thousands of Hometown Associations (HTAs) scattered across the United States that channel remittances to El Salvador, Ghana, India, Mexico, the Philippines, Vietnam, and other countries. Governments can support such projects through matching-fund programs, as has been done (but not with a sustainability focus) in El Salvador and Mexico where governments have matched HTA migrant remittances on a two-to-one basis (Pant, 2008).

It is unfortunate that most of the localized efforts to test the green-remittance concept have not been documented in a rigorous or detailed fashion. Only three (Dolma Impact Fund, EcoBazar, and Sogexpress) published information about the scale of uptake. The paucity of formal market research and impact evaluations is similarly problematic; only the Sogexpress (Fomin, 2009; Akkari and Armacost, 2013) and EcoBazar (NCF, 2015) programs have publicly done so.

5. Market challenges, barriers, and lessons learned

The early and modest efforts to marshal sustainability remittances have helped identify a variety of common challenges and market barriers. These include market and technology information, product quality, awareness of sustainability and climate resilience technology options and their application, technical challenges in implementing remittance-based finance mechanisms, and transaction costs.

Program designers must understand the markets in which they plan to operate. This includes the dynamics of remittances on the migrants' side and how they intersect with in-country market actors that may

participate in delivery of sustainability products and services, as well as widely ranging socioeconomic conditions and cultural norms on the recipients' side. As a practical example of challenges that arise, the Bolivian EcoBazar program was hampered by government subsidies for competing solar water-heating systems and gas and gas-burning equipment (NCF 2015).

A parallel requirement is that the quality of sustainability goods and services is sufficiently assured and that investments in climate change adaptation and resilience are effective. In the case of the Sogexpress solar lantern program in Haiti, after-market service and warranty support was initially provided (Arc Finance, 2014), but subsequently non-quality-assured products were substituted resulting in extensive performance problems and market spoiling. Market spoiling due to inferior quality or lack of truth-in-advertising has long been a challenge for consumers generally, and a threat to sustainable development in particular, as exemplified repeatedly in the case of solar lighting (Mills et al. 2014). Initiatives such as Verasol (created by the International Finance Corporation and GOGLA), have successfully tested and vetted solar home systems, required warranty coverage for buyers, and made that beneficial information available in the marketplace.

There are certainly many challenges in achieving a more purposeful allocation of remittances. Chief among them is topical information and financial literacy such that potential providers of remittances understand the logic and how to usefully focus a portion of the resources they provide. And, at times, there may also be a perception of competition between remittances for "basic needs" and "sustainability," with the latter seen as discretionary or otherwise a luxury; this has been shown to be misguided (Goldring, 2004). Education about the ways in which sustainable development reduces poverty would be useful in this regard (e.g., lowered expenditure on energy by eliminating dependency on costly kerosene for lighting). Moreover, about a quarter of current remittance receipts are already used for purposes other than basic needs (IFAD, 2017), suggesting scope for discretionary sustainability investments. In any case, it is always the giver's choice as to whether and how to direct their gift.

There are also technical challenges in establishing purposeful remittance-finance mechanisms, particularly linking specific remittances to specific products or services. Either a money transfer intermediary such as Western Union must partner with a local provider of the good or service in the recipient country, or directly target its diaspora through marketing efforts. This latter approach promises to be simpler and to avoid transaction costs and fees, but requires significant effort to reach the appropriate parties. While this was previously prohibitive, social media and electronic money transfer technologies offer new solutions.

Lastly, traditional remittance platforms impose significant fees (averaging 6% in 2021 and ranging to 30% in the worst cases) – particularly for small transactions – which dilute the value of the gift and discourage participation (Ratha et al., 2022; IFAD, 2017).

6. Conclusions and policy implications

Migrant remittances are an appealing and enormous source of development finance, with an inflow of $600 billion per year to low- and middle-income countries, and growing steadily. These resources significantly exceed centralized "top-down" flows such as Official Development Assistance (ODA) and private equity portfolios, and are on a par with Foreign Direct Investment (FDI). Advantages of remittances include their generally altruistic nature insofar as they are provided on a non-commercial basis by individuals with intimate knowledge of the recipients' needs, broader and more equitable distribution, relative stability and counter-cyclicity over time, speed of delivery, lower "overhead" and other transaction costs, and their insulation from the "trickle-down" inefficiencies or corruption potentially introduced by public or private third-party intermediaries. While the potential is large – and there are a handful of promising demonstrations – little has been done to direct remittance flows toward financing efforts to improve environmental sustainability through measures such as the implementation of clean energy technologies or enhancements to climate resilience. Policy and entrepreneurial efforts are needed at multiple levels if green remittances are to be scaled up and proactively focused.

For green remittances to have material impact, market-based efforts must be made on many fronts. These include diversified offerings, providing access to a much broader set of technologies and manufacturers. Greater efforts to educate and engage remittance providers are also necessary, while broadening the geographies included in the programs. Conducting detailed impact evaluations of past efforts would assist in learnings for the broader development community, thus facilitating thoughtful scale-up of the approach. Long-run dependency on grants or public-sector finding to achieve these goals is not realistic.

At the core is identifying appropriate products and services (and their providers) available in the vicinity of the intended recipient, while linking migrants, their beneficiaries, and deployment intermediaries. This could likely only be achieved efficiently with a highly dynamic and adaptable market platform based on "crowd-sourced" seller/buyer/intermediary information, not unlike the pervasive offerings of eBay, Amazon, Craigslist, and Wikipedia. The onus would be on vendors to furnish and maintain information on available products and services, distributors to bridge the "last mile" between supplier and retailer or end-user, and on consumers to provide reviews and seller ratings, while central administrators would need to provide the infrastructure and ensure that privacy and accountability standards are applied and enforced. There could be supporting roles for entities such as energy companies, environmental organizations, product-quality evaluators, and the multinational entities such as the United Nations, as well as civil society parties such as non-governmental and migrant organizations. The market mapping achieved by such a platform would also dynamically reveal gaps in the availability of goods and services, representing valuable data for business formation and planning as well as public policy.

Although creating sustainability remittances for family or entrepreneurial uses does not require managerial involvement of governments or multilateral organizations – indeed it shouldn't. Community-level remittances for infrastructure tend to require more formal government participation, which, however, adds complexity, especially for larger projects. In all cases, a variety of policy strategies can encourage and help improve the regulatory environment and help target remittances (Pant, 2008; Das et al., 2021; Ratha, 2017). These include.

- Reducing remittance transaction costs and taxation and/or creating tax incentives
- Incentivizing remittance savings or pooling for larger projects
- Establishing matching-fund programs
- Encouraging the establishment of recipient-country bank branches in the countries where migrants work
- Reducing or waiving import duties on incoming remittances and sustainable goods
- Promoting financial literacy more generally (and pre-departure training for migrants)
- Supporting market-based exchange rates
- Encouraging formation of remittance handling services
- Fostering remittance-linked financial services (e.g., via microfinance and microinsurance institutions)
- Deploying quality-assurance protocols for sustainability technologies
- Maintaining protections against the subversion of remittance systems for money-laundering and fraud

While this article has focused on applications for energy and climate adaptation and resilience, a sufficiently generalized deployment platform could be utilized for the full range of sustainability goals. These broadly include poverty alleviation, food security, health and well-

being, education, gender equality, clean water and sanitation, decent work opportunities, responsible consumption and production, urban sustainability, ecosystem protection, and peace and justice through stronger institutions.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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