Exploring the 'Gender-ICT-Climate Change' Nexus in Development:
From Digital Divide to Digital Empowerment

SAM WONG
University of Liverpool

Edited by:
Richard Heeks and Angelica Ospina

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Centre for Development Informatics
Institute for Development Policy and Management, SED
University of Manchester, Arthur Lewis Building, Manchester, M13 9PL, UK
Tel: +44-161-275-2800/2804, Web: http://www.manchester.ac.uk/cdi

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Executive Summary

How gender influences the effectiveness of information and communication technologies (ICTs) in tackling climate change is under-researched. Gender is social expectations and stereotypes of how men, women, boys and girls, should behave in society. Gender enables some groups of men and women to get access to ICTs, whilst constraining others from doing so. Different control over ICTs, built on unequal power relationships, affects how poor people adapt to the changing climate and respond to climate-related disasters.

Conceptually, this paper explains why, and how, women are more constrained than men from using ICTs in tackling climate change. In term of assets, compared to men, women have less access to technology, to information, to finance, and are more deprived of land rights. Women are more institutionally-constrained than men. With regard to social structures, women are excluded from decision-making in policy design and resource allocation. They are less represented in formal decision-making bodies, such as the Clean Development Mechanism (CDM) and the Reducing Emissions from Deforestation and Forest Degradation (REDD) initiative.

In addressing these limitations, this paper makes four digital empowerment proposals in an attempt to make 'ICT-climate change' interventions more gender-sensitive:

(1) ***Contextualise gender mainstreaming***: gender mainstreaming helps integrate gender analysis into ICT policies. It acknowledges that men and women perceive and receive information differently, and that this requires diverse approaches to adaptation. However, the attempt to re-position women and girls as 'eco-carers' is problematic because this fails to capture their protective, as well as their destructive, role in relation to natural resources. Without addressing the unequal power relations between women and girls, e-adaptive practices can also help reproduce the inter-generational equalities.

(2) ***Strengthen governance***: crafting new and reforming old, institutional arrangements is essential to improve gender inclusion. Women-only interventions are sometimes necessary to empower previously-excluded women to engage in ICT-related decisions. However, poor and powerless men should also have their say in climate change policies.

(3) ***Develop gender-sensitive funding mechanisms***: securing adequate funding to support ICT interventions is crucial to gender empowerment. Yet, targeting women by micro-credit projects risk putting an additional financial burden on them, and that needs serious re-consideration.

(4) ***Recognise agency-structure dynamics***: women are active agents, but they are socially constrained from engaging in ICT-related decisions. Women's preferences, institutional arrangements and politics need to be taken into account in order to tackle digital exclusion.

These four proposals will be useful for development agencies, governments and NGOs seeking to improve the gendered outcomes from use of ICTs in response to climate change.

1. Introduction

Information and communication technology (ICT) seems to offer a partial solution to the problems of climate change. Kalas and Finlay (2009) suggest that ICTs help 'demystify climate change and improve climate literacy at all levels of society' (p19).

One positive part of the picture is that ICT facilities and subscriptions have seen fast expansion in developing countries over the past decade. The number of internet users has increased ten-fold (World Bank, 2011b). Growth rates of 40-50% per annum have been typical for mobile phone subscriptions (ITU, 2011). Institutionalisation of ICT strategies in national plans also shows a strong determination towards bringing ICTs to full capacity (Hussain, 2010).

Despite these positive signs, the digital divide, defined as 'between those with ICT capacity and access and those without' (UNDP, n.d.: 1), has been widening, not only between developed and developing countries, but also between developing countries, as well as between rural and urban areas (Nsibirano, 2008). According to the World Bank's World Development Report, the gender digital divide remains acute. Men, on the whole, are still better connected than women. In general, women in low-income countries are 21% less likely than men to own a mobile phone (World Bank, 2012). South Asia has the widest gender gap in mobile phone ownership, a record 37%[i].

While we are gaining a deeper understanding of the relationships between ICT and climate change (Heeks and Ospina, 2010; IISD, 2011; UNDP, 2011)[ii], ICT and gender (Nsibirano, 2008; World Bank, 2007)[iii], climate change and gender (IDS, 2008; UNDP, 2010b)[iv]. The interactions between gender, ICT, and climate change are, however, under-researched[v].

One of the challenges in unpacking the 'gender-ICT-climate change' nexus is that there is a great deal of faith in ICTs in addressing climate change and, simultaneously, achieving gender empowerment (Etta, 2005)[vi]. In reality,

[i] Although the World Bank has invested US$4.3bn in ICTs between 2003 and 2010, its internal evaluation reports show that only 30% of the investments have achieved the objective of increasing ICT access for poor or under-served areas (Independent Evaluation Group, 2011).

[ii] MacLean (2008) conceptualises the functions of ICTs in climate change in three aspects: monitoring and measuring the impact of climate change, raising awareness and facilitating dialogue, and fostering 'networked governance' (p4). The International Telecommunication Union (2009) suggests that ICTs can be an 'effective tool to combat climate change', but the effectiveness hinges on whether countries 'have affordable, widespread and accessible ICT infrastructure' (p2). Heeks and Ospina (2010) argue that the relationships between ICTs and climate change need to 'acknowledge the complex set of elements, relationships and vulnerabilities that prevail in developing settings, and that further constrain the ability of developing countries to withstand, recover from and adapt to the effects of climate change' (p4).

[iii] Thas et al. (2007) accuse the ICT industry of imposing stereotypes on women, considering them as merely 'consumers', rather than 'creators', of ICTs (p8). Gurumurthy (2004) criticises ICTs for focusing too much on technical solutions, and too little on social dimensions of the problems (p1).

[iv] UNDP (2010) warns that climate change can magnify gendered and other forms of inequalities when 'resources and access to goods and services become constrained in a changing climate' (p3). Rising inequalities, IDS (2008) suggests, would also 'intensify the impacts of climate change for all individuals and communities' (p2).

[v] More funders are now aware of the research gaps. The International Institute for Communication and Development (IICD) and the International Development Research Centre (IDRC), for example, have offered grants to carry out research and projects to address the nexus.

[vi] MacLean (2008) considers ICTs as 'transformative technologies' (p1). The European Parliament (2011) regards ICTs as a 'revolution' for developing countries (p1). Hakfin and Taggart (2001) make a bold claim that: 'information technology can offer significant opportunities for virtually all girls and women in developing countries' (p4, our emphasis). UNDP (2011) also suggests that increasing access to information and education is 'essential for reducing the unequal vulnerability of women to climate change' (p8).

however, the report by the United Nations (2002) indicates that gender issues 'have yet to be introduced into ICT policy-making in Africa' (p17) and little has changed since that report. Many ICT projects do not properly analyse gender and social impact before, or during, the interventions (Castren and Pillai, 2011). In evaluating the impact of the World Bank's ICT projects, the Independent Evaluation Group (2011) suggests that evidence to demonstrate the actual impact of ICT interventions is 'more often anecdotal', and 'systematic monitoring of impact is lacking' (p.xv). Another challenge is methodological: it is quite difficult for researchers to 'uncover the context-specific social processes' of the subtle negotiation between men and women, especially at the household level (Banda and Mehlwana, 2005:iv).

1.1 Objectives of this Paper

This paper intends to offer a systematic review of the complex relationships of this three-way nexus. Drawing on examples and case studies in developing countries, it aims to explore the mechanisms by which gender influences, and is influenced by, the interaction of ICTs and climate change. It intends to highlight the positive and negative gendered outcomes of mitigation, adaptation and disaster planning policies across sectors, such as forestry, agriculture and water. This paper will also identify the gaps in literature and make suggestions for future research.

We want to stress that the focus of this study is not women-specific; instead, it examines the dynamic power relationships between, and within, women and men, along with other social and geographical factors, such as class, age, ethnicity and location, which affect access to power and resources. This paper focuses only on developing countries and draws materials largely from development literature and reports by development agencies. We adopt a content analysis method to unpack the complex meanings of the nexus.

The structure of this paper is as follows: we will first discuss the conceptual framework of the 'gender-ICT-climate change' nexus. We will then make our analysis by focusing on mitigation, adaptation and disaster management. Under each of these three themes, we will examine the role of gender in ICT-climate change interactions. We will conclude by making suggestions for future research.

2. Conceptualising the 'Gender-ICT-Climate Change' Nexus

Before we explain how the conceptual framework is developed and used, we want to unpack the meanings of ICTs and gender.

2.1 A New Generation of ICTs

ICTs are 'complex and heterogeneous sets of goods, application and services used to produce, distribute, process and transform information' (Marcelle, 2000:5, quoted in Gurumurthy, 2004:6). They include the 'hardware, software, networks, and media' that are characterised 'in the form of voice, data, text and images' (World Bank, 2011c:1).

Coyle and Meier (2009) point out that ICTs are not a new phenomenon in developing countries. Many not-so-poor communities already have televisions, telephones and radios for communication and entertainment. That said, the latest ICTs, such as mobile phones, community radio, email, blogs and other Web 2.0 applications, are potentially interactive and participatory. Information can be shared faster and more efficiently between individuals and communities. They reach a wider range of audience and help develop wider networks. In light of this, Kalas and Finlay (2009) suggest these new ICT developments can improve governance by 'empowering the poor and marginalised to raise their voice for political accountability and concrete action' (p9). The new generation of ICTs that has diffused into developing country communities since the turn of the century may therefore be changing the development landscape and development possibilities.

2.2 Gender Matters

The rosy picture has, however, been under challenge[vii]. ICTs have been criticised for being gender-blind and their implementers criticised for failing to 'consider gender an important part of project design' (Jolly *et al*. 2004: 9). UNDP (2008) argues that 'ICTs are not gender-neutral – they are not accessed, managed and controlled by all men and women equally' (p5).

Gender is defined as the 'socially constructed roles and socially learned behaviours and expectations of women and men in a particular society' (World Bank, 2001:34). Gendered relations involve 'difference, inequality and power', and that shapes 'access to, and control over, material and symbolic resources' (Wilson, 2004:8). Gendered relations are 'contextually specific and often changing in response to altering circumstances' (Moser, 1993:230).

Gender matters in ICT and climate change research and practice because it highlights the differential access to information. It questions fundamental questions about the nature of information - what is information, who produces information, and how information is used (Coyle and Meier, 2009). Resurreccion (2011) stresses that the access to, and the use of, ICTs is gender-shaped. Gender influences how the benefits, costs and risks of ICTs are distributed between, and within, women and men. For instance, in some Ugandan schools, girls are expected to be discreet and should not run like boys. Influenced by this

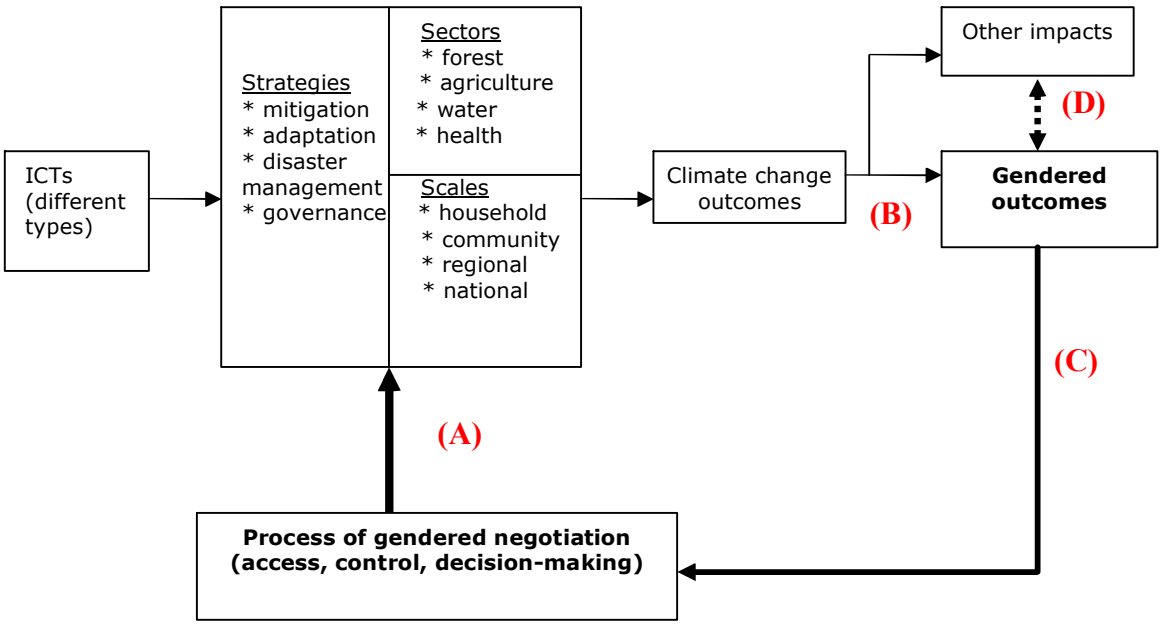
[vii] The general criticisms of ICTs underline the obstacles in maximising the impact of ICTs in developing countries. For example, Gurumurthy (2004) highlights five key challenges: absence of basic infrastructure, high costs of ICT deployment, unfamiliarity with ICTs, dominance of English language in internet content, and lack of demonstrated benefits from ICTs (p1).

specific gender norm, along with limited supplies of computers in school, boys gain access to computers and girls are left out (UN, 2002: 5). Gender also influences people to make responses to a changing climate. For example, IDS (2008) suggests that it is often men, not women, who decide what investments are made on their farms – such as investments relevant to climate adaptation – since laws and social practices enable men to have control over land, money, credit and tools.

2.3 Conceptual Framework

Figure 1 shows the interactions between ICTs, climate change and gender[viii]. It takes an instrumental perspective to consider that ICTs offer a 'technical fix' to climate change (MacGregor, 2010:8). They are tools that 'facilitate systematic awareness raising and knowledge sharing about the effects of climate change and possible coping strategies at all levels of society' (Kalas and Finlay, 2009:17).

Figure 1. Gendered Processes and Impacts on ICT-Climate Change Interactions



(Source: author's own diagram, inspired by Dankelman *et al.*, 2008 and Nelson *et al.*, 2008)

The influences of ICTs in climate change are discussed here in relation to three areas for strategic action: mitigation, adaptation and disaster management. The interactions are cross-sectoral and cross-level. Governance – sometimes separated as a fourth area – is here seen as embedded in these three strategies. It underlines the rules and institutional arrangements of how different stakeholders interact in different strategies, sectors and levels.

[viii] Gurumurthy (2004), Wong and Sharp (2009), and Ospina and Heeks (2011) offer three other approaches to conceptualising the relationships between gender and technology. Gurumurthy compares and contrasts five different theories: Liberal, Marxist, Eco-feminist, Third World, and Culture. Wong and Sharp use the 'agency-institution-structure' framework to analyse how elderly women negotiate access to cutting-edge water innovations. Ospina and Heeks, in contrast, draw on vulnerability and the livelihoods framework to assess the ICT-gender relationship.

(A), (B), (C) and (D), in Figure 1, indicate the four particular mechanisms by which gender influences, and is influenced by, ICT-climate change interactions[ix]:

(A) Process of gendered negotiation: The process explores what, and how, information is created and communicated, and how men and women understand the meanings, expectations and experiences of their gendered roles. Gendered relations are constantly negotiated and contested. They enable some groups of men and women to obtain access to information and to influence the outcomes of climate change, while denying others the facility to do so.

(B) Gendered outcomes: Men and women experience the benefits, costs and impact of the ICT-climate change interplay differently because of their differential power positions and social capabilities. The gendered outcomes can be positive, negative and also unpredictable. They are assessed on the basis of if, and how, people's practical and strategic needs are met, and if gender inequalities are challenged or reproduced.

(C) Feedback: The gendered outcomes of ICT-climate change interactions provide feedback to existing gender relations. They allow men and women to re-negotiate their gendered roles and expectations.

(D) Indirect influence: Some ICT-climate change interventions make an indirect impact on gender relations. Changing income distribution between men and women as a result of introduction of new ICTs, for example, can affect their decision-making power.

These four mechanisms provide an analytical lens for us to examine the case materials of mitigation, adaptation and disaster management policies, as discussed below in Section 3.

2.4 Discourses for Gender Inclusion in ICT-Climate Change Strategies

Arguments for including gender analysis in ICT-climate change interventions are diverse in the literature. We summarise them as four discourses: efficiency, effectiveness, equity and rights-based empowerment.

Efficiency: This perspective focuses on the cost-effectiveness of including men and women in projects. Owing to their frequent interactions with natural environments, poor men and women in rural areas are considered as 'resource managers'. Involving them in using hand-held ICT devices to monitor local forests, for example, helps lower monitoring costs and, simultaneously gain project legitimacy (IISD, 2011). This approach is, however, criticised for regarding poor people, especially women, as cheap labour. It pays insufficient attention to the triple roles of women (productive, reproductive and community) and risks increasing their already heavy workload. Defining poor people as 'eco-carers' also ignores their mixed role in environment conservation (Haynes *et al*., 2010).

[ix] Another possible influence is the gendered nature of the ICT industry itself. Wilson (2004) criticises the masculine culture of ICTs for causing an under-representation of women in the ICT workforce. Light (2006) also suggests that, without adequate female participation in the process of design, development and diffusion of ICTs, ICT products are rarely 'women-friendly'. Despite the significance, we, however, decide not to include this influence in our analysis because the design and production processes of most ICTs are controlled in developed countries, not in developing countries, even while actual production is itself often located in the latter.

Effectiveness: This approach acknowledges the differences of men and women in experiencing vulnerability to climate change and possessing skills in adopting ICTs (Leduc, 2009). Understanding the differences offers better strategies, and thus enhances the chance of achieving the goals of the interventions (UNDP, 2011). This approach stresses participation of men and women in voicing their concerns. However, IDS (2008) is concerned that participation could increase women's workload, without successfully meeting their strategic needs and challenging power inequalities.

Equity: Similar to the discourse of effectiveness, this perspective recognises the diverse interests, needs and priorities of women and men, but it goes further and explains how underlying power inequalities widen the differences (Thas *et al*., 2007). The advocates of this perspective define both the digital divide and climate change as social justice issues. Challenging the fundamental power asymmetries helps remove gender disparities in the access to, and use of, ICTs (Banda and Mehlwana, 2005).

Rights-based empowerment: This perspective points out that poor women and men are deprived of 'their rights to information, knowledge, skills, resources and participation in decision-making' (Economic Commission for Africa, 2009:3). It stresses that rights to information are a basic human right, and that right can only be achieved by true empowerment.

On the one hand, these multiple rationales for gender inclusion can be seen as an incremental change for deprived women, and men, from being powerless to getting involved in the decision-making process. The changes are made possible by moving away from individual actions to collective mobilisation. On the other hand, the complex process of gender inclusion also highlights the tension between different goals of gender inclusion. While an increasing number of powerless women, and men, gain recognition in public participation in the discourse of efficiency, the rights-based activists lay emphasis on the quality of that participation as well as on the long-term impacts of the changes (*Cornwall et al*., 2007).

3. ICT-Climate Change Interventions and Gender

The conceptual framework suggests an inter-relation between 'e-climate change' interventions and gender. But what is the nature of that inter-relation? How do ICT-climate change interventions affect gender equalities; and how does gender, as a social factor, influences the effectiveness of such interventions. Three aspects, i.e. mitigation, adaptation and disaster management, are selected for the discussion below because they are the common policy arenas for interaction of ICTs and climate change strategies. In this section, the notion of governance is crucial to the understanding of the 'gender-ICTs-climate change' nexus. Defined as the ways in which policies are introduced and implemented (Wong and Sharp, 2009), governance plays a key role in affecting digital equalities. However, since governance is strongly embedded within mitigation, adaptation and disaster management interventions, its role will be discussed in each policy arena.

3.1 Mitigation

The conventional view of ICTs and climate change mitigation recognises that ICTs mainly help reduce CO_2 emissions through their application in key emissions sectors, and that will be the focus here; incorporating what 'gender-sensitive mitigation' is, as defined by IDS (2008). However, in doing this, we also note that there needs to be a more critical – and gender-sensitised – examination of the ICT industry itself, given it produces considerable CO_2 in its manufacturing and implementation processes (OECD, 2009).

3.1.1 Clean Development Mechanism

IDS (2008) suggests that existing mitigation policies are over-technical and over-scientific, and leave little room for gender-focused work (p14). The set-up of the Clean Development Mechanism (CDM), for instance, was intended to ensure technology transfers from developed to developing countries, in order to limit or prevent the occurrence of climate change. CDM is the largest source of mitigation finance to developing countries. ICTs, in the form of hardware, software and information, and incorporated into a wide range of new technologies in household energy, agriculture and food processing, forest management, and water pumping in rural areas, are part of the CDM programmes, although there is no statistical breakdown to indicate the actual proportion of ICTs in the CDM projects (Schalatek, 2009).

CDM as a whole, has, however, been criticised for being 'top-down' in nature. The limited consultation with local communities fails to 'give women and men an opportunity to define and have power over their livelihoods' (UNDP, 2010a:2). CDM is also accused of taking an implicit assumption of gender neutrality. UNDP (2010b) suggests that 'little research has been done on the gendered impacts of the CDM, making it impossible to discern the precise degree to which current projects have impacted women and men differently' (p3). Wamukonya and Skutsch (2002) explain that technology transfer in CDM is usually directed towards men, which reproduces the gendered norms that 'men are considered the decision-makers and the eventual managers of technology' (p121). A lack of recognition of women's contribution is also reflected in CDM governance. Of the 61 people who have served as Executive Board members, UNDP (2010b) shows that only 14 were women (p3).

3.1.2 Deforestation and REDD

Deforestation is the second most important human-induced source of greenhouse gases (GTZ, 2007). Tropical deforestation annually releases 1.5 billion tonnes of CO_2 into the atmosphere and this accounts for 17% of total greenhouse gas emissions (ITU and GeSI, 2007). Illegal logging, overgrazing, farming encroachment, rising population pressure, and exploitation of forest products by local communities for subsistence purposes are all responsible for forest degradation and a rapid reduction of tropical forest cover.

ICTs, supporting forest management and avoiding forest degradation, play a significant role in one of the main climate mitigation mechanisms, known as Reducing Emissions from Deforestation and Forest Degradation (REDD). Geographical information systems (GIS) and remote sensing images are used to monitor the geographical changes of forest cover over time. ICTs also help examine the change in quality of forests, helping avoid degradation on the ground. They help acquire information, such as soil type, topography, wildlife, growth and yield, to measure the changing stock (Nsita, 2010). Skutsch *et al*. (2009) also suggest that ICTs can be used to promote community participation in forest management. By providing community members with hand-held ICTs, they can help count species in their forests, thus allowing 'inexpensive and bottom up monitoring initiatives to take place' (IISD, 2011:28)

GPS and mobile phones provide efficient communication to track illegal activities which then facilitates law enforcement. However, if ICTs are in the hands of illegal traders, they can also make illegal logging easier. To avoid being caught, they might also use calls and messaging to identify and avoid law enforcement agency activity. Illegal loggers and wildlife poachers might also intercept communications between forest authorities and informants and take revenge on the involved communities and individuals. Castren and Pillai (2011) warn that this may put local communities at risk.

The perception of danger, associated with forest monitoring, has some gender implications for local ICT forest surveillance. Drawing on examples in Usangu, Tanzania, Cleaver (2001) suggested that people form village defence committees to protect their community resources. The youth are recruited as foot-soldiers and the elders act as advisors on tactics. While women and girls are excluded from the forest policing teams, because the tasks are seen as dangerous and physically-demanding, the full responsibilities fall on the shoulders of men and boys.

While some groups of men take up the role to protect their forests, others can collude with illegal loggers, and that undermines the prosecution efforts. Studies by Nsita (2010) show that corrupt politicians, mainly men, take bribes from forest encroachers. Driven not only by financial incentives, but also by winning votes, especially during elections, the political leaders give the illegal dealers cover, such as altering forest reserve boundaries. All these would reduce the effectiveness of the ICTs in arresting illegal loggers, and it also illuminates the genderisation of such activities.

Women and girls are partners as well as pariahs in forest conservation. In their participatory research in Indonesia, Haynes *et al*. (2010) demonstrate that children 'choose which trees to cut when [they] go to collect the firewood either after school or during holidays. But [they] can also plant trees' (p23). Despite their mixed and important roles, existing forest governance arrangements in many poor countries exclude women from the decision-making processes. They are under-represented in forest committees (Castren and Pillai, 2011).

In a nutshell, improving forest governance by ICTs needs to take gender seriously. In forest monitoring and protection, men may bear higher personal risks and physical threats than women in confronting illegal loggers by ICTs. The uneven distributions of risks may legitimise men's domination of decision-making. However, forests help sustain women's livelihoods. Without equal participation of women in forest conservation, ICTs alone will not be effective in slowing down the rates of deforestation.

3.1.3 e-Agriculture

Agriculture, according to FAO (2002), is an important source of greenhouse gas emissions, 'representing 14% of the global total' and developing countries are 'the sources of 74% of these emissions' (p10). Methane and ammonia, generated from dairy production and animal manure, are 20 times more powerful than CO_2 in their warming action. FAO warns that, by 2030, emissions of methane and ammonia from the livestock sector in developing countries could be 60% higher than at present (*ibid*).

The concept of 'e-agriculture' suggests that farmers in developing countries should have better access to agricultural information via various ICT applications (Fernando and Okuda, 2009). EU (2010) also argues that increasing farming productivity does not necessarily worsen greenhouse gas emissions because ICTs 'could improve the monitoring of several phases of production and improve their management' (section 19).

For example, ICTs help reduce energy usage by optimising the harvest time via growth forecasting. The electronics company, Hitachi, claims in its own website that satellite image analysis provides 'a visual indication of the best time to harvest wheat, rice and other crops' (www.hitachi.com). Creating a database of land, crops and fertilizers also 'ensure[s] an optimum level of agricultural chemical application'. Hussain (2010) suggests that the Space Research and Remote Sensing Organisation has been monitoring agricultural crops and making forecasts to attain food security (p48). On the ground, wireless-enabled water management devices monitor soil water content and optimise crop growing conditions. They assess and control irrigation on a just-in-time basis by incorporating weather information and water evaporation, plant transpiration and sub-soil leakage data (IISD, 2011:29)

In addition, ICTs provide farmers with information about pest and disease control, planting dates, seed varieties and irrigation applications and early warning systems. This approach, according to Wollenberg and Negra (2011), increases the energy efficiency of farming, maintains existing biomass and soil carbon, and reduces emissions. Offering real-time climate information through mobile phone messages and internet also helps farmers make faster responses in finding solutions to crop-related problems (Fernando and Okuda, 2009).

Nevertheless, the potential of e-agriculture is mediated by gender relations. AfDB (2011) points out that effective mitigation depends on land ownership. Owing to traditional custom and legal barriers, women are restricted from land ownership. Without legal rights to land, women do not make the decisions about whether, and which, agriculture-related ICTs would be adopted. Without land to serve as security, women have great difficulty securing formal credit or loans. Without proper access to loans and extension services, women are less able to afford ICTs. As a result, Hafkin and Odame (2002) indicate that many successful agriculture-related ICT projects are 'often taken over by men' (p6).

3.2 Adaptation

Climate change brings about erratic climatic conditions and seasonal unpredictability. Changing rainfall patterns result in prolonged droughts and floods and trigger shifting patterns of agriculture. The reduction of agricultural productivity could lead to food shortages and malnutrition, worsening poverty and vulnerability (IISD, 2011).

Changing farming and water management practices, induced by climate change, has significant gender impact. Research by IDS (2008) shows that 80% of women in Sub-Saharan Africa are involved in food production. Women and girls are also expected to secure water, energy and food resources for their families. Water stress, caused by prolonged droughts, means that they have to walk a longer distance to find water in rural areas or spend more time queuing for intermittent water supplies in urban areas. These changes have long-term implications for their health in light of the rising workload and physical exhaustion (Bathge, 2010). Rural women and girls often take up the role as domestic carer. This gender norm constrains them from migrating to cities and towns (Oxfam, 2011).

3.2.1 ICTs and Adaptive Capacity

The concept of 'e-adaptation' suggests that ICTs could enhance adaptive capacity of the vulnerable by strengthening their 'coping strategies to withstand, recover from, and adapt to climate change' (Ospina and Heeks, 2010: 1). E-resilience strategies are also claimed to offer an opportunity to identify innovative tools, to foster social learning and to promote multi-stakeholder collaboration.

There are three main functions of ICTs in adaptation. Firstly, aerial photographs, satellite imagery and grid technology predict, identify and measure the extent of the problems of climate change (ITU, 2009). Weather projections and vulnerability assessments predict climate change impact, such as rainfall patterns. Locally-specific information feeds into decision support tools, and these inform policy makers and local stakeholders to enable them to come up with different adaptation strategies. Secondly, ICTs reduce the costs of information exchange and raise awareness and facilitate dialogue. For example, Harvey and Mitchell (2011) show how ICTs have been used to share information about adaptation strategies across Africa. Thirdly, ICTs promote community-based adaptation exchange and citizen involvement. For instance, UNDP (2011) shows that participatory sensing by mobile phones and scenario planning workshops promote community-based solutions.

ICTs also provide adaptation tools for specific sectors. In agriculture and food security, ICT-based agrarian information systems use scenario mapping and local crop modelling to assist farmers to make long-term planning, crop diversification, food storage and distribution decisions (Hogan *et al*., 2011). According to Munang and Nkem (2011), agro-meteorological information can be linked to seasonal growing features of various crops, and that enables farmers to identify alternative seed varieties and livestock breeds that address environmental variations. ICTs also promote self-organisation and build networks for pastoralists to find suitable land for grazing (Hussain, 2010). Community radio and village knowledge centres can provide farmers with information about pest and disease control and provide contacts to local climate change organisations (Braun and Islam, 2012). In water, GIS and remote sensing provide information, such as the source, quantity and quality of water resources, for better water management. On the occurrence of floods and droughts, mobile phones facilitate participatory monitoring systems by passing on real-time data (IDS, 2008). For instance, a

small network of telecentres was developed in the Huaral Village, Peru to help farmers improve their irrigation techniques; helping them adapt to changing water availability levels (CEPES, 2010).

3.2.2 Gendering e-Adaptation

Different perceptions and interpretations of climate change between men and women highlight the need to take diverse adaptation strategies to match their needs. In relation to technologies for agricultural adaptation, for example, Oxfam (2011b) shows that women do not use pits or stone walls to protect their farms because they believe they 'do not have the necessary physical strength and support' to do so (p4). Turning to gendered use of ICTs, while most women use emails to build social networks, Bathge (2010) finds that men tend to use ICTs for business or education. In addition, men and women have different priorities in receiving information, so their use of mobile telephony, community video or other social media applications to disseminate information could have a differing impact. Acknowledging that women 'have particular knowledge and skills that can contribute to climate solutions' (UNDP, 2011:1), some NGOs particularly target women in their e-adaptation interventions. Oxfam (2011a), for example, provides support for women's village water committees to identify alternative water sources. GenARDIS initiated women's drama groups and used community radio to deliver the message of pest control (Radloff, 2010).

There is a sense of optimism in the e-adaptation literature that ICTs could open up an opportunity for previously-marginalised groups, especially poor women, to re-negotiate their roles in their communities. IDS (2008), for example, suggests that the process of selecting heat-tolerant plants and drought-resistant animal breeds would help women farmers assert their authority in their farms (p11). Nelson *et al*. (2002) also indicate that building women's resilience would improve farm productivity. Increasing women's incomes would result in economic and other forms of empowerment. Nevertheless, Resurreccion (2011) argues that many e-adaptation interventions focus too much on technical solutions to reduce the impact of climate change, and too little on 'a complex set of responses to existing climatic and non-climatic factors that contribute to people's vulnerability' (p2). Men and women may re-negotiate their roles in the process of adaptation, but Ospina and Heeks (2010) warn that the process gives 'voice to the interests of certain groups that may not be the most vulnerable' (p30).

In particular, women feel more constrained from building adaptive capacities because they are deprived of 'land rights, ownership rights for the means of production, technology, finances, information and training in climate adaptation' (Bathge, 2010:5). Without control over productive resources and with lower access to loans, credit and agricultural extension services, Olson *et al*. (2010) argue that women do not have the power to decide what changes are needed in their farms. All these constraints, IDS (2008) suggests, reduce their incentives 'to engage in environmentally sustainable farming practices and make long-term investments in land rehabilitation and soil quality' (p4).

Nelson *et al*. (2002) also warn that many adaptation practices build on women's unpaid labour. It assumes that 'rural women are predisposed to taking an environmental care-tending role' (MacGregor, 2010: 8). Their e-adaptation involvement could increase their workload, without properly addressing their strategic needs. In order to juggle increasing demands, women may shift more domestic responsibilities to their daughters, and that could reproduce inter-generational inequalities (Oxfam, 2011b).

3.3 Disaster Management

ICTs are considered to play a crucial role in disaster management including disaster prevention, early warning and emergency communication, and post-disaster coordination (ITU, 2009). Satellite-based systems capture detailed meteorological data and offer more accurate weather forecasts. On the ground level, wireless sensor networks can monitor localised weather changes and can create a database of disaster history to enable trend- and pattern-analysis (IISD, 2011). Local hazard mapping and vulnerability assessments help identify houses and farmlands at risk and illustrate evacuation routes. Early warning systems help reduce causalities. Furthermore, mobile phones, text messaging and real-time on-line collaboration are useful for immediate response (Hussain, 2010). Rapid data gathering, during emergency response, facilitates logistics and provides decision-making support. ICTs also allow more flexible response to post-disaster reconstruction efforts.

Alongside typical climate-related disasters such as landslides and flooding, global warming also increases the risk of infectious water- and vector-borne diseases, such as malaria and dengue fever (Dankelman *et al*., 2008). ICTs provide detailed maps to show the extent and the spread of the diseases and rationalise allocation of resources for disease control (Ospina and Heeks, 2010). Community radio also helps raise public awareness and promote public health campaigns.

The effectiveness of ICTs in disaster planning, however, depends on who has, and uses this, access to information. Radio provides a simple and effective tool to transmit information in emergency, but research by Gurumurthy (2004) shows that it is often men, rather than women, who control the access to radio. In Gurumurthy's words, 'if the household has one radio, it is most likely to be used by men. Women may not have the leisure to listen to the radio, nor may be allowed to join the men sitting outside the house listening to radio' (p5).

Disaster management is also gendered. This cannot be completely generalised because 'the relationships between natural hazards and gender do vary' (Nelson *et al*., 2002:56). Men and boys may be in greater danger, considering attempts to save others such as family members to be heroic, and placing themselves at additional risk (UN, 2011). However, there seems to be greater weight of evidence pointing to increased vulnerability for girls and women.

In their participatory gender study in Indonesia, Haynes *et al*. (2010) find out that both male and female adults have negative perceptions of girls' responses to disasters. While they praise the boys for being able to evacuate the elderly and move livestock from the affected areas, they think 'girls can't escape from disaster' because they only know screaming (p24). As a result, boys are allocated more disaster-relevant resources and roles, and girls are left more vulnerable.

Using the major floods in Bangladesh in 1991 as an example, Rohr (2005, quoted in IDS, 2008) highlights gender biases in the early warning systems. Rohr explains that warning information was rarely communicated to women:

> '…… warning information was transmitted by men to men in public spaces, but rarely communicated to the rest of the family and, as many women are not allowed to leave the house without a male relative, they perished waiting for their relatives to return home and take them to a safe place' (p7).

Early warning systems also need to address the cultural constraints that delay the timely escape of the vulnerable. Swimming and tree climbing, for example, are useful to escape flash floods, but women are not equipped with the same skills as

their male counterparts (IDS, 2008). Women's clothes in some countries could reduce their mobility. Many were drowned because of this in the 1991 Bangladesh floods.

Bathge (2010) suggests that women's lack of land rights affects post-disaster re-construction efforts. They are denied the rights to buy a new plot of land for resettlement. In case of disaster, women are expected to stay at home and take care of the sick and the elderly. This also constrains them from enacting alternative coping strategies.

4. Indirect ICT Impact on Gender Relations

ICTs try to address many problems in developing countries; tackling climate change is only one of many. Many ICT projects have the potential to raise people's incomes by improving farm productivity and creating job opportunities. For example, the World Bank (2011d) suggests that women's income in India has increased through telephony as they are getting information on the market price of the vegetables they grow. Mobile applications reduce the costs of job searching by 'connect[ing] informal sector workers with potential employers in India' (IISD, 2011:34). In addition, more ICT projects also encourage poor people to become service providers and entrepreneurs. Raising incomes makes ICTs more affordable to poor people and increases their access to information. Women earning more money, Speranza (2010) argues, would re-shape their relationships with men because they have more power to decide how money is spent (p3).

Mobile phones provide women with greater flexibility in managing their business and domestic obligations. They allow women to re-negotiate their productive, reproductive and community roles. ICTs also make an impact on inter-generational relationships. Using ICTs to identify water sources, for instance, helps free up girls' time in water searching and collection. This may encourage girls to spend more time in schools. As a result, improving their literacy may have positive impact on their use of, and control over, ICTs; pointing to the potential for a 'virtuous circle' of ICT-enabled empowerment (World Bank, 2006).

Lowering information costs by use of ICTs could encourage a higher rate of rural-urban migration and worsen regional imbalance. However, ICTs could also reduce the costs of sending remittances to families in villages (Ospina and Heeks, 2010). The absence of men in villages, because of migration, could speed up the process of feminisation in agriculture. Oxfam (2011a) found that women become employers, hiring male farming services that involve physical strength and use of mechanisation. In the longer run, women controlling more and more everyday farming decisions could raise their bargaining power in negotiating the inheritance and land rights (Radloff, 2010). This could both be, and have, a significant impact on their use of ICTs.

To summarise, ICTs have indirect impact on women's lives in areas such as income generation, human capital building and land ownership. These, in turn, will affect the outcomes of the efforts of mitigation, adaptation and disaster management. The increasing rate of women's literacy, for instance, may raise their awareness of using ICTs in natural disaster prevention. Rising incomes and more land rights may make women less reluctant to adopt ICT-related mitigation and adaptation practices. But of course this only occurs if women are able to take the first steps onto the 'ICT ladder'.

5. Potential Recommendations: Interrogating Four Digital Empowerment Proposals

The previous sections have examined how gender mediates the effectiveness of ICTs in mitigation, adaptation and disaster management. They have also highlighted the obstacles that constrain some groups of men and women from exercising agency in using ICTs to tackle climate change. In this section, we will focus on four proposals in the literature which claim to shift ICT-climate change interventions from gender inadequacy to gender empowerment. These proposals are: gender mainstreaming, governance strengthening (including women-only interventions), gender-sensitive financial mechanisms, and linking agency and structure.

5.1 Gender Mainstreaming and Sex-Disaggregated Data Collection

Gender mainstreaming aims to integrate gender analysis into project design and public policy-making. UNDP (2008:3) defines gender mainstreaming as:

> 'The process of assessing the implications for women and men of any planned action, including legislation, policies or programmes, in all areas and all levels. It is a strategy for making women's as well as men's concerns and experiences an integral dimension of the design, implementation, monitoring and evaluation of policies and programmes in all political, economic and societal spheres, so that women and men benefit equally and inequalities are not perpetuated'.

The intention of gender mainstreaming is to avoid the absence of a clear ICT strategy and policy which could affect gendered outcomes (World Bank, 2011d) and to ensure that gender concerns are incorporated from the beginning and not as a corrective afterwards (Hafkin and Taggart, 2001).

The main obstacle to achieving gender mainstreaming in developing countries, Etta (2005) claims, lies in a lack of a clear set of sex-aggregated data over the use of ICTs and the impact of climate change interventions. UN (2011) also suggests that a systematic gender analysis requires a good set of sex-aggregated data in order to establish gender-sensitive benchmarks and indicators to measure changes and improvement.

A gender-sensitive approach, IDS (2008) argues, requires more than a set of disaggregated data since it risks reinforcing fixed binary roles assigned to women and men. Instead, good quality data should reflect the 'contested, changed and reinforced' processes of gender and social inequalities (Resurreccion, 2011:7). Qualitative information, such as local power structures, control over key economic assets and social norms, is crucial to 'evaluate women's situation as compared to that of men in relation to specific environmental concerns' (Lambrou and Piana, 2006:12). In addition, Gurumurthy (2004) stresses that engendering ICTs is not simply about greater use of ICTs by women or men, but it is about 'transforming the ICT system' to meet their strategic needs (p2).

5.2 Governance Strengthening and Women-Only Interventions

Gender disparities in ICT and climate change policies, Marcelle (2000) suggests, are a result of a lack of participation of the powerless in the decision-making process. Governance strengthening is, therefore, intended to identify and overcome barriers to gender participation in decision-making. To enhance gender involvement, two key questions are raised in the literature: firstly, who participates, and secondly, how the institutions are designed.

The first question touches on whether women are targeted exclusively in the interventions or whether men should equally be considered. The women-only advocates suggest that women are generally poorer than men (70% of the world's poor are women (MacGregor, 2010)), and consequently, they are more vulnerable to climate change. More women live in rural areas than men, and they rely more on natural resources for survival. Yet, their land rights are often denied (Oxfam, 2011b). In addition, the literacy rate of women is lower than that of men. In Sub-Saharan Africa, for example, only 53.3% of women are literate whilst men have achieved 71.2% (UNDP, 2011). We have also seen above the greater vulnerabilities or exclusions of women at the interface of ICTs and climate change.

To enhance female participation, gender experts and female scientists are targeted and invited to join in the preparation of climate change policies in order to 'improve dialogue between IT and gender policy makers' (Hafkin and Taggart, 2001:5). A quota system, such as fixing the number of senior female officials and a percentage of women's activities per district, is proposed to foster women's leadership in key institutions and gender-responsive funding for action (Jolly *et al*., 2004). Another women-only group example includes women's community gardens in Malawi to ensure food security in times of flooding, and women-only self-help groups to produce organic staple crops to cope with climate change (MacGregor, 2010).

The women-only interventions have, however, been criticised for homogenising women's experiences. UN (2002) suggests that single mothers, widows, disabled women, aged women and women in urban and rural areas have different identities, and their strategies to adapt to climate change can be very different. Furthermore, not all women in developing countries lack ICT access. South Africa and Chile are two examples that have achieved 50% internet connection nationally. Cleaver (2003) warns that a single-minded focus on women as excluded also risks considering the power relationships between men and women a 'zero-sum game'. She argues that, while not all men are powerful, not all women are powerless. Middle class women, for example, usually have higher access to ICTs than most poor men in rural areas (World Bank, 2011b).

Men are 'gendered beings' too (MacGregor, 2010). Poor men and boys are also vulnerable to climate change. Older men, for instance, are less tied into social networks than women, and that would put them at a disadvantage when they seek help from their communities (IDS, 2008). Understanding masculinity also helps understand how men and boys facilitate, as well as hinder, women and girls in building resilience and using ICTs. For example, in the 'hole of the wall' computer experiment in India, Hafkin and Odame (2002) find that: 'the aggressiveness of boys pushing away girls prevented the girls from using the computers' (p13).

Despite an at-first-sight incompatibility, women-only interventions and the proposal to include men are not mutually exclusive, but they may often require

separate approaches. In many cases, women feel more comfortable to express their concerns in meetings, without the presence of their husbands or other men. Thus, when UNDP (2010a) conducted vulnerability assessments in Morocco, men and women were consulted separately, but the interests of men and women were equally taken into account.

The second question concerning institution building is about how institutions are built. Developing a close partnership with local NGOs is one recommended approach to governance. NGOs may offer ICT training and access in their outreach strategies and climate change-related capacity building programmes (UNDP, 2011). However, UN (2002) finds that many women's organisations and gender-focused groups perceive ICT policies 'an issue reserved for specialists' (p10). This reflects the concern by Dankelman (2002) that ICT components remain techno-centric and are imposed in a top-down manner. A genuine bottom-up approach working with local stakeholders to develop ICT capacity rarely materialises. Although the World Bank (2011c) suggests that improving governance provides an opportunity to combine modern communication systems with indigenous knowledge, Gillard *et al*. (2007) find that indigenous knowledge is often ignored or unnoticed. The 'bureaucratisation of gender guidelines' and the prescribed initiatives, they argue, do not pay adequate attention to cultural specificity of gender relationships (p6).

5.3 Gender-Sensitive Funding Mechanisms

The financing of ICT and climate change projects has significant implications for affordability, accessibility and gender. The World Bank (2011a) suggests that privatisation and liberalisation help lower user prices of ICTs. Reforming the telecommunication sectors in developing countries and licensing of new operators to introduce competition, the Bank argues, would ensure ICT access to the poor and the underserved. To finance broadband infrastructure, innovative public-private partnerships are seen as 'catalytic vehicles to attract additional private sector investment' (*ibid*, p2).

But such ideas may be gender-blind, and hence perpetuate gender divisions. UN (2002) shows scepticism of privatisation. It suggests that: 'ICT policy is frequently driven by the politics of the ICT sector, often impelled by commercial interests' (p11). Even ideas like micro-finance may be problematic. Oxfam (2011a) argues that expanding financing options by micro-finance would risk imposing greater financial burden and stress on vulnerable women and men. Oxfam instead stresses the need to set up 'gender-sensitive funding guidelines' and 'equal gender representation in all decision-making bodies' (*ibid*, p3).

Likewise, UNDP (2011) suggests improving women's access to micro-finance and other sources of credit. It also encourages the development of 'gender-sensitive climate change investment plans' which will facilitate access to financing for those most in need, particularly women and community groups (p13). In Ghana, for instance, a specific fund was set up to support initiatives that target women and promote gender equality in adaptation strategies.

5.4 Linking Agency and Structure

ICT and climate change solutions lie on the continuum of agency and structure. The agency approach focuses on 'the individual capability to be and to act' (Bebbington, 1999:5) and considers access to information an act of empowerment. Sending SMS messages to alert individual members about forest

deforestation, as described in section 3.1.2, for example, stresses personal responsibility and action. The structural approach, in contrast, highlights social enablement and constraints. The denial of women's rights to land, for example, underlines the constraints that women face in mitigating and adapting to changing climate.

This agency-structure dualism, however, may not be that useful in understanding the 'gender-ICT-climate change' nexus. It is not clear how individual and collective interests are aligned, across sectors and levels, in the agency approach. Neither is it clear in the structural approach that individuals negotiate and contest gender relations in relation to the technology environment (Gurumurthy, 2004). This paper suggests the social embeddedness approach, exploring the interplay between agency and structure, is more useful in understanding the mechanisms of how gender shapes, and is shaped by, ICT and climate change interventions. Ospina and Heeks (2010) adopt a similar approach, highlighting the combination of personal preferences, social pressure and other decision-making mechanisms that influence adaptive capability and the outcomes of *achievable* and *actual* functionings (p9-10, original emphasis). Women, for example, feel constrained from using public cybercafés and rural information centres, not only because cultural norms restrict their mobility, but also because of the perception of safety and of the unsuitability of opening hours (Bathge, 2010). By understanding agency-structure interactions rather than duality, for example, we may see that design of ICT projects and climate change projects must seek to work with – but extend – existing structures, while enhancing women's agency (UN, 2002).

5.5 Summary

In a nutshell, to improve the likelihood of positive gender outcomes when using ICTs to address climate change, policy-makers and practitioners should contextualise the process of gender mainstreaming in their interventions and consider how women, and men, respond differently in various cultural contexts. Enhancing gendered governance of ICTs and climate change, for example by ensuring equal participation of both men and women in natural resource conservation, is of paramount importance. It may be desirable to implement women-only interventions on some occasions, but the interests of powerless men should also be considered. Securing adequate funding to support ICT interventions is crucial to gender empowerment. Yet, putting an additional financial burden on already-poor populations should be avoided. Lastly, recognising the interplay of agency and structure helps better understand all processes, from climate change adaptation to digital exclusion. Building new, and reforming old, institutional arrangements can promote digital inclusion.

6. Conclusions

This paper has offered a systematic review of how gender shapes, and is shaped by, the interaction of ICTs and climate change. Based on our devised conceptual framework in section 2.3, it has demonstrated the underlying processes by which gender inequalities are challenged, and reproduced, in the process of using ICTs to reduce CO_2 emissions, to adapt to the changing climate and to manage disasters.

To conceptualise the exclusion of women in ICT-climate change interventions, we can draw on Ospina and Heeks' climate change adaptation model (2010). In our analysis, women are systematically disadvantaged in terms of assets, institutions

and structures. Firstly, compared to men, women have less access to ICT-based information. Deprived of land rights, they cannot make decisions about whether, and which, agriculture-related ICTs would be implemented. In addition, women struggle to make their voice heard in mitigation policies because of their restricted access to finance.

Secondly, women are more institutionally-constrained than men. Cultural norms of behaviour shape what decisions women, and men, can take and what responsibilities they are required to take on. The exclusion of women in forest governance, for example, is related to the perceived danger to women of using ICTs to monitor illegal logging activities. Men bearing risk to protect their forests are given a legitimate voice to make decisions on behalf of women. In disaster management, rigid gender norms and cultural practices delay the evacuation of women and girls in cases of emergency. (That said, on some occasions, the heroic culture among men and boys puts them at risk.)

Thirdly, in term of social structures, women are excluded from decision-making in policy design and resource allocation. The effectiveness of ICTs in disaster prevention is undermined by the masculine culture of information dissemination. Women are also less represented in formal decision-making bodies, such as CDM and REDD.

To summarise, restricted access to assets, gender-biased institutional arrangements, and unfavourable social structures have reduced women's capability to draw on ICTs in tackling climate change. In addressing these limitations, we have made four digital empowerment proposals that may make 'ICT-climate change' interventions more gender-sensitive:

(1) ***Contextualise gender mainstreaming***: gender mainstreaming helps integrate gender analysis into ICT policies. It acknowledges that men and women perceive and receive information differently, and that this requires diverse approaches to adaptation. However, the attempt to re-position women and girls as 'eco-carers' is problematic because this fails to capture their protective, as well as their destructive, role in relation to natural resources. Without addressing the unequal power relations between women and girls, e-adaptive practices can also help reproduce the inter-generational equalities.

(2) ***Strengthen governance***: crafting new and reforming old, institutional arrangements is essential to improve gender inclusion. Women-only interventions are sometimes necessary to empower previously-excluded women to engage in ICT-related decisions. However, poor and powerless men should also have their say in climate change policies.

(3) ***Develop gender-sensitive funding mechanisms***: securing adequate funding to support ICT interventions is crucial to gender empowerment. Yet, targeting women by micro-credit projects risk putting an additional financial burden on them, and that needs serious re-consideration.

(4) ***Recognise agency-structure dynamics***: women are active agents, but they are socially constrained from engaging in ICT-related decisions. Women's preferences, institutional arrangements and politics need to be taken into account in order to tackle digital exclusion.

We believe that these four proposals are useful for development agencies, governments and NGOs to improve the gendered outcomes from use of ICTs in response to climate change.

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Annex: Glossary of Acronyms

AfDB	African Development Bank
CDM	Clean Development Mechanism
EU	European Union
FAO	Food and Agriculture Organisation
GeSI	Global eSustainability Initiative
GIS	Geographical information systems
GTZ	Deutsche Gesellschaft fur Internationale Zusammenarbeit
ICT	Information and communication technology
IDPM	Institute for Development Policy and Management
IDS	Institute of Development Studies
IISD	International Institute for Sustainable Development
ITU	International Telecommunication Union
REDD	Reducing Emissions from Deforestation and Forest Degradation
UN	United Nations
UNDP	United Nations Development Programme
WB	World Bank