The Future Research Agenda for ICTs, Climate Change and Development

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This Strategy Brief explores the future research agenda for information and communication technologies, climate change and development (ICCD). It argues that new research on the role of digital tools is needed to identify innovative, locally-appropriate approaches to face the challenges and benefit from the opportunities posed by climate change. Emerging research in this field has started to shed light on the role of ICTs to mitigate, monitor and adapt to the effects of climate change within developing country settings. However, much remains to be done in order to provide evidence-based knowledge that can be used by decision-makers at the community, sectoral, national and international levels.

This Brief identifies key enablers and constraints for ICCD research. It then summarises a series of current knowledge gaps which can set the agenda for future research priorities in the field. The Brief concludes with concrete action steps to move the ICCD research agenda forward.

1. Relevance of ICTs, Climate Change and Development (ICCD) Research

As climate change-related impacts grow in developing countries, there is an increasing need to develop innovative approaches which help vulnerable populations to better cope with, mitigate and adapt to the effects of both short- and long-term climatic effects. Alongside the momentum gained by climate change within national and international agendas, research in the field has risen exponentially – albeit from a very small and recent base – opening new ground for emerging fields of study where traditional climate change science, development studies and the application of innovative tools converge.

The emerging field of *Information and Communication Technologies (ICTs), Climate Change and Development (ICCD)* is situated at this junction (see Figure 1). ICCD research seeks to explore the linkages that exist between ICT tools (such as mobile telephony, community radio and Internet applications) and key climate change issues that are affecting the global South in the areas of mitigation, adaptation, monitoring and strategising. It is based on the recognition that information and knowledge are crucial enablers of action and change, and that the lack of appropriate information resources and knowledge sharing often lie at the core of developing countries' vulnerabilities to a multitude of stressors, including climate change.

Available research suggests the existence of close links between ICTs' potential in the climate change field, and the vulnerabilities and resource constraints that characterise developing regions[1]. But it also suggests that the availability and increasing use of ICT tools offers new opportunities for the way in which climate change information is gathered, analysed, processed and disseminated and, ultimately, for the way in which knowledge is created and used as part of climate change responses within vulnerable contexts.

Exploring the future research agenda at the intersection of ICTs, climate change and development is essential to understand the opportunities and the risks involved in ICTs' role within developing contexts facing increasing climate change-related challenges.

2. ICCD Research: Enablers and Constraints

Recent developments suggest an increasing level of interest and awareness about the ICCD field from a number of stakeholders. Among these developments are the availability of new research-oriented resources[2], the creation of a multi-stakeholder Study Group on ICTs and Climate Change[3] led by the International Telecommunication Union (ITU), as well as the unprecedented visibility that the topic had during the climate change Conference of Parties (COP17) held in Durban, South Africa in 2011[4]. These efforts coincide with the launch of a global 'Coalition on ICTs and Climate Change'[5] whose objectives include raising awareness, showcasing innovative initiatives, mobilising political will, and encouraging governments to include ICTs as part of climate change policies.

While these constitute encouraging developments that build upon and could help advance research in the ICCD field, there are also critical factors that need to be considered in order to move the research agenda forward:

- ***A Hybrid Field of Research:*** The role of ICTs in the climate change field cannot be understood in isolation from wider development processes, stressors and vulnerabilities. These include not just issues of infrastructure and connectivity, but also socio-economic, cultural and scientific factors that are not limited to the lens of a single discipline, or to a single method of study. Thus, ICCD research is a 'hybrid' field that builds upon knowledge from the climate change, the development and the information systems fields. This therefore favours inter- and multi-disciplinary approaches, which can be more methodologically challenging to enact.

- ***Bridging Knowledge Gaps:*** ICTs are transversal tools, used by stakeholders from different sectors and at different scales (i.e. macro, meso and micro). One starting point of ICCD research is acknowledgement of the diversity of interests and stakeholders that play a role in mitigation, adaptation, monitoring and climate change strategies, and of the need to bridge existing knowledge and information

[1] http://www.niccd.org/casestudies.htm
[2] See for example: http://www.niccd.org, http://www.itu.int/ITU-T/worksem/climatechange/resources.html
[3] http://www.itu.int/ITU-T/studygroups/com05/index.asp
[4] Side events focused on ICTs' role in adaptation and mitigation were led by the United Nations Climate Change Secretariat (UNFCCC), ITU, the Global e-Sustainability Initiative (GeSI) and TechAmerica. http://www.itu.int/themes/climate/events/cop17/ICTcoalition.html
[5] Organisations in the coalition include the International Telecommunication Union, the Global e-Sustainability Initiative, the UNFCCC Secretariat, the UN Global Compact, TechAmerica, as well as high-level representatives from the governments of Ghana, South Africa and Egypt http://www.itu.int/themes/climate/events/cop17/coalitionflyer.pdf

sharing gaps across sectors and scales. Of particular importance is the gap that exists between academic/university-based research, and the needs of climate change and ICT-for-development stakeholders in the field.

- ***The Need to Build South-Based Research Capacities:*** ICCD research is delivering ever-more empirical knowledge and experiences about the use of ICTs within climate change responses. However, it also demonstrates the need to build and strengthen research capacity - particularly of developing country organisations – in order to produce the required level of locally-relevant research outputs.

- ***Integrating Emergent and Traditional Knowledge:*** Researchers at the intersection of the ICTs, climate change and development fields need to acknowledge and integrate both new and traditional knowledge. While the former is key to cope with and prepare for the magnitude and intensity of emerging climatic challenges, the latter is fundamental in bottom-up/community-based strategies. Thus, both types of knowledge should be considered and integrated as part of holistic research approaches in the ICCD field.

- ***Building a Conceptual Foundation*:** ICCD research to date has often been somewhat anecdotal[6]. This has limited its transferability and impact. ICCD research needs to adopt a foundation of frameworks and models – which are readily drawn from its constituent disciplines – in order to ensure rigour and value[7].

- ***Adopting a Balanced Systemic Perspective*:** ICCD research should acknowledge that ICTs can have both positive (e.g. efficient transport and travel substitution) and negative effects on the environment (e.g. increased energy consumption and e-waste). ICCD research approaches should go beyond the effects of particular applications to include the lifecycle of ICT products[8], as well as the systemic effects that may be associated with new production or consumption processes[9]. Likewise, it should consider the way in which ICTs may contribute to both adaptation and maladaptation, at both the local and national levels.

The interaction of these factors is illustrated in Figure 1. The integration of multi-stakeholder perspectives and audiences in the development and dissemination of ICCD research, the strengthening of South-based capacities, as well as the acknowledgement of both new and traditional knowledge (e.g. Western/scientific and indigenous/empirical) and ICT tools (e.g. radio, television, as well as mobile phones and Internet-based applications) constitute key contributing factors to research at the intersection of the ICTs, climate change and development fields.

Research products resulting from the interaction of these factors include models and frameworks (conceptual tools to support the planning, implementation and monitoring of interventions in the field), analysis of key topics (as reflected in Section 3) as well

[6] Ospina, A.V. & Heeks, R. (2010a) *Unveiling the Links between ICTs & Climate Change in Developing Countries: A Scoping Study*. Centre for Development Informatics, Institute for Development Policy and Management (IDPM), University of Manchester, UK http://www.niccd.org/ScopingStudy.pdf

[7] See, for example, Ospina A.V. & Heeks, R. (2010b) *Linking ICTs and Climate Change Adaptation: A Conceptual Framework for e-Resilience and e-Adaptation*. Centre for Development Informatics, Institute for Development Policy and Management (IDPM), University of Manchester, UK http://www.niccd.org/ConceptualPaper.pdf

[8] Pamlin, D. & Szomolanyi, K. (2005) *Saving the Climate @ the Speed of Light: First Roadmap for Reduced CO_2 Emissions in the EU and Beyond,* Brussels: World Wide Fund (WWF) and European Telecommunications Network Operators' Association (ETNO). http://assets.panda.org/downloads/road_map_speed_of_light_wwf_etno.pdf

[9] Ospina & Heeks (2010a), ibid.

as developing country case studies on the role of ICTs in climate change mitigation, adaptation, monitoring or strategising, among others.

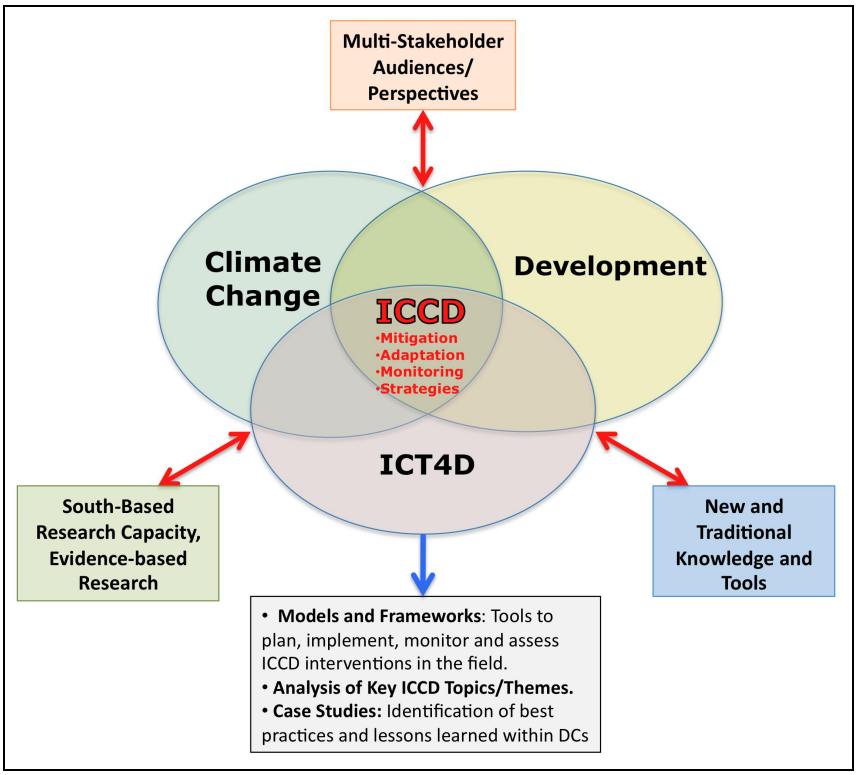

Figure 1. Mapping the ICCD Research Field

3. Moving Forward: Future ICCD Research Priorities

The following key topics constitute research gaps identified through a review of available literature in the field[10], and through multi-stakeholder discussions held at the international workshop on ICTs, Climate Change and Development in Johannesburg, South Africa, January 22nd and 24th 2012[11]. They have been categorised according to four key areas for developing country action in the climate change field (i.e. mitigation, adaptation, monitoring and climate change strategies), and constitute current knowledge gaps – and, hence, future research priorities – for the ICCD field.

[10] Ospina & Heeks (2010a), ibid.
[11] This event was attended by 35 key individuals with strategic responsibilities for either ICTs or climate change in development organisations in the NGO, public and private sector. It was organised by the University of Manchester and the Association for Progressive Communications (APC), with funding support from Canada's IDRC. http://niccd.org/workshop2012.htm

ICTs and Climate Change Mitigation

(a) Strengthening the Links between Mitigation and Development Agendas

- Most available resources in the area of ICTs and climate change mitigation continue to be focused on addressing the needs and agendas of developed countries. Further research is needed on the links between mitigation efforts and the development agenda of developing countries in key areas, including (1) the opportunities and challenges associated with fostering low-carbon societies within developing contexts, (2) the operationalisation of ICT-enabled mitigation options such as journey substitution, smart energy generation and use, and dematerialisation of goods/services within developing contexts, and (3) the role of ICTs in mitigation efforts linked to CO_2 emissions in the agricultural sector. Research in these topics could contribute to change the current perception of mitigation as a 'developed country issue', and foster actions among decision makers in the public, private and civil-society sectors.

(b) ICT-Enabled Income-Generating Opportunities in Mitigation

- Closely related to the above, the potential of ICT tools as part of income-generating activities linked to mitigation (e.g. carbon bonds and emission-reduction incentives, organic agriculture and new markets, reforestation, among others) constitutes an emerging field of research, particularly with respect to the strengthening of rural livelihoods. Research in this area could include the identification of ICT-emerging business models consistent with carbon-neutral livelihoods, including 'green IT' opportunities, and the evaluation of "smart technology" innovation and transfer models in the global South.

(c) Holistic Approaches to ICT Industry Processes and Practices

- The production, distribution and consumption processes of the global ICT industry contribute to carbon emissions. Understanding the contribution and the role of ICTs in the mitigation of carbon emissions requires the adoption of holistic, process-driven (as opposed to output-driven) research approaches. Further research is needed from developing country perspectives on issues such as ICT production models, equipment obsolescence and replacement practices, energy consumption, energy efficient materials and savings, as well as in the development of environmentally-responsible software.

(d) Climate Change Mitigation and e-Waste

- The linkage between climate change and e-waste within developing countries has yet to be fully clarified. Future research in this topic could explore the costs and benefits associated with e-waste management within vulnerable contexts, its linkages with carbon sequestration, as well as the development of indicators to measure and assess their role/contribution within mitigation strategies.

(e) Innovative/Low-Cost ICTs and Mitigation

- As part of the efforts to bring the climate change mitigation agenda closer to the priorities and the challenges faced by developing countries, research could explore the potential of innovative, low-cost ICT solutions (including open-source software, mobile and non-wireless applications) that can contribute to mitigate climate change impacts. It could also identify new pro-poor innovation models, and the role of the innovation context such as investment, business and intellectual property rights policies.

(f) ICTs and Citizen-Driven Mitigation

- The power of social media and Web 2.0 is rapidly permeating citizen-driven campaigns, mobilisation and advocacy in a number of areas, including climate change mitigation. Research could address the role of social media tools in citizen-driven approaches (e.g. online networks and digital campaigns) towards consumer practices, responsible consumption patterns and energy awareness-raising to reduce carbon emissions. Research could also address the role of ICTs in emerging trends such as "immaterialisation" and "demarketing", aimed at modification of consumer values and demands.

ICTs and Climate Change Adaptation

(a) ICTs and Adaptation Capacities / Resilience within Vulnerable Contexts

- While emerging research and field experiences suggest the existence of positive linkages between the use of ICTs and climate change adaptation, research is still required to better understand the role of ICT tools in regards to the adaptive capacity / resilience of vulnerable populations. This requires research to specify the nature of community capacity and resilience. It also includes issues such as ICTs role in the adaptation of local productive systems to the effects of acute/short term events and chronic/long term trends, their contribution to participatory natural resource management and adaptation planning, their role in advocacy and public awareness, and their support for the type of emergent actions that communities will adopt in response to climate change.

(b) ICTs, Infomediaries and Multi-Level Interactions

- ICCD research suggests that infomediaries (local agents such as agricultural extension officers who mediate between external and local stakeholders) play a crucial role in the effective delivery, appropriation and use of climate change information and knowledge. Research is still required to identify the best ways in which ICTs can enable and support their role, while strengthening knowledge sharing between stakeholders at the local, meso and macro levels (e.g. enabling information flows between national and local governments, NGOs and community members).

(c) ICTs and Institutional Capacity Strengthening for Adaptation

- Institutions play a critical role within processes of adaptation and change, as they can either enable or constrain access to key resources needed for the implementation, sustainability and potential scalability of adaptation actions in the field. Future research is required to explore the potential of ICTs to strengthen the adaptive capacity of South-based institutions, including issues of information management and knowledge sharing, as well as their capacity to support, monitor and assess adaptation initiatives.

(d) ICTs as Catalysts of Accountable Adaptation Financing

- Acknowledging the growing flows of adaptation-related funding, further research is required to explore ICTs potential to increase the transparency and accountability of these financial flows, and to enhance broader monitoring and evaluation of adaptation initiatives.

(e) ICTs and Gender-Sensitive Approaches to Adaptation

- Women constitute key agents of change within communities, and their role is crucial in the promotion of ICT tools and approaches. Considering the heightened vulnerability of female-headed households to climatic events, future research could explore the role of ICTs within gender-sensitive approaches to adaptation, including the impacts of information access, capacity building and empowerment on their adaptive capacity.

(f) ICTs and the Role of the Private Sector in Adaptation

- While private sector firms have been actively involved in the design and implementation of mitigation initiatives, their role in the adaptation field has been less prominent. Research is needed to help develop a clear innovation agenda for ICTs and adaptation, which identifies clear entry points for private sector engagement and partnerships in the field.

(g) ICTs, Climate Change Communication and Social Learning

- Research could explore the role of ICT tools in relation to climate change risk perceptions, awareness and understanding among different audiences. In terms of social learning, research could explore the technology's role in behaviour change, engagement and participation, and empowerment and action within populations impacted by climate change and variability.

ICTs and Climate Change Monitoring

(a) ICTs and Participatory Monitoring Approaches

- Gathering, analysing and disseminating climate change information through locally appropriate tools (i.e. community radio, SMS, Internet access points, community video and other interactive media) constitute key factors for capacity strengthening and empowerment within vulnerable communities. Research in this field could explore ICT-enabled participatory monitoring mechanisms, and the way in which they can contribute to implementation of bottom-up approaches in the climate change field.

(b) Empowerment and the 'Information Chain'

- If participatory monitoring is to be fully effective, it must complete an "information chain" that not only gathers data, but delivers that as information back to local communities, and – further – empowers them to then take decisions with that information, and provides the resources necessary to turn those decisions into developmental actions (thus making the connection from monitoring to mitigation and adaptation). More research is required to understand the components of the information chain for local communities, and the way in which climate change monitoring initiatives can deliver all the resources needed to ensure the chain is completed.

(c) ICTs Monitoring Local 'Hotspots'

- Use of ICTs plays a key role in the field of disaster management and response. Research in this area could explore the links that exist between ICT-enabled monitoring in key vulnerable hotspots, to be identified by local communities with the support of both digital and non-digital ICT tools. Research could include the role of ICTs in disaster prevention and planning in key vulnerability areas, and the way in which this potential could be articulated into comprehensive/national or regional climate change strategies.

(d) Citizen-Based Monitoring of CO_2 Emissions

- Research is required to look at innovative ways of monitoring emission of greenhouse gases, utilising citizen-based, collaborative approaches that build on social networking and digital mobilisation to report and measure the level of emissions in key areas of energy consumption. This research area relates to the role of ICTs in public climate change perception and digital advocacy.

ICTs and Climate Change Strategies

(a) ICTs and National Climate Change Policies and Strategies

- As the design and adoption of Nationally Appropriate Mitigation Actions (NAMAs) and National Adaptation Programmes of Action (NAPAs) rises up the climate change agenda of developing countries, further research will be required on the potential of ICT tools within national climate change policies and strategies, in particular as enablers of multi-lateral, measurable and reportable mechanisms for the implementation of NAMAs and NAPAs.

(b) ICTs and Global Climate Change Processes

- Acknowledging the increasing role of ICTs within global climate change processes such as the UN Conference of Parties (COP), future research could look at the integration of information society perspectives in international climate-related strategies, addressing the role of ICTs in assisting global strategising on climate change and in enabling policy frameworks that foster their effective use in the field.

(c) ICTs and Sectoral Development Strategies

- As the impacts of climate change emerge more clearly, they are seen to have specific implications for particular development sectors – water, health, education, rural development, housing, etc. ICTs will need to be integrated into strategies for each one of these sectors, and research is therefore needed that identifies the role of ICTs within each sectoral strategy.

(d) ICTs and Enabling Policy Frameworks

- Research is required to look at the role of public policies and regulatory frameworks for the integration of ICTs in the climate change field, including issues related to barriers of access to ICTs in developing regions; governance, accountability and service delivery; as well as other factors that impinge upon the level of ICT and climate change knowledge appropriation.

(e) ICTs and Political Inclusion

- Whatever the level of strategic climate change process – sectoral, national or global – there is a pressing need for local voices to be heard. ICTs can help enhance this and other forms of political inclusion, but further research is required to identify good practice models and technologies.

(f) ICCD Policy and Programme Integration

- As Figure 1 suggest, strategic actions on ICTs, climate change and development require at least four elements of integration – integrating ICTs with climate change; integrating climate change with development; integrating ICTs with development; and integrating all three components. Research is required to pinpoint exactly what integration means and requires in each given context, and to identify more generally some of the data, institutional and other barriers that must be overcome if integration is to be successful.

(g) Implications of Emerging Digital Technologies

- Research to date demonstrates that a technology-driven approach to strategising ICTs and climate change can easily lead to failure. Hence, the call for digital technologies to be subsumed within broader climate change and development agendas as tools: as means rather than ends. However, there are dangers that this integrated approach is not future-proofed. There is a therefore a research agenda to identify emerging ICTs and to identify the climate-relevant opportunities and issues associated with those technologies. The need is to focus not on "blue-sky" applications, but those which are emerging into the mainstream in developing countries. Examples would include Web 2.0, broadband, wireless sensor networks, mobile Web and smartphones, cloud computing, and convergent new/traditional ICTs.

4. Action Steps

The following action steps are suggested to take the ICCD research agenda forward:

- ***Take an Integrated, Multi-Disciplinary Perspective*** in order to ensure that the component parts of the ICCD field – ICTs, climate change, development – are all considered within the design and implementation of research projects.

- ***Develop an Effective ICCD Research Dissemination Strategy*** that identifies the specific audience which will benefit from the ICCD research, identifies the research demand and knowledge gap which needs to be filled for that audience, and identifies appropriate content and channels by which to reach that audience with research results.

- ***Explore Public-Private-NGO and South-North Partnerships*** as a way to draw on the richest-possible set of ideas, perspectives and capacities for ICCD research.

- ***Foster Participatory ICCD Research Approaches*** including action research methodologies that help – within the research itself – to bridge the gap between research and practice, and between new and traditional knowledge, and which draw multiple stakeholders into the research process.

- ***Provide Actionable ICCD Research Outputs*** to maximise the effectiveness of research impact, including policy briefs, practitioner guides and toolkits, and capacity-building outputs such as training workshop and materials.

- ***Build Upon Experiences, Knowledge and Lessons Learned*** that are already available in the ICCD field, to ensure that research builds upon and adds to the existing sum of knowledge, rather than just reinventing the wheel.

- ***Utilise Conceptual Frameworks*** since these are shown to be the most effective means by which policy-makers and practitioners can understand and then address the world around them.

- ***Raise Donor Awareness on ICCD***. A number of international organisations are funding ICCD research[12], but the field is still somewhat nascent. To ensure the continuity and sustainability of a research agenda and research capacity, particularly in the global South, new funding mechanisms need to be identified and fostered as part of the long-term programmatic approach of international donors in the climate change field.

Research in the ICCD field suggests that the viability and appropriateness of ICT-enabled responses to the climate change cannot be disconnected from the broader development context within which developing countries operate, including local livelihoods, capabilities and governance. The future research agenda in this field holds significant promise in terms of supporting pockets of local innovation and fostering multi-stakeholder partnerships that contribute to the ability of vulnerable groups to cope with and transform in the face of climate change challenges and uncertainty.

[12] IDRC, IISD, ITU, OECD

Further Reading

Braun, P. & Faisal Islam, M. (2011) *ICT-enabled Knowledge Brokering for Farmers in Coastal Areas of Bangladesh*. ICTs and Agricultural Adaptation to Climate Change Case Study, Centre for Development Informatics, University of Manchester, UK, http://www.niccd.org/NICCD_AgricAdapt_Case_Study_CoastalFarmers.pdf

Caceres Cabana, Y. (2011) *Using Radio to Improve Local Responses to Climate Variability: The Case of Alpaca Farmers in the Peruvian Andes*. ICTs and Agricultural Adaptation to Climate Change Case Study, Centre for Development Informatics, University of Manchester, UK, http://www.niccd.org/NICCD_AgricAdapt_Case_Study_PeruRadio.pdf

Chohan, F., Hester, V. & Munro, R. (2012) *Pakreport: Crowdsourcing for Multipurpose and Multicategory Climate-related Disaster Reporting. ICTs, Climate Change and Disaster Management Case Study.* Centre for Development Informatics (CDI), University of Manchester, UK, http://www.niccd.org/NICCD_Disasters_Case_Study_Pakreport.pdf

Giri, S. & Malakar, Y. (2012) *Using Mobile Phones to Reduce the Adversities of Climate Change in Rural Nepal. ICTs, Climate Change and Disaster Management Case Study.* Centre for Development Informatics (CDI), University of Manchester, UK, http://www.niccd.org/NICCD_Disasters_Case_Study_MobileNepal.pdf

Gross, I. (2012) *Mitigating ICT-Related Carbon Emissions: Using Renewable Energy to Power Base Stations in Africa's Mobile Telecommunications Sector. ICTs and Climate Change Mitigation Case Study.* Centre for Development Informatics (CDI), University of Manchester, UK, http://www.niccd.org/NICCD_Mitigation_Case_Study_MobileBasestations.pdf

Jones, R. & Siemering, B. (2012) *Combining Local Radio and Mobile Phones to Promote Climate Stewardship. ICTs and Climate Change Mitigation Case Study.* Centre for Development Informatics (CDI), University of Manchester, UK, http://www.niccd.org/NICCD_Mitigation_Case_Study_Cookstoves.pdf

Harvey, B. & Mitchell, T. (2012) *ICT-Enabled Knowledge Sharing in North-South Partnerships: Lessons from the AfricaAdapt Network. New ICT Routes to Climate Change Adaptation Case Study.* Centre for Development Informatics (CDI), University of Manchester, UK, http://www.niccd.org/NICCD_NewICT_Case_Study_AfricaAdapt.pdf

Heeks, R. & Ospina, A.V. (2009) ICTs, Climate Change and Development Overview Model. *NICCD* http://niccd.wordpress.com/2009/12/14/overview-model-of-icts-climate-change-and-development/.

Lemaire, I. & Muniz, S. (2012) *Participatory Video for Monitoring and Evaluation of Community-Based Adaptation to Climate Change. New ICT Routes to Climate Change Adaptation Case Study.* Centre for Development Informatics (CDI), University of Manchester, UK, http://www.niccd.org/NICCD_NewICT_Case_Study_ParticipVideo.pdf

Mahalik, D. (2012) *Reducing Carbon Emissions through Videoconferencing: An Indian Case Study. ICTs and Climate Change Mitigation Case Study.* Centre for Development Informatics (CDI), University of Manchester, UK, http://www.niccd.org/NICCD_Mitigation_Case_Study_VideoConferencing.pdf

Ospina, A.V. & Heeks, R. (2010a) *Linking ICTs and Climate Change Adaptation: A Conceptual Framework for e-Resilience and e-Adaptation*. Centre for Development Informatics, University of Manchester, UK http://www.niccd.org/ConceptualPaper.pdf

Ospina A.V. & Heeks, R. (2010b) *Linking ICTs and Climate Change Adaptation: A Conceptual Framework for e-Resilience and e-Adaptation*. Centre for Development Informatics, University of Manchester, UK http://www.niccd.org/ConceptualPaper.pdf

Rezaul Haq, A. H., Bakuluzzaman, M., Dash, M., Uzzaman, R. & Nandi, R. (2011) *An ICT-Based Community Plant Clinic for Climate-Resilient Agricultural Practices in Bangladesh*. ICTs and Agricultural Adaptation to Climate Change Case Study, Centre for Development Informatics, University of Manchester, UK, http://www.niccd.org/NICCD_AgricAdapt_Case_Study_PlantClinic.pdf

Saravanan, R. (2011) *e-Arik: Using ICTs to Facilitate Climate-Smart Agriculture among Tribal Farmers in North-East India*. ICTs and Agricultural Adaptation to Climate Change Case Study, Centre for Development Informatics, University of Manchester, UK, http://www.niccd.org/NICCD_AgricAdapt_Case_Study_eArik.pdf

Wickramasinghe, K. (2012) *Role of ICTs in Early Warning of Climate-Related Disaster: A Sri Lankan Case Study. ICTs, Climate Change and Disaster Management Case Study.* Centre for Development Informatics (CDI), University of Manchester, UK, http://www.niccd.org/NICCD_Disasters_Case_Study_EarlyWarning.pdf

The **Climate Change, Innovation and ICTs** Project is an initiative led by the Centre for Development Informatics (CDI) of the University of Manchester, UK, with funding support from Canada's International Development Research Centre (IDRC). Further information about the project and related resources can be found at: http://www.niccd.org