ICT-Enabled Responses to Climate Change in Rural Agricultural Communities

Angelica V. Ospina & Richard Heeks
Climate Change, Innovation & ICTs Project
Centre for Development Informatics
University of Manchester, UK
2012

Rural agricultural communities play a pivotal role in the economic, social, and cultural fabric of developing countries. At the same time, they are placed at the forefront of multiple development stressors that include increasing climate change impacts. Within contexts often characterised by poverty, remoteness and marginalisation, information and communication technologies (ICTs) can enable new responses to the challenges posed by more frequent and intense climatic events.

This Strategy Brief identifies the role of ICTs within the climate change responses of rural agricultural communities in developing countries. It argues that ICTs can become strategic enablers of action to create awareness about, mitigate, monitor and adapt to climate change within these communities. Despite their differences, rural agricultural contexts share similar attributes and challenges (geographical, economic and social) that are exacerbated by climate change impacts, and that require the adoption of innovative strategies based on emerging and traditional knowledge and information tools.

The analysis identifies different types of ICT interventions, key enablers and constraints to the use of these tools within rural agricultural settings impacted by climate change. It suggests the importance of adopting an 'Information-plus' approach that targets the improvement of local livelihoods through a variety of content and tools, while tackling climatic impacts as part of a broader set of development vulnerabilities.

1. Climate Change in Rural Agricultural Communities

Rural agricultural communities (RAC) are placed at the forefront of climate change impacts, and are the most prone to suffer from its effects. The unpredictability of weather patterns and the increased frequency and intensity of severe events such as floods and cyclones, are posing unprecedented challenges on vulnerable sectors such as agriculture (crop and livestock production, fisheries and forestry), affecting the livelihood of nearly half of the economically active population in developing countries[1].

[1] Nelson, G. C., Rosegrant, M., Koo, J., Robertson, R., Sulser, T., Zhu, T., Ringler, C., Msangi, S., Palazzo, A., Batka, M., Magalhaes, M., Valmonte-Santos, R., Ewing, M. & Lee, D. (2009) *Climate Change: Impact on Agriculture and Cost of Adaptation*. International Food Policy Research Institute (IFPRI), Washington, DC. http://www.ifpri.org/sites/default/files/publications/pr21.pdf
WRI. (2008) *World Resources 2008: Roots of Resilience- Growing the Wealth of the Poor*. World Resources Institute (WRI), Washington, DC., http://pdf.wri.org/world_resources_2008_roots_of_resilience.pdf

What makes rural agricultural communities a priority in the design of innovative climate change responses?

The agricultural sector remains at the core of developing countries' economies, playing a critical role in food security (at the local, national and international levels) and in the sustainability of millions of livelihoods of small producers and rural inhabitants. Rural agricultural communities are closely linked to the conservation of natural habitats and vulnerable ecosystems, and to the cultural identity of developing nations.

In spite of their developmental significance, these communities are also characterised by systemic poverty and marginalisation, which aggravate – and are aggravated by – the effects of climatic variations, seasonal changes and constant uncertainty caused by climate change.

Increasing climatic manifestations on critical water resources, fragile ecosystems and crop yields are fostering the proliferation of new pests and diseases, and the decline in production and income levels in rural regions of Africa, Asia and Latin America[2]. According to FAO (2011)[3], "while farmers in some regions may benefit temporarily from the effects of CO_2 fertilization, longer growing seasons and higher yields, the general consequences of climate change are expected to be adverse, particularly for the poor and marginalized", who, in turn, constitute the main inhabitants of rural agricultural communities.

Located in areas of high environmental risk and climatic exposure, the subsistence of these communities is largely resource-based, and thus, dependent on the sustainability of vulnerable agricultural livelihoods. More intense and uncertain weather patterns and extreme events such as floods and droughts contribute to deforestation, desertification, land degradation, depletion of water sources, infrastructural and social damage, among others[4], eroding not only local incomes but ultimately the ability of rural agricultural communities to respond to the challenges posed by a changing climate.

In spite of the differences that exist between these communities (both among and within countries) they share similar attributes and challenges related to the prevalence of poverty, remoteness and marginalisation[5]. These include low levels of education and access to health, weak infrastructure and difficult transportation, as well as exclusion from political decision-making processes, among others. The lack of livelihoods assets (e.g. economic, human, informational) heightens their vulnerability to climatic impacts, and also undermines their capacity to respond to the challenges and to benefit from potential opportunities derived from climate change.

---

[2] According to the IPCC, approximately 20–30 percent of plant and animal species will be at increased risk of extinction if the global average temperature increases more than 1.5–2.5°C. IPCC. (2007) *Fourth Assessment Report (AR4)*: Intergovernmental Panel on Climate Change (IPCC). http://www.ipcc.ch

[3] FAO. (2011) *FAO-Adapt: Framework Programme on Climate Change Adaptation*. Food and Agriculture Organization of the United Nations, Rome http://www.fao.org/docrep/014/i2316e/i2316e00.pdf

[4] Parry, M.L., Canziani, O.F., Palutikof, J.P., Linden, P.J.v.d. & Hanson, C.E. (eds.) (2007) *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change: Cambridge University Press, Cambridge, UK.

[5] The marginalisation of rural agricultural communities takes place in several fronts. Geographic marginalisation is linked to their remoteness and establishment in often hazardous locations, economic marginalisation is linked to low-income levels and high dependence on agriculture, social marginalisation to the lack of social protection and deficient access to health services, and political marginalisation to exclusion from political processes and low representation in government structures, among others. Gaillard, J.C. (2010) 'Vulnerability, Capacity and Resilience: Perspectives for Climate and Development Policy', *Journal of International Development,* 22:218-232.

In addition to the multiple exogenous and endogenous stressors within which they operate, rural agricultural communities face the need for action in four key climate change related areas: awareness, mitigation, monitoring and adaptation.

Climate Change Awareness in RAC
• Climate change awareness plays a critical role within decision-making processes and is the basis to mobilise action within and for rural agricultural communities. The lack of appropriate climate change information (i.e. information that is reliable, context-specific, targeted to local audiences, delivered in non-technical language and in user-friendly format) has been identified as one of the most serious constraints to the capacity of rural agricultural communities to undertake effective responses in face of the challenges – and the opportunities – posed by climate change[6].
In Practice…
Within rural agricultural communities of Uganda, where climate change has affected productivity and food security, drama, songs and radio broadcasts are being used to raise awareness about the causes and effects of climate change, particularly among women (who constitute 80% of the agricultural workforce)[7]. Heightened awareness motivates community discussions on potential responses and willingness to engage in action.
Climate Change Mitigation in RAC
• Within rural agricultural communities, mitigation challenges have been linked for the most part to strategies for the maintenance and enhancement of natural carbon stocks, the sustainable management of forest resources, and the adoption of sustainable practices in agricultural production[8]. Agricultural and livestock-based livelihoods can play an important role in the regulation of carbon emissions and flows, as well as in the protection of forests to enhance biodiversity, in water regulation and soil conservation, among other ecosystem services, which in turn impact the livelihoods and quality of life of local populations.
In Practice…
Rural agricultural communities are starting to adopt 'climate-smart' agricultural practices (e.g. integrated soil nutrient management, crop diversity and alternative energy sources) and organic agriculture (e.g. agricultural management practices can enhance soil carbon sequestration)[9]. In Kenya, smallholder dairy producers are testing alternatives for reducing the climate change 'footprint' of the dairy industry with the goal of raising 'carbon-neutral' cattle. In Tanzania, methods are being developed to measure carbon accumulation resulting from climate-smart practices, while in Ecuador farmers are substituting intensive monoculture cultivation of maize, sugar cane and rice, a major contributor to deforestation[10].
Climate Change Monitoring in RAC
• The ability to monitor and track the impacts of climate change in the local environment constitutes a key enabler of action, and when based on participatory methodologies, it can act as a source of empowerment for rural communities facing unprecedented change and uncertainty. Monitoring gathers up-to-date data on climatic trends relevant at the local level, contributing to the decision-making process of policy makers and community-based stakeholders.

[6] 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/casestudies.htm

[7] http://www.adaptationlearning.net/project/climatic-change-awareness-creation-and-adaptation-improved-livelihoods-among-rural-communiti

[8] Bertzky, M., Ravilious, C., Araujo Navas, A. L., Kapos, V., Carrion, D., Chiu, M. & Dickson, B. (2010) *Carbon, Diversity and Ecosystem Services: Exploring Co-Benefits. Ecuador*. UNEP-WCMC, Cambridge, UK http://www.unep-wcmc.org/carbon-biodiversity-ecosystem-services-ecuador_571.html

[9] Muller, A. (2009) *Benefits of Organic Agriculture as a Climate Change and Mitigation Strategy for Developing countries*. Environment for Development, Discussion Paper Series http://www.ifr.ac.uk/waste/reports/benefitsoforganicagriculture.pdf

[10] http://www.fao.org/climatechange/micca/70795/en/

In Practice…
Local communities can participate by monitoring the climate – temperature, rainfall, water flows and levels. Monitoring is also enabling rural agricultural communities to track species and the amount of vegetation to assess the impacts of climate change within the local ecosystem. By reporting changes in growing patterns and the emergence of diseases in their crops, farmers can help create awareness and adopt measures to protect their livelihood. Participatory monitoring methods are helping to generate natural resource management interventions in Philippine forests, while helping to strengthen adaptive capacities amongst Tanzania's rural communities[11].
Climate Change Adaptation in RAC
• Adaptation – the implementation of strategies to moderate, cope with and take advantage of the consequences of climatic events – constitutes a priority within rural agricultural settings[12]. Within these communities, climate change adaptation involves measures to withstand and recover in face of short-term climatic stimuli and events like storms and landslides, but also measures to adapt to the long-term impacts of change and uncertainty upon vulnerable livelihoods. Experiences from the field indicate that within agricultural contexts, adaptation is closely linked to the impacts of climate change on food productivity and food security, and thus to the maintenance of local livelihoods as a fundamental base for the adoption of anticipatory or reactive adaptation measures. Traditional knowledge plays a key role in the adaptive capacity of rural agricultural communities, as local and indigenous practices have enabled them to cope with change over centuries.
In Practice…
Faced with increased temperatures and the recurrence of extreme weather events, communities located in the Colombian Andes are developing 'Adaptation Life Plans': social-participatory initiatives that document local vulnerabilities and lessons learned, and reach social agreements on adaptive practices[13]. Farming systems have adopted more sustainable practices, including water management to improve conservation and restore ecosystem services in high mountain regions. In Zambia, crop diversification and conservation farming to improve the quality of the soil and minimise erosion has been central to efforts to adapt to changes in rainfall patterns, while in Mozambique rural communities have relied on strong social networks to adjust to severe drought and storms[14].

While the implementation of climate change awareness, mitigation, monitoring and adaptation is taking place, to varying degrees, within developing contexts, their implementation within rural agricultural communities still faces crucial challenges.

Awareness is constrained by issues such as geographical remoteness, difficult transportation and social marginalisation, low literacy levels, and lack of relevant and appropriate information that reaches local audiences. Mitigation actions face challenges related to the lack of adequate skills and technologies to record and analyse carbon emissions data, while monitoring efforts are often restricted by the lack of appropriate tools to gather, report and reflect on the use of natural and financial resources within rural agricultural settings. Adaptation efforts are often constrained by the lack of appropriate information and knowledge-sharing mechanisms, by scarce economic resources, and the lack of public policies and decision-making mechanisms to implement local adaptive actions, among others.

[11] http://www.asp.ucar.edu/ecsa/wcrp_docs/Shaffer.pdf
[12] UNDP (2004) *Adaptation Policy Frameworks (APF) for Climate Change: Developing Strategies, Policies and Measures*, Cambridge University Press, Cambridge, UK http://www.undp.org/climatechange/adapt/apf.html#about
[13] IUCN. (2010) *Building Resilience to Climate Change: Ecosystem-based Adaptation and Lessons from the Field*. International Union doe Conservation of Nature (IUCN), http://data.iucn.org/dbtw-wpd/edocs/2010-050.pdf
[14] Mitchell, T. & Tanner, T. (2006) *Adapting to Climate Change: Challenges and Opportunities for the Development Community*. Institute of Development Studies (IDS) and Tearfund http://www.preventionweb.net/files/567_10352.pdf

In view of the challenges and the potential opportunities that emerge amidst changing conditions, the use of ICTs can enable new approaches to address climate change within rural agricultural communities.

2. ICT-Enabled Responses in Rural Agricultural Communities

Diffusion of ICTs in the global South has been characterised by a very dynamic uptake of these tools in rural areas, where their adoption has been led by the rapid growth of mobile telephony[15].

The increasing importance of ICTs – not just mobile phones but also telecentres, community radio, etc – in rural livelihoods can be related to multiple factors, among them, the limited availability/uptake of fixed telephony, the rapid expansion of mobile networks, relatively low barriers to adoption and use (e.g. low cost, payment plans, easy use), growth of wireless Internet connectivity, donor and government universal service actions, etc.

The potential of ICTs in regards to climate change and rural agricultural communities can be linked to the four key areas of action identified before, within which there are different types of possible interventions, as reflected in Table 1.

Area	Role of ICTs	Intervention Focus
CLIMATE CHANGE AWARNESS	Emerging experiences in rural agricultural communities suggest that the use of ICTs such as mobile phones, radio, TV and video can facilitate the dissemination of climate change messages among vulnerable populations. Within geographically dispersed, remote populations or communities with low-literacy rates and a strong oral culture, the use of voice-based and visual applications (e.g. participatory community videos, podcasts, audio-blogs, radio) has contributed to reach and engage wider audiences in climate change-related topics[16].	• **Initial/Generic Awareness of Climate Change:** ICTs used to disseminate generic information about key climate change concepts and terminology, and sensitise wide rural audiences about its relevance (e.g. national radio and TV programmes, Internet). • **Specific Awareness of Local Issues:** ICTs used to raise awareness on community risks/vulnerabilities to climate change, and climatic impacts on specific local issues (e.g. crop diseases, production levels, water availability, land distribution, migration), and localised seasonal forecasts. Message is targeted to more specific audiences/needs (e.g. Internet-based applications used to map and visualise local vulnerabilities, community-produced radio and video programmes, and circulation of specific alerts or information via mobile phone contact networks).

[15] ITU. (2010) *ITU Sees 5 Billion Mobile Subscriptions Globally in 2010: Strong Mobile Cellular Growth Predicted Across All Regions and All Major Markets*. Press Release, International Telecommunication Union (ITU), Geneva. http://www.itu.int/newsroom/press_releases/2010/06.html

[16] 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 Chage Case Study, Centre for Development Informatics, University of Manchester, UK http://www.niccd.org/casestudies.htm

CLIMATE CHANGE MITIGATION	Within rural agricultural settings, use of ICTs can facilitate analysis of the spatial relationships that exist between carbon emissions and local socio-economic conditions, contributing to decision-making processes and to the implementation of incentive-based mitigation mechanisms such as REDD (Reducing Emissions from Deforestation and forest Degradation). Applications such as geographic information systems (GIS) and remote sensing technologies can enable innovative approaches to the analysis of forest carbon stocks, as well as to the participatory management of forest resources within rural and marginalised settings (e.g. forestry information systems, geo-referenced databases of land tenure, and local awareness regarding reforestation/afforestation trends).	• **Natural Resource-Oriented:** -**Forest Management:** ICTs used to record, measure and analyse local information on carbon stocks and emission levels, and inform decision makers (e.g. GIS used to systematise the rates and trends of deforestation, local forest cutting and burning). **-Agriculture Management:** ICTs used to foster the use of sustainable agricultural practices among farmers (e.g. telecentres used to access information on soil conservation and organic farming) that contribute to mitigate climatic impacts on local production and to protect ecosystems. **-Land Evaluation and Use:** ICT-based tools and software to support land evaluation and land use planning involving local communities, in order to identify land with the highest productivity and potential for carbon sequestration under different climate scenarios. • **Capacity-Building Oriented:** ICTs used to build local capacities and support on-site and distance learning targeted to agricultural producers on the control of carbon emissions and income-earning opportunities derived from sale of carbon stocks.
CLIMATE CHANGE MONITORING	Climate monitoring is closely linked to the lifecycle of information systems, and as such, it can be strengthened through the use of ICTs for data capture, processing and dissemination by and among local stakeholders in rural contexts. ICTs are being increasingly used in remote areas to map, record and analyse changes in local resources such as water basins, animal and vegetal species and biodiversity, as well as changes in pollution levels and greenhouse gas emissions, fostering the engagement of community actors in participatory monitoring and information exchange. Members of rural agricultural communities are being trained in use of ICTs to monitor changes in local conditions, e.g. rain levels, number of frost days or the length of growing seasons, which contribute to the understanding of local climatic impacts, and the adoption of measures to adjust/adapt to new conditions. ICT-based tools such as Internet portals and online databases are used to track the allocation and disbursement of climate change-related funds[17], contributing to transparency and accountability; while GIS applications are playing an increasing role in REDD programmes[18]	• **External Data:** ICTs used to monitor climate change based on data captured externally to the community (e.g through remote sensing, satellite or aerial photography, meteorological systems, Global Positioning Systems, and modelling). • **Local Data:** ICTs used to monitor change through the local collection and analysis of data (e.g. data collected by community stakeholders using smart-phones or mobile devices to report on forest cover, crop levels and quality, pest forecast and control, biodiversity or water levels; Internet-based platforms to report on the use of mitigation or adaptation funds at the local level and the status of climate change projects implemented locally). ICTs can also support local hydro-agro-meteorological early warning systems to decrease risks. • **Hybrid Local-External Systems** ICTs used to monitor change using both external and local data.

[17] http://www.undp-adaptation.org/portfolio/
[18] Mukama, K., Mustalahti, I. & Zahabu, E. (2012) 'Participatory Forest Carbon Assessment and REDD+: Learning from Tanzania', *International Journal of Forestry Research,* 2012:1-14.

CLIMATE CHANGE ADAPTATION	The availability, access and use of livelihood assets are closely related to adaptive capacity of vulnerable communities. Emerging adaptation experiences from rural agricultural areas in Bangladesh, India and Perú[19] suggest that the role of ICTs in the field is closely linked to the strengthening of agricultural and livestock production systems (i.e. through information about pest and disease control, planting dates, seed varieties and irrigation applications, and early warning systems)[20], as well as to the improvement of rural livelihoods through enhanced access to markets (e.g. through information on prices, consumer trends and dissemination opportunities)[21]. ICTs are also playing an increasing role in the delivery of emergent climatic knowledge, in the facilitation of cross-scale networking (e.g. interactions by community members with scientists, diagnosticians, researchers or government officials located in urban areas) and in the implementation of capacity building programmes for local farmers[22].	• **Vulnerability-Oriented:** ICTs used to address adaptation needs in key vulnerability areas for rural agricultural communities, for example: ▪ **Food Security:** ICTs used to access information about resistant seed varieties and planting methods, or to access agro-meteorological information to protect crops. ▪ **Water Supply:** ICTs used to build local capacity for the conservation of water sources and more efficient water management during the production cycle. ▪ **Income Generation:** ICTs used to explore/access alternative sources of income generation, including the productive use of ICTs (e.g. to access agricultural markets, prices, or to commercialise products) ▪ **Health:** ICTs used to disseminate information on prevention and treatment of new diseases triggered by climatic impacts, or in early warning systems on disease forecast and control. ▪ **Infrastructure:** ICTs used to share lessons on safe building practices in areas of high risk for rural communities. ▪ **Political Participation:** ICTs used to facilitate the participation of rural communities in democratic processes. ▪ **Security:** ICTs used among social networks to share security risks and early warning related to climatic events. • **Climatic Threat-Oriented:** ICTs can also be used in the design and implementation of adaptation actions focused on specific climatic threats that affect rural agricultural communities (e.g. disseminating information about flood prevention, supporting capacity building on managing extended droughts, knowledge sharing on the local impacts of glacier melting, or implementing early warning and response systems for storms and landslides).

Table 1. ICTs and Climate Change Interventions in Rural Agricultural Communities

[19] '*Climate Change, ICTs and Innovation'* Project Case Studies, http://www.niccd.org/casestudies.htm
[20] Ospina, A. V. & Heeks, R. (2010) *Unveiling the Links between ICTs & Climate Change in Developing Countries: A Scoping Study*. Centre for Development Informatics, Institute for Development Policy and Management, University of Manchester, UK http://www.niccd.org/ScopingStudy.pdf
[21] Stienen, J., Bruinsma, W. & Neuman, F. (2007) *How ICT can Make a Difference in Agricultural Livelihoods*, International Institute for Communication and Development, The Hague http://www.iicd.org/files/ICT%20and%20agricultural%20livelihoods.pdf
[22] 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/casestudies.htm

These examples suggest that ICT interventions within rural agricultural communities can be used to foster both ***one-way*** and ***interactive*** information flows. While one-way flows can be effective in dissemination of relevant information and best practices, interactive flows can foster mutual learning and sharing among multi-sector stakeholders on issues of climate change awareness, mitigation, monitoring and adaptation. Ultimately, the design of ICT interventions should be based on an initial assessment of local vulnerabilities, capacities, needs and priorities, and can combine mechanisms for one-way and interactive information flows.

Further enablers and constraints to be considered in the design of ICT initiatives in the climate change field are explained below.

2.1. Key Enablers and Constraints

Emerging experiences from rural agricultural communities suggest positive linkages between use of ICTs and climate change responses in mitigation, adaptation, monitoring and awareness. But while use of traditional and emergent ICTs is starting to contribute to the actions that rural agricultural communities undertake in face of climatic challenges, experiences from the field[23] also indicate the existence of factors that can either *enable* or *constrain* the role of ICT tools within these contexts.

The analysis of available case studies suggests six key factors that can ultimately determine the effectiveness of ICTs' role within rural agricultural communities. In other words, these are critical success/failure factors which should therefore be a main focus during design and implementation of ICT and climate change initiatives:

- **Access**

  In spite of the growing penetration and adoption of ICTs in developing countries, barriers of access (that range from power supply to infrastructure provision) still persist in many rural agricultural communities, limiting their ability to implement ICT-enabled actions in relation to climate change[24]. These access constraints require 'hybrid' technological approaches that integrate both digital and non-digital ICTs: building on the important role that traditional/widespread tools such as radio and TV play within rural contexts, and complementing it with the value added of emerging, mobile and Internet-based applications. The potential of a hybrid approach can be illustrated by the 'mobile-telecentre' architecture that combines the reach of mobiles with the power of the telecentre[25]. Hybrid approaches can also bring mobility to traditional telecentre services through smart mobile 'info-carts' (carts equipped with different ICTs), in order to expand the reach of services to a broader set of users. This mobile-plus-fixed-telecentre approach integrates telephone calls, SMS, email, Internet browsing and digital literacy classes, and is led by the local telecentre operator as a way to help develop local capacities that in turn contribute to adaptation[26].

[23] '*Climate Change, ICTs and Innovation'* Project Case Studies http://www.niccd.org/casestudies.htm
[24] Ospina & Heeks *op.cit.*
[25] Pant, L.P. & Heeks, R. (2011) *ICT-Enabled Development of Capacity for Climate Change Adaptation*. Centre for Development Informatics, University of Manchester, UK http://www.niccd.org/PantHeeksClimateChangeAdaptationICTs.pdf
[26] Pant & Heeks *op.cit.*

- **Knowledge Infomediaries**

  Rural agricultural communities often lack the economic and human capacity required to access, interpret and analyse climate change data, and to implement response measures. The engagement of local knowledge infomediaries (e.g. agricultural extension officers and other trained professionals drawn from local residents, particularly youth) contributes to ensure a 'last mile' approach in the delivery of information and knowledge within rural agricultural communities. Their 'insider' knowledge of the local context, and relationships based on trust play a pivotal role in the effective delivery and local appropriation of messages related to climate change awareness, mitigation, adaptation and monitoring. Local knowledge brokers help to complement ICT-based information through face-to-face meetings and field visits, train local stakeholders in the use of ICT tools (helping to reduce digital scepticism and age-related barriers to adoption), help to identify sources of credit and funding to implement action, and personalise the delivery of agricultural supply chain information (e.g. inputs, processes and outputs).

- **Content Appropriateness**

  The availability of appropriate climate change content constitutes one of the most critical challenges for the effective use of climate change information at the local level[27]. Appropriateness refers not only to the provision of scale-relevant climatic data (e.g. local forecasts, models and projections), but also to the way in which the information provided responds to the livelihood priorities of rural agricultural stakeholders, and to the format in which it is delivered. Experiences from the field suggest that successful approaches go beyond the provision of climatic information and agricultural practices, integrating resources that relate to the complete agricultural supply chain (e.g. inputs such as machinery, seeds and fertilisers; processes like planting weeding and harvesting; and outputs such as post-harvest procedures and access to markets)[28]. ICTs can be part of the production and delivery of holistic resource packages, thus fostering the transformation of information into agricultural action. Applications such as participatory videos and radio programmes can deliver content in appropriate formats, using indigenous languages and integrating traditional knowledge and culturally-recognised symbols to facilitate local appropriation.

- **Multi-Stakeholder Engagement**

  The complex set of vulnerabilities within which developing country communities operate require multi-stakeholder strategies that build upon the complementary roles, resources and strengths of these actors. Experiences from the field suggest the value of engaging a wide variety of actors in ICT-enabled solutions to mitigate, adapt, monitor and create awareness of climate change within rural agricultural communities. But while the use of ICTs can facilitate dialogue and exchange among community members, local governments, NGOs and funding bodies, among others (e.g. through online communities, e-mail exchange or more frequent mobile communications), these relations can also add new layers of complexity to local

[27] Braun, P. & Faisal Islam, M. *op.cit.*
[28] 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/casestudies.htm

interactions and to the management of local resources, becoming time-consuming and politically sensitive. Clarity about the roles and responsibilities of each actor, as well as the role of community leaders can help mediate and manage multi-stakeholder interactions.

- **New and Traditional Knowledge**

  In addition to ICT-enabled access to new climatic knowledge and information, the traditional knowledge of indigenous peoples and local communities plays a critical role in their capacity to respond and adjust to climate change. Adaptation practices in the agricultural sector can be strengthened with the integration of local knowledge on resilient crop species and varieties, plant breeding, wild crops to supplement diets, traditional farming practices and natural resource conservation, as well as local climate forecasting techniques[29]. ICTs can play an important role ensuring the two-way flow of climate knowledge and resources, helping document and disseminate new and traditional practices, while fostering dialogue and exchange between the scientific community and local stakeholders. ICTs can also facilitate market access to traditional crops and local varieties, and support adoption of resilient seed varieties and good practices for sustainable production.

- **Focus on the Information Chain**

  In addition to facilitating *availability* and *access* to relevant information, ICTs should foster the *usability* of climate change information within vulnerable agricultural contexts. ICTs can help disseminate information on loans and credits targeted to local producers, as well as strengthening local productive practices (e.g. through online training and access to information on new agricultural technologies) and market access, thus helping to access additional resources for the implementation of climate change actions.

As summarised in **Figure 1**, the potential of ICTs within rural agricultural communities affected by climate change goes well beyond the provision of climatic information, and is subject to the effect of key enablers and constraints. Integrated within broader development and climate change strategies, ICTs' contribution to local climate change actions is largely based on the strengthening of agricultural livelihoods (e.g. through increased and diversified income sources and capacities), and on a holistic, action-based approach that enhances the ability of these communities to respond to the challenges and opportunities posed by climate change.

[29] Swiderska, K., Song, Y., Li, J., Reid, H. & Mutta, D. (2011) *Adapting Agriculture with Traditional Knowledge*. Briefing, International Institute for Environment and Development, The Hague http://pubs.iied.org/17111IIED

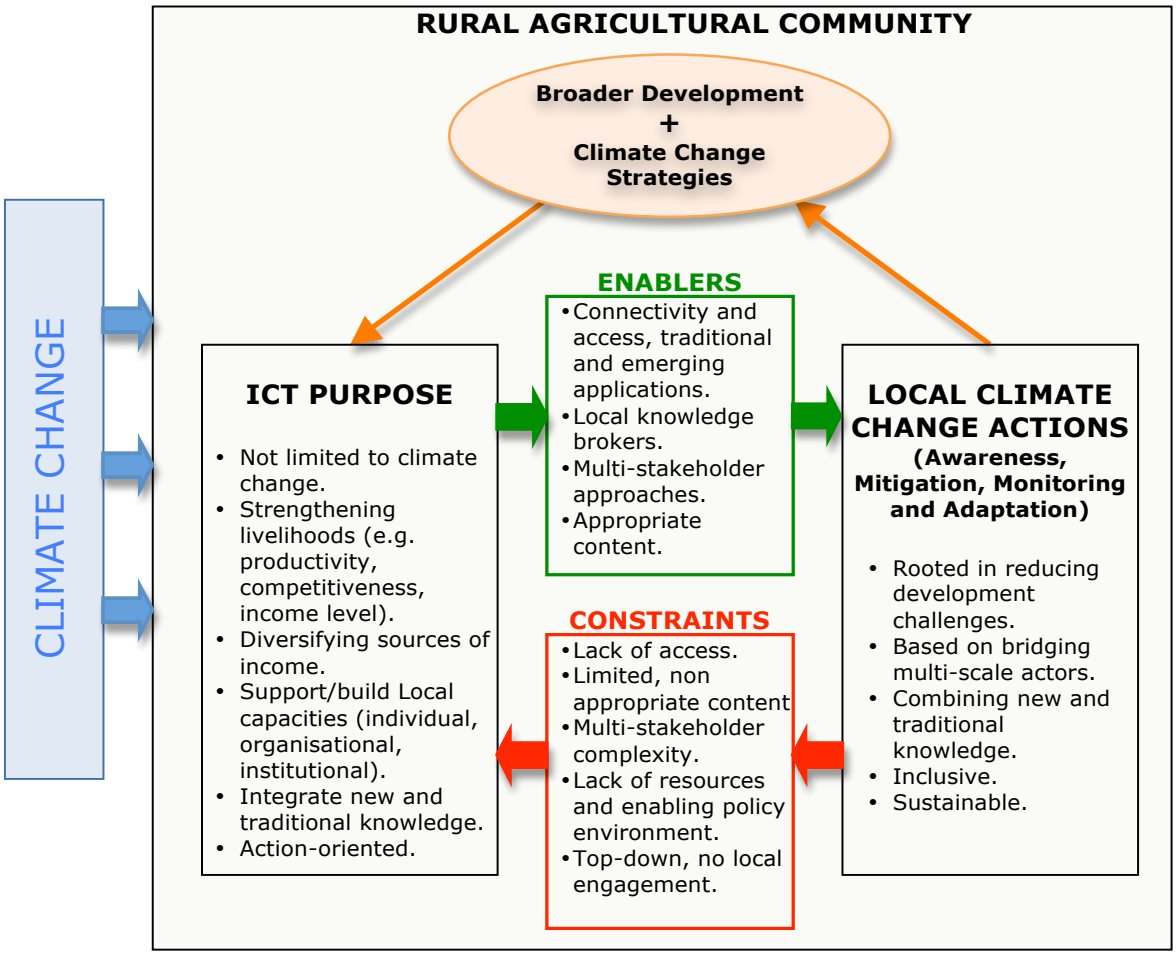

Figure 1. ICTs' Role in Rural Agricultural Community Climate Change Actions

3. Moving Forward: The 'Information Plus' Approach

How can this analysis contribute to climate change initiatives implemented within rural agricultural communities? By identifying the key success factors that have emerged from experiences in the field, these can then be integrated into ICT-enabled approaches to climate change awareness, mitigation, monitoring and adaptation at local level.

Some of these factors are presented in Table 2, and reflect an '***Information Plus***' approach to various areas of climate change action within agricultural communities. This approach is based on the recognition that use of ICTs within contexts affected by climate change needs to go beyond the provision of information in order to involve new and more inclusive ways of accessing, appropriating and using knowledge resources and then turn these into adaptation actions.

For that potential to be realised in climate change awareness, mitigation, monitoring and adaptation, ICT strategies must incorporate three key factors:

(a) the role of local knowledge infomediaries to facilitate the delivery and appropriation of climate change messages;

(b) the dissemination of information 'packages' that are not limited to climate change but that address a wider set of development stressors and vulnerabilities that are relevant at the local level; and

(c) the implementation of various (digital and non-digital) applications 'bundled' together in order to address the challenges (e.g. connectivity, remoteness, literacy, etc) and potential opportunities (e.g. income and skills diversification, collaborative networks) related to climate change within vulnerable contexts.

The first row of the 'Information Plus' matrix provides examples of stakeholders that can play the role of knowledge infomediaries at the local level, supporting the use of ICTs for climate change awareness, mitigation, monitoring and adaptation. The second row provides examples of content that can be relevant for different actors within rural agricultural communities, and that can be combined with climate change-oriented content. It is key for this content to be presented in appropriate formats, targeting the specific needs and capacities of local audiences (e.g. considering literacy levels, age groups, local practices and cultural traditions). The last row of the matrix provides examples of ICT applications that can be useful, especially when combined, in the achievement of climate change and broader development goals within rural agricultural communities.

Area of ICT Contribution: ***Key Factors to Consider in ICT Strategies:***	**Climate Change Awareness**	**Climate Change Mitigation**	**Climate Change Monitoring**	**Climate Change Adaptation**
Local Knowledge Infomediaries **(Engaging Trusted Agents for Information Delivery/Appropriation)**	Agricultural Extension Officers Local Associations and NGOs Telecentre Operators Local Youth	Local NGOs Farmer Cooperatives	Community Leaders Local Youth Local NGOs	Agricultural Extension Officers Local Youth and Elders Trained Professionals Women Associations Telecentre Operators
Info-Package **(Ensuring Content Relevance + Addressing Broader Range of Development Stressors)**	Climate Change Concepts Local Vulnerabilities, Risks and Impacts Importance of Ecosystem Services Protection of Natural Resources Available Sources of Climate Change Funding Role and Responsibilities of Local Actors/Institutions	CO_2 Emissions Forest Protection Income-Generating Opportunities Access to Carbon Markets	Meteorological Information Climatic Trends Deforestation Trends/ Reforestation Practices Biodiversity Water Sources Local Natural Resources (e.g. river levels)	Meteorological Information Agricultural Supply Chain Emerging and Traditional Knowledge (e.g. seeds) Strengthening Production & Increasing Productivity Diversifying Income Sources Credits, Access to Adaptation Funds

Area of ICT Contribution: ***Key Factors to Consider in ICT Strategies:***	**Climate Change Awareness**	**Climate Change Mitigation**	**Climate Change Monitoring**	**Climate Change Adaptation**
(Cont. Info-Package)	Relevant Policies/Legislation			Water Access and Management Other Local Priorities
ICT-Bundle **(Combine Digital and Non-Digital Applications and Ensure their Appropriateness within Rural Areas)**	- Radio - Television - Mobile Phones/SMS - Internet - Online Networks - Social Media - Web 2.0 Tools - Videos **PLUS:** - Face-to-Face Meetings/Training	- Internet - Mobiles/Smart Phones - GIS/Remote Sensing	- Mobile Phones/SMS - Internet - GIS/Remote Sensing - Online Communities - Software Apps - Databases - Spatial Analysis Tools - Data Sharing Platforms - Open Source Software Tools	- Radio - Television - Mobile Phones/SMS - Internet - Databases - Online Portals - Online Networks - Social Media - Web 2.0 Tools - Videos **PLUS:** -Face-to-Face Meetings/Training

Table 2. 'Information Plus' Matrix

4. Action Steps

The effective integration of ICTs into climate change responses within rural agricultural communities can be achieved through concrete action steps:

- **Focus on Income Generation** as a key enabler of action in the climate change field, and a pillar upon which rural agricultural livelihoods can build resilience in face of increasing change and uncertainty.

- **Localise Interventions** by fostering bottom-up approaches that start by identifying the needs and priorities of rural agricultural communities, and engage local actors in the design, monitoring and evaluation of initiatives.

- **Foster the Role of Local Knowledge Infomediaries** as trusted sources through whom climate change information can be translated and integrated into local practices, helping to bridge power, knowledge and digital gaps[30]. They are crucial for the multi-channel reinforcement of climate change strategies, and the integration of ICTs into broader development strategies (e.g. food security and productivity) within rural agricultural communities.

- **Build Capacity for Emergent Action** among local communities, in order to provide them with new tools to cope with change and uncertainty using new and traditional ICTs, while strengthening local decision-making capacity.

- **Drive the Whole Information Chain** by planning all the connections from information provision to decision-making to actions to results, including the economic and human resources necessary to implement actions at each stage of the chain.

[30] Saravanan, R. *op.cit.*

- **Strengthen the Foundations** by building climate change and ICT awareness, providing locally-relevant information, and developing indicators and action plans based on current and future vulnerabilities.

- **Combine Different Applications,** exploiting the potential that both emergent and traditional, digital and non-digital tools can provide within the local context.

- **Build upon Traditional Knowledge,** thus helping to bridge the existing gap between scientific resources and indigenous/local practices.

- **Integrate Climate Change and ICTs** into livelihood information systems and within broad development interventions, thus contributing to their sustainability.

- **Adopt a Process Approach** that involves beneficiary participation, flexible and phased implementation, learning from doing, as well as mechanisms for local and multi-stakeholder support. Process approaches include measures to address climate impacts in both the short and the long term (acute and chronic impacts).

Rural agricultural communities are not only key in the provision of food security and in the socio-economic and cultural fabric of developing countries, but are also the subject of a wide set of development stressors and vulnerabilities that are exacerbated by the effects of climate change. Acknowledging the broader development context within which they operate constitutes the departure point of any ICT-related intervention in the climate change field.

Ultimately, the enabling role of these tools for climate change awareness, mitigation, monitoring and adaptation is closely linked to their contribution to local agricultural livelihoods (e.g. income and productivity), and to the capacity of local actors and institutions to respond to the challenges and the opportunities that may emerge from change. Issues of financial sustainability, gender and inclusion, as well as evaluation and monitoring of ICTs' role within climate change processes, are among the key areas that remain to be explored through further academic research and practical experiences.

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

2012

Further Reading

Akoh, B., Bizikova, L., Parry, J., Creech, H., Karami, J., Echeverria, D., Hammill, A. & Gass, P. (2011) *Africa Transformation-Ready: The Strategic Application of Information and Communication Technologies for Climate Change Adaptation in Africa*. International Institute for Sustainable Development, Winnipeg http://etransformafrica.org/sites/default/files/Final-Report-Climate%20Change%20Adaptation.pdf

APC. (2007) *Huaral Valley: Wireless Technology for Traditional Agriculture,* Association for Progressive Communications, Montevideo http://www.apc.org/en/news/all/lac/huaral-valley-wireless-technology-traditional-agri

Bapna, M., McGray, H., Mock, G. & Withey, L. (2009) *Enabling Adaptation: Priorities for Supporting the Rural Poor in Changing Climate*. World Resources Institute, Washington, DC http://www.wri.org/publication/enabling-adaptation-climate-change

Boulahya, M., Cerda, M., Pratt, M., Sponberg, K. (2005) Climate, Communications, And Innovative Technologies: Potential Impacts and Sustainability of New Radio and Internet Linkages in Rural African Communities*, Climatic Change*, 70 (1-2): 299-310.

DEAL. (2010) *High Level View of Digital Ecosystem for Agriculture & Rural Livelihood,* Digital Ecosystem for Agriculture & Rural Livelihood http://opaals.iitk.ac.in/deal/

Dolan, H. A., Smith, B., Skinner, M. W., Bradshaw, B. & Bryant, C. R. (2001) *Adaptation to Climate Change in Agriculture: Evaluation of Options*, University of Guelph http://adaptation.nrcan.gc.ca/projdb/pdf/agri7_e.pdf

FAO. (2003) *Communication and Natural Resource Management*. Food and Agriculture Organization of the United Nations. Prepared by The Communication Initiative in collaboration with the Communication for Development Group, Rome. http://omec.uab.cat/Documentos/11.pdf

GTZ. (2008) *The Participatory Web: New Potentials of ICT in Rural Areas,* Deutsche Gesellschaft fur Technishe Zusammenarbeit, Eschborn, Germany http://www.gtz.de/de/dokumente/en-ict-web.pdf

Heeks, R. & Leon Kanashiro, L. (2009) *Remoteness, Exclusion and Telecentres in Mountain Regions: Analysing ICT-Based Information Chains in Pazos, Peru*. IDPM Development Informatics Working Paper no.38. University of Manchester, UK http://www.sed.manchester.ac.uk/idpm/research/publications/wp/di/documents/di_wp38.pdf

Labelle, R., Rodschat, R. & Vetter, T. (2008) *ICTs for e-Environment: Guidelines for Developing Countries with a Focus on Climate Change*. International Telecommunication Union, Geneva, http://www.itu.int/ITU-D/cyb/app/docs/itu-icts-for-e-environment.pdf

Sala, S. (2011) *The Role of Information and Communication Technologies for Community-Based Adaptation to Climate Change*. Food and Agriculture Organization of the United Nations, Rome http://www.gg.rhul.ac.uk/ict4d/ICT4CBA-draft_layout.pdf

Tiwari, S. P. (2008) 'Information and Communication Technology Initiatives for Knowledge Sharing in Agriculture', *Indian Journal of Agricultural Sciences,* 78(9): 737-747.

Various authors (2011/2012) *Case Studies*, Nexus for ICTs, Climate Change and Development, Centre for Development Informatics, University of Manchester, UK http://www.niccd.org/casestudies.htm