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Best practices on how countries can utilize ICTs to adapt to the effects of climate change

Recommendation ITU-T L.1501

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Best practices on how countries can utilize ICTs to adapt to the effects of climate change

Summary

Recommendation ITU-T L.1501 provides guidance on how information and communication technologies (ICTs) can help countries to adapt to the effect of climate change. It also provides a framework and a checklist for countries to integrate ICTs in their national climate change adaptation strategies. The recommendation is part of the ITU-T L.1500 series Recommendations on adaptation to the effects of climate change. It is designed to assist countries in integrating ICTs into their national climate change adaptation strategies.

The Recommendation describes the complexity of climate change and explains why countries need to adapt. It also describes the role of ICTs in helping countries respond to the effects of climate change by looking at how various sectors use ICTs; including the ICT sector. It is designed to be a guide for regulators and policymakers to minimize the impact of climate change and provides a *'multi-level framework for ICTs integration in climate change adaption'* to assist countries in integrating ICTs in their national climate change adaptation strategies.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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FOREWORD

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Best practices on how countries can utilize ICTs to adapt to the effects of climate change

1 Scope

This Recommendation considers how countries can utilize ICTs to adapt to the effects of climate change. It provides a framework for countries on how to integrate ICTs into their national strategies for adaptation to climate change.

A checklist is provided as an instrument for policymakers to ensure that they have the necessary pre-requisites to adapt the suggested framework in their national legislations, and enabling them to assess the adoption and implementation of the framework.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T L.1500] Recommendation ITU-T L.1500 (2014), *Framework for information and communication technologies and adaptation to the effects of climate change*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 climate change [b-IPCC 2007] and [b-IPPC SPM]: Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. The Intergovernmental Panel on Climate Change (IPCC) uses a relatively broad definition, referring to a change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

NOTE – The IPCC makes a distinction between climate change that is directly attributable to human activities, and climate variability that is attributable to natural causes. For the purposes of this report, either definition may be suitable depending on the context of analysis.

3.1.2 climate change adaptation [b-IPCC 2001]: Adaptation to climate change can be defined as the adjustment in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects. It refers to changes in processes, practices and structures to moderate potential harm or to benefit from opportunities associated with climate change.

3.1.3 deforestation [b-UNFCCC Glos]: Those practices or processes that result in the conversion of forested lands for non-forest uses. This is often cited as one of the major causes of the enhanced greenhouse effect for two reasons: 1) the burning or decomposition of the wood releases carbon dioxide; and 2) trees that once removed carbon dioxide from the atmosphere in the process of photosynthesis are no longer present.

3.1.4 enhanced greenhouse effect [b-UNFCCC Glos]: The concept that the natural greenhouse effect has been enhanced by anthropogenic emissions of greenhouse gases. Increased concentrations of carbon dioxide, methane, and nitrous oxide, CFCs, HFCs, PFCs, SF6, NF3, and other photochemically important gases caused by human activities such as fossil fuel consumption, trap more infra-red radiation, thereby exerting a warming influence on the climate.

3.1.5 eutrophication [b-UNEP GEO]: The degradation of water quality due to enrichment by nutrients, primarily nitrogen and phosphorus which results in excessive plant (principally algae) growth and decay. Eutrophication of a lake normally contributes to its slow evolution into a bog marsh and ultimately to dry land. Eutrophication may be accelerated by human activities that speed up the aging process.

3.1.6 global warming [b-IPCC 4th AR]: The increase in global average temperature due to the increase of atmospheric greenhouse gas (GHG) concentrations.

3.1.7 maximum sustainable yield (MSY) [b-OECD]: The yield corresponding to the level of maximum productiveness of the stock in stable conditions; the maximum average catch of a given stock which can be taken over the entire period of its exploitation.

3.1.8 water cycle [b-OECD]: The water cycle is the sequence of climatological events. The heat of the sun evaporates water from land and water surfaces; vapour, being lighter than air, rises until it reaches the cooler upper air level where it condenses into clouds; further condensation produces precipitation that falls to earth as rain, sleet or snow; some of the water is retained by the soil and some run—off returns to rivers, lakes and oceans.

3.1.9 wetland [b-UNFCCC Glos]: Land that stays flooded all or part of the year with fresh or salt water.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 bioaccumulation: Accumulation of toxic substances within an organism.

3.2.2 biomagnification: Accumulation of toxic substances along the food chain with the level of toxicity increasing at each trophic level.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BOD Biochemical Oxygen Demand

CAF Cancun Adaptation Framework

EPA Environmental Protection Agency

GHG Greenhouse Gas

GIS Geographic Information Systems

GOS Global Observation System

GPS Global Positioning System

ICT Information and Communication Technology

IPCC Intergovernmental Panel on Climate Change

MSY Maximum Sustainable Yield

NAP National Adaptation Plan

UNEP United Nations Environment Programme

UNFCCC United Nations Framework Convention on Climate Change

UNPF United Nations Population Fund

5 Conventions

This Recommendation is in line with international conventions including; United Nations Framework Convention on Climate Change, 1992.

6 Overview of climate change adaptation

This clause offers a general overview of climate change adaptation including effects and possible impacts. Climate change is one of the major challenges that all countries face. It involves numerous stakeholders at the international, regional, national and community levels and entails the imperative need to foster collaboration among these stakeholders. The impact of climate change is likely to become progressively more significant in the decades to come [b-UNEP 2011].

Recently the effects of climate change seem to have grown quickly. In some cases, it might already be too late or too costly to cope with the impact by improving the hardware, e.g., by making various social infrastructures physically strong, resilient and highly durable. *"The earth's climate has already been altered to such an extent that mitigation (efforts to reduce the concentrations of greenhouse gases in the atmosphere) alone will be inadequate. Therefore adaptation (responding to the impacts of climate change) is increasingly necessary" [b-UNPF 2013]*. It is therefore extremely important to make the best use of ICTs in saving human lives and minimizing social damages and difficulties. Special attention should be given to remote and rural areas in developing countries where the social infrastructures and economic support are weak and thus effects and impacts of climate change could lead to worse damages than in cities and in developed countries.

Having recognized adaptation as one of the core pillars of global response to climate change (along with mitigation), there has been a rapid growth of interest in the subject and expansion in the development and implementation of adaptation projects. The UNFCCC addresses two fundamental response strategies to cope with climate change: mitigation and adaptation. While climate change mitigation aims at tackling and reducing causes of the climate change (e.g., GHG emissions and energy consumption), climate change adaptation aims at adjusting in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects (e.g., surface temperature change, sea level raise, coastal wetland migration, increase in intense rainfall and increase in tornado, heavy rain, thunder and hail). The adaptation to such effects of climate change is realized, for example, by taking measures to reduce social infrastructure damages and/or facilitating opportunities.

ICT permeates every aspect of human endeavour and climate change adaptation is no exception. Leveraging and harnessing the immense potential of ICT will act as a force multiplier in increasing the impact of efforts to tackle climate change. In this context, ICT delivers innovative products and services that have a role to play at different stages of climate change adaptation processes. It can provide support in the process of information gathering, decision making, implementation and evaluation for climate change adaptation. For this purpose, ICT applications could support the delivery of particular adaptation actions in areas of vulnerability that are heightened by climate change impacts, including , water supply, food security, health services, ecosystem services and disaster management [b-IISD].

The ICT applications or tools used for the purpose of climate change adaptation should be developed with a holistic and integrated view of adaptive processes. This could incorporate mobile phones, internet application and mass media to foster adaptation at community, sectoral, national level and international levels [b-CDI 2012].

A supplement on ITU-T L.1500-series Recommendations will provide details on the effects and possible impacts of climate change.

7 Country-level adaptation to climate change

Since the 1950s several unprecedented events related to climate change have occurred. These include a rise in the mean temperature of the atmosphere (attributed to the increase in GHG concentration) which has caused snow and glacial melting, leading to a rise in the sea and ocean levels and temperature [b-UN 2014].

The important aspect to understand is the link between human activity and its influence on the climatic system. Anthropogenic activities like industrialization and urbanization has led to the increase in the atmospheric concentrations of GHG leading to the aforementioned changes in the climatic system [b-UN 2010].

The evidence of dramatic change is compelling: dynamic shifts in the Earth's climatic system; detailed climate modelling systems (with high levels of confidence); and the observable correlation between increase in intensity of human activities and recordable environmental changes [b-UN 2014].

The continued emissions caused by human activities without the required intervention is predicted to cause further warming, leading possibly to more unpredictable imbalances in the climatic system. Some of the current challenges faced on a global scale include (but are not limited to):

1) Rise in mean sea level: This is one of the observable consequences of climate change. Apart from loss of glacial mass, rise in sea level poses the danger of unpredictable coastal flooding events which would cause loss of life and property [b-UNFCCC 2002]. Low lying islands such as the Maldives are particularly prone.
2) Changes in the global water cycle: Due to the atmospheric changes in temperature, the contrast in precipitation between wet and dry regions and between wet and dry seasons will increase, though there may be regional exceptions [b-UNEP 2008].
3) Ocean acidification: Water bodies tend to absorb CO_2 from the atmosphere. As the atmospheric CO_2 increases, the uptake of CO_2 by oceans also rises leading to considerable decrease in pH making the waters acidic [b-PMEL 2014]. These acidic waters are unsuitable for some aquatic species and lead to decrease in aquatic biodiversity and are likely to adversely impact fishing industries in some areas.
4) Increase in cumulative emissions: "Cumulative emissions of CO_2 largely determine global mean surface warming by the late 21st century and beyond. Most aspects of climate change will persist for many centuries even if emissions of CO_2 are stopped. This represents a substantial multi-century climate change commitment created by past, present and future emissions of CO_2" [b-UN 2014].

While more focus may be given to mitigating the problems caused by climate change, the Cancun Adaptation Framework (CAF) of 2010 highlighted that appropriate attention should be given to the need to adapt to reduce human vulnerability to the current climate change crisis. This is because the burning need for immediate action may not addressed by mitigation procedures alone. Also the impact of climate change may vary in different regions and may manifest itself in the form of floods or drought [b-UNFCCC 2011]. As such, potential climatic risks can be identified with the help of research and technology. In practice it may not be possible to prevent a natural disaster from occurring, it is however possible to reduce vulnerability to the hazard by being prepared for it.

"All Parties to plan, prioritize and implement adaptation actions and to use existing channels to provide information on support provided and received for adaptation actions and on activities undertaken…" [b-UNFCCC, CAF]

8 The role of ICTs in adaptation to climate change

ICTs including mobile phones, radios, computers and internet-based applications can be effective in enabling countries to better adapt to climate change. ICT tools are used for environmental

observation, climate monitoring and climate change prediction [b-ITU 2012]. ICTs make available vital information on the changing environment to enable adaptive responses.

Climate change adaption can be of two types:

a) Emergent: spontaneous action to climatic stimuli.

b) Planned: policy driven adaptation processes and measures to address climate change impacts.

ICT could assist with adaptive responses to both the above types of climate change adaptation. The initial perception may limit the use of ICT merely for data handling despite there being potential for productive and transformation potential through their support to social and market transactions [b-CDI 2011].

"*Further collaboration is needed between the private sector and social enterprise to innovate; to roll out new hardware, software, and systems that can shift outdated ICT paradigms in regards to climate change; and to fulfil ICTs' adaptational potential*" [b-CDI 2011].

8.1 Advantages of using ICT in adapting to climate change

ICT can provide the basic access to information and to human and economic resources that can improve the achievement of development goals and reduce vulnerabilities.

"In many cases, the risk that climate change brings to other sectors and individuals translates into opportunity – or new problems to solve – for the ICT sector. As the sector continues to develop solutions for climate mitigation and adaptation, and enable broader access to ICTs, the overall carbon footprint of the sector is projected to increase, even taking into consideration efficiency gains" [b-BSR 2011].

Thus, the ICT sector is not only in a position to facilitate its own industry to adjust to the effects of climate change, but is also capable of helping other sectors prepare for and adjust to the effects of climate change by generating awareness and providing the innovative tools for the process.

An important example of the role of ICT in climate change adaptation is highlighted by the agricultural sector. Tools like WOFOST (developed by the Centre for World Food Studies along with University of Wageningen), GOSSYM (the Universities of Clemson and Mississippi and the Agriculture Department of United States) can be used to simulate the growth of food crops (field bean, maize, potato, rice and soybean) and cash crops (cotton) respectively. This helps with the decision making process of agricultural producers. These systems include factors that can influence climate change and related responses, both exogenous (government policies, economy, etc.) or endogenous (location, scale, etc.) [b-CPD]. This can help facilitate the planning of adaptation responses at the farm and regional levels, starting from comprehensive assessment of the impacts of climate change and different farming techniques on crop productivity and agro-ecological systems [b-FAO 2010].

Different strategies are being developed and adjusted according to local conditions. ICT can be used in support of the following steps in the process [b-CPD]:

i) Observation (combining existing data in new ways): Climate variations occurring in a specific region can be determined in this step. This can be carried out through data collection tools (remote sensing techniques, sensor-based networks etc.). The data can be stored in digital repositories and shared among the stakeholders committed to develop the appropriate adaptation strategy.

ii) Analysis and planning: The stored data can then be analysed by scientists and policy makers to plan and design adaptation strategies. This analysis of climate change scenarios can be conducted using software based modelling systems (decision support systems and geographic information systems (GIS)). The results of analysis derived from these modelling systems can then be used to facilitate the development of adaptation plans on a sectoral basis.

iii) Implementation and Management: a number of factors involving stakeholders, the sector and the scale of application can affect the nature of adaptation processes. *"ICT support the implementation and management of adaptation strategies with a wide variety of tools: among the others, forecasting tools, early warning system and resource management systems play a prominent role in this phase" [b-CPD]*.

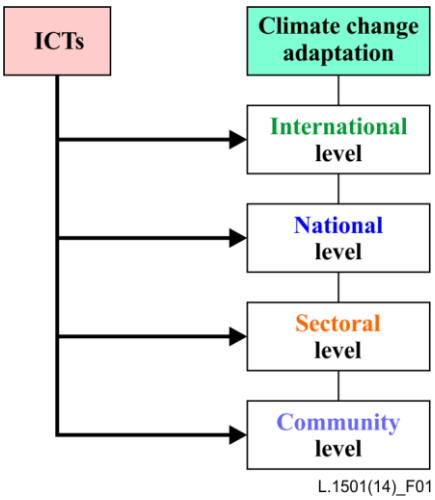
iv) Capacity building: Raising awareness of the negative effects of climate change with the help of ICT.

v) Networking: ICT can be used for knowledge sharing to ensure that all stakeholders are aware of the effects of climate change as well as the possible measures to build up resilience to climate change at the different levels [b-CPD]. "*Social media tools can also support public awareness and education campaigns, as well as foster participative processes. ICT applications such as participatory videos, photo-diaries or the use of mobile phones for collective mapping/monitoring exercises, could be used to foster greater involvement of low-income urban dwellers in climate change and risk-reduction initiatives, involving them in decisions such as the best location for drinking water supplies in case of sudden salinization, or failures in drainage systems due to floods" [b-CDI 2011]*.

vi) Monitoring and evaluation: "The final stage of every adaptation process is its monitoring and assessment: the performance of the initiative must be constantly verified in order to reach the goal defined during the planning phase" [b-CPD].

9 Framework for ICTs and climate change adaptation

This Recommendation provides a multi-level framework for countries to integrate ICTs into their national climate change adaptation strategies.



Source: Adapted from [b-CDI 2012]

Figure 1 – Relation between ICTs and climate change adaptation

This framework assists countries in coordinating stakeholders and efforts at different levels to enhance work on different aspects of technologies and know-how for adaptation, as well as on opportunities for their development, diffusion, and transfer. This framework will also assist stakeholders to strengthen international, national and local-level decision-making processes on adaptation, and improve the planning, implementation and monitoring of adaptation initiatives (the focus is on decision making processes).

The framework requires three main components to formulate and implement effective policies and strategies at the intersection of the ICTs and climate fields: content, structure and processes (which shall be elaborated in the ensuing Sections) [b-CDI 2012].

1) Community level: Efforts are made at this level to systematize and analyse data and experiences linked to climate change effects (data collected on the community level can be complemented by regional data). This would help determine the exact role of ICTs in specific areas of vulnerability (agriculture, water management, and infrastructure) that may be intensified by climate change.

   ICTs such as mobile phones and radio are widely available at local levels can be used to impart the required technical knowledge on efficient agricultural practices, disaster management, advantages of the use of resistant seed varieties, water management, predicted climatic trends thereby significantly improving the adaptive capacity to climate change at local/community levels. This is particularly important in developing countries which are heavily reliant on agriculture [b-CDI 2011].

   For example, small cocoa producing farms in Ghana are dependent on the cocoa produce for at least 70-100% of their household income. Cocoa as a crop is highly sensitive to temperatures and variations in precipitation which makes it extremely vulnerable to the effects of climate change. In order to protect these cocoa farmers from the potential ruin of their crops, knowledge sharing through ICTs would improve their crop's resilience to climate change significantly [b-ITU 2012].

2) Sectoral level: Incorporating ICTs into functioning systems can be done at sectoral levels (elaborated in Table 1).

   In order to incorporate ICT into climate change adaptation responses and monitoring, (within specific development contexts) policies referred to as ICTs, Climate Change and Development Policies (ICCD) can be developed. These policies consist of the required legal framework, action plan for the government and other stakeholders. ICCD Policies aim to develop policies for climate change resilience using the application of ICTs [b-CDI 2012]. The main focus areas of ICCD polices include:

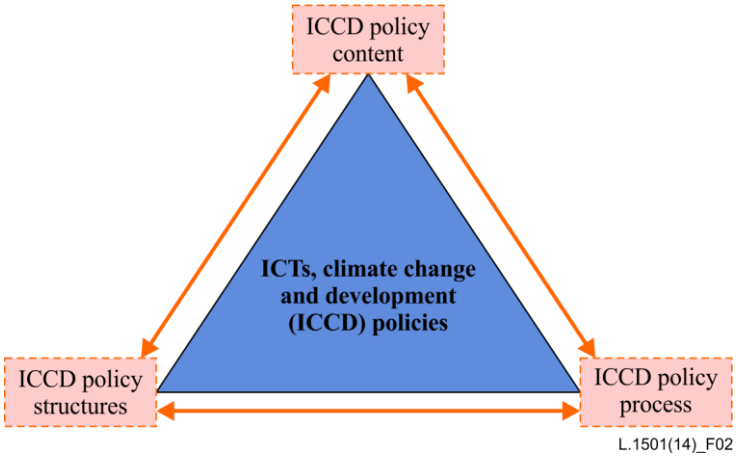
   a) ICT-CC Linkages;

   b) e-Mitigation;

   c) e-Adaptation;

   d) e-Monitoring;

   f) Other climate change priorities (sector specific) (see Figure 2).

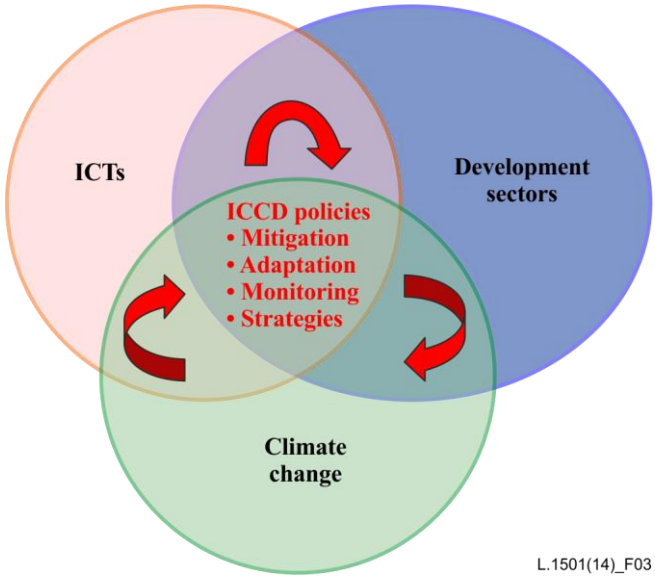


Source: [b-CDI 2012]

Figure 2 – Key components of ICT, climate change and development policies

The three main components required for the formulation of ICCD policies namely *content*, *structures* and *process* (refer to Figures 2 and 3) [b-CDI 2012] which are interconnected and aim to address the

issues of: mitigation, adaptation, monitoring and climate change strategizing. These components are elaborated in the coming clauses.



Source: [b-CDI 2012]

Figure 3 – Integrating the Aspects of ICCD Policies

3) National level: The national adaptation plan (NAP) process was established under the CAF (refer to clause 7). The CAF forms the basis to formulate and implement NAPs as a means of identifying the short-term and long-term adaptation needs and developing and implementing the required strategies to address those needs. This process is continuous and follows a country driven, gender sensitive, participatory and transparent approach.

The objectives of the NAP process are:

a) To reduce vulnerability to the impacts of climate change, by building adaptive capacity and resilience.

b) To facilitate the integration of climate change adaptation, in a coherent manner, into relevant new and existing policies, programmes and activities, in particular development planning processes and strategies, within all relevant sectors and at different levels, as appropriate.

c) To promote informed decision making: This involves the generation of NAPs which would promote the use of ICT applications (e.g., GIS or meteorological information systems) to help understand the current extent of climate change and model future impact on not just for weather predictions but also for agricultural productivity, health and disease, disaster incidence, etc. [b-UNFCCC 2011].

d) To promote stakeholder involvement: "ICTs can facilitate the inclusion of multiple voices in the design of adaptation strategies at various levels, from simple broadcast awareness-raising of issues to be decided; to fuller engagement through the use of social media and online polling of those likely to the affected; to the use of group decision support systems to model and analyse different scenarios and enable decisions to be made." [b-CDI 2011]

e) Feedback and learning: Formulation of the NAP is not the end of the road. It should be considered a part of the process of climate change adaptation. The NAPs can be constantly updated as new technology is introduced. "ICT can help bridge the missing link by providing feedback on the impact of adaptive actions through geographical and sectoral information systems" [b-CDI 2011]. The use of ICTs for environmental observation, monitoring and networking enables users to assimilate, translate, use and share information in novel ways, enhancing the learning cycle. E-governance is capable of promoting transparency and accountability with reference to the resources being invested for adapting to climate change.

9.1 Content

The Content refers to the development of policy content aimed at integrating the use of ICTs in climate change adaptation strategies at the international, national, sectoral and community levels.

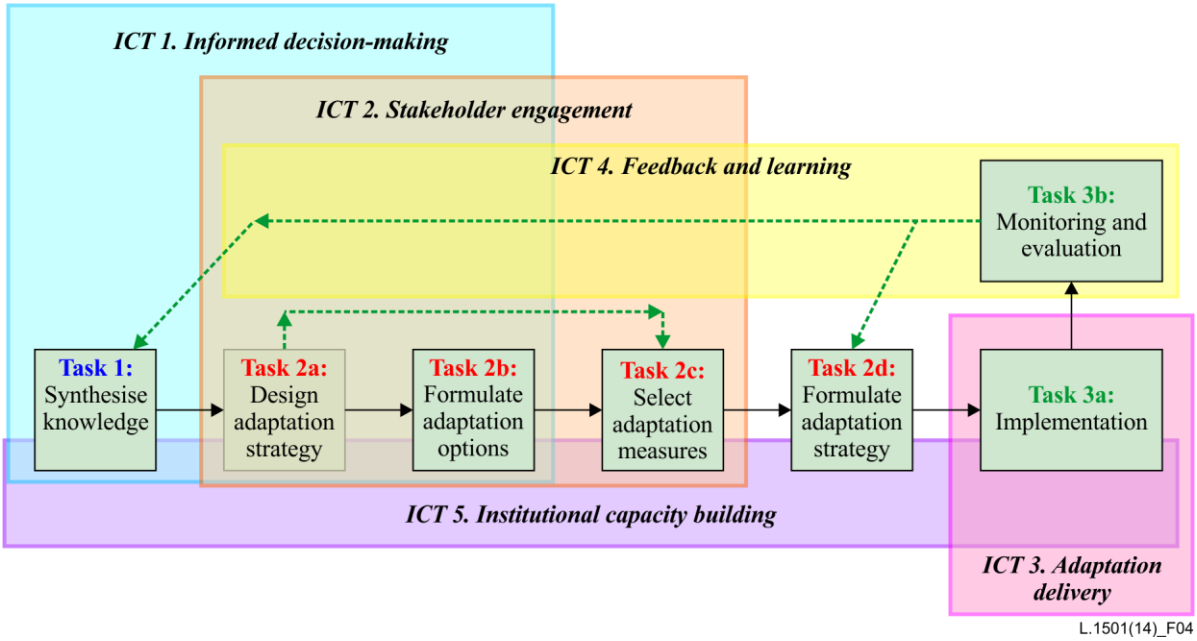
Table 1 – ICT and climate change policy content

a) International level	
ICT and climate change content at the international level should aim at incorporating ICTs explicitly into global (climate change) adaptation strategies.	
b) National level	
Key stages of adaptation processes (Depicted in Figure 3)	ICT and climate change content to strengthen adaptation processes.
Informed decision making	ICTs contribute to climate change adaptation strategies by strengthening informed decision making. ICT tools should be used to identify climate change related needs and priorities at the local, regional or national levels, and support the identification of resources and capacities available to respond to climatic (opportunities) and threats. • Countries should develop policy content that fosters the use of applications such as GIS and meteorological information systems to understand both the current extent of climate change and to model future climatic impacts on agricultural productivity, health and disease, disaster incidence, etc.
Stakeholder engagement	ICTs facilitate the inclusion of multiple voices in the design and implementation of adaptation strategies. • Countries should develop policy content that promotes the use of ICTs (e.g., social media and online polling) to foster new forms of interaction and engagement of multiple stakeholders in the design and implementation of adaptation initiatives and crisis response.
Adaptation delivery	ICTs support the delivery of adaptation priorities in regard to specific development vulnerabilities, sectors or issues. • Countries should develop content aimed at fostering the use of ICTs as part of the adaptation measures in vulnerable sectors such as agriculture and food security, human habitat and health, water resources, terrestrial ecosystems, marine and coastal ecosystems, and disaster management, among others.

Table 1 – ICT and climate change policy content

Feedback and learning	ICTs facilitate networking, feedback and learning, across different levels, in regard to adaptation options and lessons learned. • Countries should develop strategy content that fosters the use of ICTs for environmental observation, monitoring and networking to involve users in the analysis, translation and use of climate change information.
Institutional capacity building	ICTs help strengthen the capacity of institutions involved in processes of climate change adaptation, improving the availability of resources and skills needed for effective adaptation. • Countries should develop content that promotes the use of ICTs as part of capacity-building processes, e-learning and skills-update programmes on climate change issues, as well as to foster coordination of intra-/inter-institutional actions in the adaptation field.
c) Sectoral and community levels	
ICT and climate change content at the sectoral and community levels should foster the integration of these tools in the design and implementation of sub-regional projects and initiatives. Countries should develop content addressing the key vulnerabilities faced by the sectors impacted by climate change and variability, including: • Agriculture and food security: Promote the use of ICTs to disseminate information about resistant seed varieties and planting methods, or to access agro-meteorological information to protect crops. • Water supply: Promote the use of ICTs to build local capacity for the conservation of water sources and more efficient water management during the production cycle. • Health: Foster ICT adoption 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: Promote the use of ICTs to share lessons on safe building practices in areas of high risk for rural communities.	

Source: Adapted [b-CDI 2012]



Source: [b-CDI 2011], adapted from [b-UNDP 2004]

Figure 4 – ICTs and the formulation process of a climate change adaptation strategy at the national level

9.2 Structures

Structures of ICCD policies refers to the provision of effective institutional arrangements, including stakeholder capacities, roles and responsibilities required for the integration of ICTs and climate change adaptation strategies (Figure 5 gives an example of a national ICCD policy structure) [b-CDI 2012].

The proposed model [b-UNDP 2004] to formulate ICTs and national adaptation plans has three stages:

1) Gathering of information and synthesizing available knowledge about the current and future state of climate change and adaptation requirements.

2) Design of the adaptation strategy, including making decisions about the required adaptation measures.

3) Implementation of the adaptation strategy and evaluation of the impact of that strategy.

Key factors that need to be considered in the design of ICT and climate change structures in developing countries include:

– Multi-stakeholder collaboration;

– ICTs and climate change perspectives;

– adaptation as a key area of action;

– active international engagement;

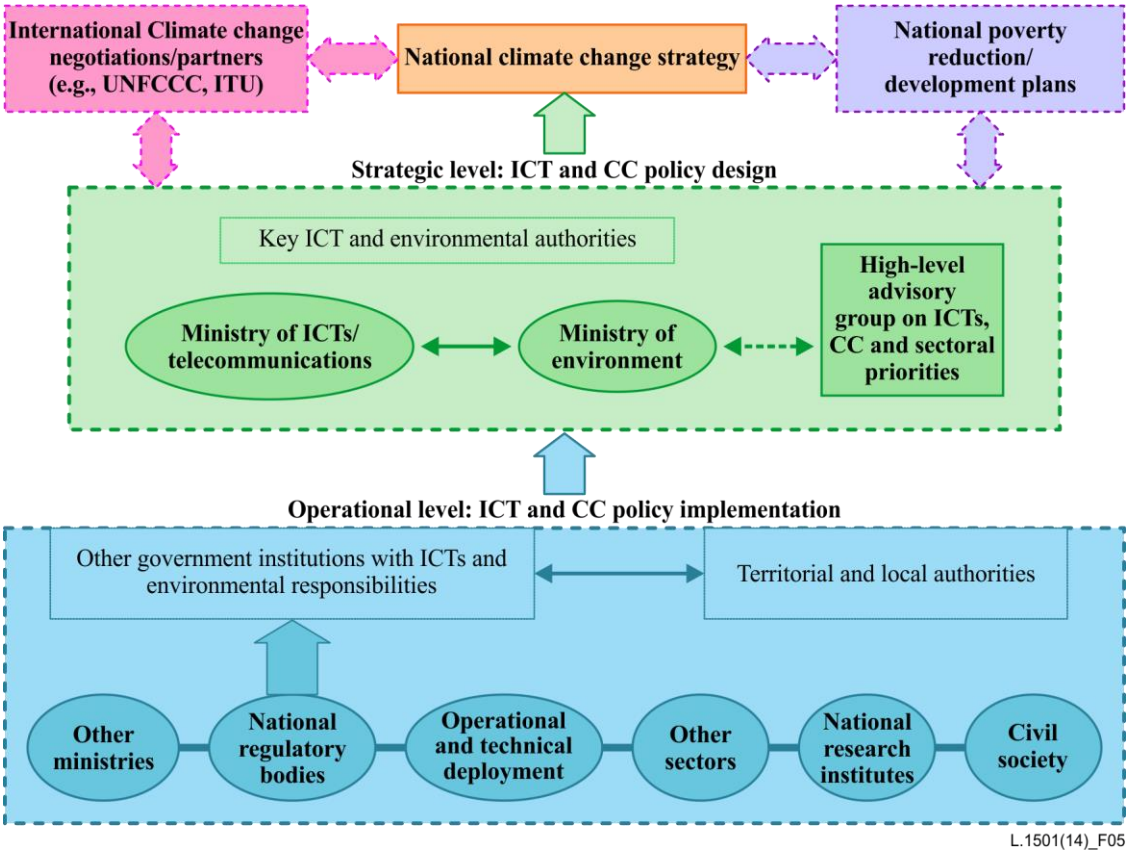
– complement policy with research and practice.

The structure distinguishes between two levels of the ICCD policy process [b-CDI 2012]:

i) The strategic level (see Figure 5): Involves national authorities of the ICT and climate change (Ministry of ICT/Telecommunications and Ministry of Environment) along with development sector representatives.

ii) The operational level (see Figure 5): Involves private actors, scientific societies, local authorities (to incorporate local priorities), and stakeholders from other governmental institutions (other than the ones mentioned above).

Note, the structure is also to ensure coherence with international agreements and must also maintain a level of flexibility to conform to the changing nature of the science of ICT and climate change, and include emerging actors.



Source: [b-CDI 2012]

Figure 5 – Example of a national ICT and climate change structure

9.3 Process

This clause elaborates the design and implementation of a coherent process to integrate ICTs and climate change adaptation, from the process of content development and structure design, to the actual integration of ICTs and climate change issues in policy implementation.

The Process [b-CDI 2012] aims to achieve:

i) Horizontal coherence: referring to the alignment of the components required for the incorporation of ICT in climate change adaptation and monitoring responses (ICT tool availability, economic resources, political support, technical skills).

ii) Vertical coherence: Aims at ensuring consistency between sub-regional, regional, national and international policy domains as required by the constantly changing fields of ICT and climate change (conformity of legislations, international documents, planning strategies).

The policy process has six stages [b-CDI 2012]:

1) Awareness raising strategy: Generating awareness among policy makers/stakeholders about climate change issues (in sector specific context).

2) Problem definition: Defining the problem linked to climate change through technological needs in consultation with stakeholders from multiple sectors.

3) Identification (of e-mitigation, e-adaptation and e-monitoring strategic options): Identifying the required ICT tools to address mitigation, adaptation and monitoring issues and identify the relevant stakeholders.

4) Identification and selection of policies: Designing the required policies to adapt to climate change while integrating the use of ICT tools.

5) Policy implementation: Collaboration between international, national and sub-national/region stakeholders to ensure coherence.

6) Policy evaluation: Appointing an external body to conduct an assessment of the ICCD policies to provide strategic recommendations for improvement.

Key stages that need to be fulfilled in the process of integrating ICTs and climate change adaptation strategies are:

1) Awareness raising and strategizing, with a focus on the specific climatic issues, needs and priorities of the context.

2) Problem definition, based on vulnerability and technology assessments, conducted in collaboration with local stakeholders.

3) Identification of ICT-enabled solutions, with a focus on identifying ICT-enabled applications appropriate to the local needs and conditions.

4) Identification and selection of policies/strategies/standards that integrate ICTs and adaptation actions.

5) Implementation and evaluation of ICT and climate change policies/strategies/standards, which could be conducted by an external body.

10 Checklist of indicators

Given the above procedures for incorporating ICT into the policy framework for climate change adaptation, the following checklist would provide countries with the proposed indicators associated with climate change adaptation. This list is designed to assist countries to ensure that they meet the necessary requirements for the adoption and the implementation of the framework for ICT and climate change adaptation while keeping a record of the possible trends linked to climatic impacts.

The table below has been adapted to provide examples of indicators and trends of climate change. For the purpose of this recommendation, users and decision makers may add more examples of ICT use and areas of vulnerability as the need arises.

Table 2 – Some indicators of climate change and ICT implementation in adaptation to climate change

Indicator (trends) of climate change	Causes of the observed trends	Changes in ecosystems	Impact on agriculture	Impact on economic systems	Impact on public health	ICT use (some examples include)
Changes in surface temperature (global warming)	Deforestation, industrialization, increased fossil fuel use leading to enhanced greenhouse effect.	Changes in: species distribution, vegetation cover, increased glacial melting, changes in weather patterns, affecting biogeochemical cycles, forest fires, encroachment of invasive species.	Droughts, decrease in yield in warmer environments (endangering food security), increased vulnerability to weeds and pests, increased expenditure on irrigation.	More investment of energy for cooling facilities, increased demand for water supplies, migration to wetlands from arid regions.	Changes in disease vectors (possible epidemics caused by strains of viruses or bacteria which thrive in warmer temperatures, heat strokes, starvation due to reduced agricultural yield.	Recording surface temperature changes to maintain records and as well as predict possible disaster events using global observation system (GOS) which include weather satellites, earth observation satellites; improved communication with farmers using radio and mobile networks; geographic information system (GIS) for monitoring deforestation; mobile health management systems.

Table 2 – Some indicators of climate change and ICT implementation in adaptation to climate change

Indicator (trends) of climate change	Causes of the observed trends	Changes in ecosystems	Impact on agriculture	Impact on economic systems	Impact on public health	ICT use (some examples include)
Sea level rise	Rise in temperature (as a result of global warming)	Coastal flooding, floods, shoreline erosion, wetland flooding, saltwater intrusion into groundwater resources, displacement of marine ecosystems, risk of coastal land submergence.	Affected in case of proximity to coastal areas.	Increased monetary investment to prevent damage to coastal areas and flood proofing as well as ecosystem reconstruction in post flood situations.	Affects communities living near coastal areas, Risk of floods, damage of coastal property, Increased risk of drowning.	Monitoring and recording sea level rise (to keep a record of any anomalies) using satellite altimetry thereby helping predicting disasters to avoid loss of life and property.

Table 2 – Some indicators of climate change and ICT implementation in adaptation to climate change

Indicator (trends) of climate change	Causes of the observed trends	Changes in ecosystems	Impact on agriculture	Impact on economic systems	Impact on public health	ICT use (some examples include)
Changes in precipitation	Changes in the water cycle (as a result of sudden temperature changes in the atmosphere).	Increased precipitation may cause run-off, landslides, Soil erosion, changes in vegetation cover, habitat destruction, Decrease in precipitation causes droughts, increased risk of forest fire, Changes in water table.	Increase in precipitation may increase yields but there may also be a risk of flooding leading to destruction of crops before harvest, Decrease in precipitation causes drought leading to reduced yields.	Reduced water availability and over-reliance on ground water supplies in case of decrease in precipitation, Investment required in case of flooding.	Risks to water borne diseases, stagnant water sources act as breeding grounds for disease parasites, loss of life in heavy rainfall situations.	Measure and maintain records (GOS, global telecommunication system) of seasonal as well as monthly rainfall/snow/hail; GIS for flood risk management; promoting awareness among farmers through radio and mobile systems; use of GIS and global positioning system (GPS) to identify new freshwater sources; use of smart pipes.

Table 2 – Some indicators of climate change and ICT implementation in adaptation to climate change

Indicator (trends) of climate change	Causes of the observed trends	Changes in ecosystems	Impact on agriculture	Impact on economic systems	Impact on public health	ICT use (some examples include)
Dune movement/ migration	Drought, rising temperatures, erosion, deforestation.	Erosion, changes in habitat structure, loss of soil nutrients.	Affects desert agricultural systems.	Desert agricultural systems require irrigation systems hence loss soil will require most investment for desert irrigation systems, problems linked to travelling and transport.	Sandstorms exacerbating asthma and other respiratory disorders.	Monitoring and predicting dune movement using satellite imagery, GPS.
Glacial melting	Rise in temperature of the Earth's surface (global warming).	Flooding, loss of glacial mass, erosion leading to loss of soil nutrients.	Run-off from crops lands, soil degradation, decreased in yield.	Monetary investment required for habitat reconstruction in post flood areas.	Communities affected by floods, lack of freshwater supplies.	Satellite systems (GIS, GPS) record glacial movement and mass of glaciers lost to help predict floods and runoffs; smart water harvesting.

Table 2 – Some indicators of climate change and ICT implementation in adaptation to climate change

Indicator (trends) of climate change	Causes of the observed trends	Changes in ecosystems	Impact on agriculture	Impact on economic systems	Impact on public health	ICT use (some examples include)
Eutrophica-tion levels	Deforestation leads soil to be exposed to erosion agents which results in run-offs of soil and into nearby water bodies inducing excessive algal growth.	Algal bloom, death of aquatic species increase in biochemical oxygen demand (BOD).	Loss of soil cover and nutrients, reduced crop yield, lack of clean water for irrigation.	Reduced maximum sustainable yield (MSY).	Reduced food supply from aquatic sources, contaminated aquatic food supplies.	Track and record polluted water sources, measure and maintain records of the levels of toxicity, promoting awareness among fishermen.
Forest fires	Rise in temperature of the Earth's surface.	Habitat destruction, risk of species extinction, reduced vegetation cover, particulate emissions.	Affects nearby agricultural areas.	Increased investment for habitat re-construction.	Asthma, bronchitis and other respiratory disorders caused by particulate or smoke emission.	Record and maintain satellite imagery (GIS, GPS), emergency communication using mobile communication systems.

Table 2 – Some indicators of climate change and ICT implementation in adaptation to climate change

Indicator (trends) of climate change	Causes of the observed trends	Changes in ecosystems	Impact on agriculture	Impact on economic systems	Impact on public health	ICT use (some examples include)
Water pollution	Dumping of industrial and sewage waste into water bodies without the required level of treatment.	Death of aquatic species, increase in – biological/ BOD.	Soil pollution, crop destruction, reduced yield.	Investment required for treatment of water from contaminated sources.	Water borne diseases, biomagnification, bioaccumulation.	Monitoring of industrial activities, smart metering, regular testing of water samples, adequate information through ICT given to communities living around contaminated water bodies.
Soil Erosion	Deforestation.	Loss of soil cover, reduced availability of nutrients, loss of plant cover.	Reduced yield, loss of precious soil cover.	Investment for landscaping schemes.	Respiratory disorders.	GIS, GPS system to monitor and record soil movement.
Air Pollution	Industrialization, landfills site emissions, incineration of waste, burning of fossil fuels.	Global warming, changes in weather patterns, smog, acid rain, soil pollution.	Reduced yield due to changes in weather patterns and rainfall, soil acidification.	Reconstruction of acid rain affected areas and urban constructions, smog disturbs traffic and transport.	Respiratory disorders, nervous system damage, cancer, skin irritation, headaches.	GIS to map pollution caused by transportation, spatial analysis techniques.

Source: Adapted from [b-AKP 2010]

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