



INFORMATION AND COMMUNICATIONS TECHNOLOGY
AND DISASTER RISK REDUCTION DIVISION

Digital technologies for climate change adaptation in Asia and the Pacific

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Abstract

While some countries in the Asia-Pacific region are adapting to climate change, countries with special needs (CSNs) with less resources and capacities face significant challenges implementing adaptation projects. Yet, CSNs are particularly vulnerable to climate change impacts, and most in need of adaptation interventions.

Despite this urgency to adapt to the changing climate and the promising solutions that digital technologies offer, the interlinkages between the two sectors at the policy level are not clear. In fact, while significant contributions of digital technologies to mitigate climate change have been widely applied across the region, fewer examples can be found for climate adaptation. Comprehensive evaluations of key enablers for using digital technologies to adapt to climate change remain scarce.

This working paper addresses this gap by assessing the key enablers and commonalities between different case studies worldwide in the use of digital technologies for climate adaptation. Based on the assessment results, policy recommendations for the advancement of climate adaptation in Asia-Pacific countries, particularly CSNs, are provided.

This working paper calls, first, for capacity building to bridge the existing climate change data gaps in CSNs from Asia and the Pacific. Second, given the limitation of global funds, it raises the importance of applying financial alternatives to fund digital climate adaptation projects, such as tax incentives and crowdsourcing mechanisms for key players in climate adaptation. Third, it recommends strengthening governance and institutional capacities to mainstream climate adaptation into digital technology-related policies to advance climate adaptation. Fourth, it raises the need to accelerate the development and implementation of digital climate adaptation projects through multi-stakeholder collaboration to fill human and financial gaps. Last but not least, it requests for the acceleration of climate adaptation in regional platforms that aim at advancing digital development, such as through the Asia-Pacific Information Superhighway initiative.

The findings from this working paper raise important messages for future research around the interlinkages between the lack of access and adoption of digital technologies and climate adaptation and vulnerability in CSNs from the region. It also brings to attention the need for the creation of a platform to facilitate technology transfer to more vulnerable and least developed countries.

Keywords:

Climate change data | technology transfer | countries with special needs
ICT policy and strategy | climate adaptation constraints



01

Introduction

1.1 Background

Asia-Pacific is one of the most vulnerable regions to climate change, and its impacts are projected to intensify in the future if no actions are taken.¹ Furthermore, the faster the climate changes, and the longer adaptation efforts are put off, the more difficult and expensive it will be to lessen or avoid damages and losses.²

While some countries in the Asia-Pacific region are adapting to climate change (such as Australia and the Republic of Korea), countries with special needs (CSNs)³ with less resources and capacities face significant challenges implementing adaptation projects. Yet, CSNs are particularly vulnerable to climate change impacts, and most in need of adaptation interventions.

Digital technologies⁴ can potentially unlock innovative solutions to complex development challenges brought by climate change, and help CSNs leapfrog development gains.⁵ But despite the urgency to adapt to the changing climate and the promising solutions that digital technologies offer, the interlinkages between the two sectors at the policy level are not clear. In fact, while significant contributions of digital technologies to mitigate climate change⁶ have been widely applied across the region, fewer examples can be found for climate adaptation.

Although mitigation helps in lessening climate change impacts through the reduction of greenhouse gas emissions, climate adaptation remains vital to protect population and infrastructure against the

unavoidable impacts of climate change. Climate change adaptation (or climate adaptation) can be defined as: “changes in processes, practices and structures to moderate potential damages or to benefit from opportunities associated with climate change, in response to actual or expected climatic stimuli and their effects or impacts”.⁷ Comprehensive evaluations of key enablers for using digital technologies to adapt to climate change remain scarce.

This working paper addresses this gap by assessing the key enablers and commonalities between different case studies worldwide in the use of digital technologies for climate adaptation. Based on the assessment results, policy recommendations for the advancement of climate adaptation in Asia-Pacific countries, particularly CSNs, are provided. CSNs from the region are not only more vulnerable to climate change impacts than other countries in the world,⁸ they are also more excluded from the use, adoption and adaptation of digital and frontier technologies.⁹

The findings from this research have important policy implications for CSNs and for Asia-Pacific countries in general on ensuring a timely and effective adaptation to the climate, while leapfrogging development gains and reducing disaster losses.

1.2 Research objectives

The aim of this research proposal is to answer the following research question:

How and what digital technologies contribute to climate change adaptation?

1 United Nations Environment Programme, “Helping countries tackle climate change”. Available at <https://www.unep.org/regions/asia-and-pacific/regional-initiatives/helping-countries-tackle-climate-change> (accessed on 27 September 2021).

2 Ibid.

3 The group of CSNs in Asia and the Pacific is comprised of least developed countries, landlocked developing countries and small island developing states.

4 Digital technologies include electronic tools, systems, devices and resources that generate, store or process data.

5 World Bank, “Digital Development”, 27 October 2020. Available at <https://www.worldbank.org/en/topic/digitaldevelopment/overview>.

6 Climate change mitigation refers to efforts to reduce or prevent emission of greenhouse gases (United Nations Environment Programme).

7 United Nations Framework Convention on Climate Change, “What do adaptation to climate change and climate resilience mean?” Available at <https://unfccc.int/topics/adaptation-and-resilience/the-big-picture/what-do-adaptation-to-climate-change-and-climate-resilience-mean> (accessed on 20 June 2021).

8 ESCAP, *The Disaster Riskscape Across Asia-Pacific: Pathways for Resilience, Inclusion and Empowerment – Asia-Pacific Disaster Report 2019* (Bangkok, 2019). Available at https://www.unescap.org/sites/default/files/publications/Asia-Pacific%20Disaster%20Report%202019_full%20version.pdf.

9 United Nations Conference on Trade and Development, *Technology and Innovation Report 2021: Catching technological waves – Innovation with equity* (New York, 2021). Available at <https://unctad.org/webflyer/technology-and-innovation-report-2021>.

The main research question is complemented with the following sub-questions:

- What policy gaps exist in the use of digital technologies for addressing key issues of climate change adaptation in Asia and the Pacific?
- What policies and strategies worldwide have been successful in the use of digital technologies for climate change adaptation?
- What are the key enabling factors that allow the use of digital technologies for climate change adaptation?
- How can CSNs from Asia and the Pacific replicate the good practices from the case studies to mainstream climate change adaptation into digital technology-related policies?

1.3 Methodology and limitations

1.3.1 Methodology

The research methodology used in this working paper is mainly qualitative. The working paper starts with an assessment of existing national digital policies and strategies from all the Asia-Pacific countries to identify if climate change adaptation is included or mainstreamed.

Only approved and current policies and strategies (ongoing in 2020 or later) related to information and communications technologies (ICTs) and digital technologies were selected for assessment. Environmental and climate change policies were not considered, under the assumption that mainstreaming of climate change adaptation in digital policies implies vice versa.

Once the digital policies and strategies were identified and selected, and verified with International Telecommunication Union (ITU) data, keyword searches were undertaken for:

“adaptation”, “climate”, “environment” and “disaster”, among other terms. This helped to identify the main policy gaps and challenges countries in the region have in the use of digital technologies for climate adaptation, which are discussed in Section 2.

In Section 3, case studies from around the world that provide good practices in the use of digital technologies for climate adaptation are presented. The selection of case studies was based on data availability and relevance, and on the following category of key sectors established by the Global Commission on Adaptation: food security, the natural environment, water security, cities and urban areas, infrastructure, disaster risk management, and finance.¹⁰ Only those cases that were ongoing at the time of research or have ended but have demonstrated successful outcomes and impacts were considered.

An attempt was made to select case studies regardless of the level of development and location of the country. A total of five case studies were selected, which were complemented with an assessment of related national policies and strategies, implementing agencies, and other relevant information to better understand the initiatives’ success. Knowledge gaps found in one of the case studies were complemented with a survey questionnaire, available in Annex 2.

Section 4 summarizes the good policies and practices from the assessment of the case studies in Section 3 to address the key barriers for CSNs in using digital technologies for climate adaptation, which are based on the Intergovernmental Panel on Climate Change (IPCC) findings discussed in Section 2. This is followed by policy recommendations in Section 5 to strengthen the linkages between digital development and climate adaptation, and accelerate the use of digital technologies for climate adaptation.

10 Global Commission on Adaptation, “Adapt now: A global call for leadership on climate resilience”, 13 September 2019. Available at <https://gca.org/reports/adapt-now-a-global-call-for-leadership-on-climate-resilience/> (accessed on 23 September 2021).

1.3.2 Limitations

This research is based on publicly available information in national official websites and from development agencies. Lack of data is a key limitation of this research due to the inherent lack of linkages at the policy level between digital technology use and climate adaptation fields. Part of this limitation was found in a case study, which was overcome with a survey questionnaire. This limitation was also encountered when identifying case studies, which was very hard to find for three

main reasons. First, most of the case studies focus on climate mitigation; second, those that focus on climate adaptation are mostly pilots that are not further implemented; and third, not all digital climate adaptation projects are systematically documented for assessment.

The language barrier was also a limitation as some national plans and strategies were only available in the national language and did not allow a thorough assessment of the respective documents.



02

Digital technology policies and strategies and climate adaptation in Asia-Pacific countries

Despite the development gains that digital technologies bring,¹¹ only 28 out of 56 countries from the region have an overarching national ICT policy or master plan.¹² Moreover, among the 28 countries, only 14 link the use of digital technologies or ICTs with climate adaptation. For those countries with no data available in the ITU dataset, 6 of them link the use of digital technologies for climate adaptation in ICT and development-

related policy documents – bringing the total number of countries that link the use of digital technologies with climate adaptation to 20. However, 11 of these 20 countries do not explicitly mention climate adaptation in their ICT policies or strategies, but focus only on one or two specific sectors, instead of tackling adaptation comprehensively. See Annex 1 for details.

Table 1. Countries in Asia-Pacific that link the use of digital technologies with climate adaptation

Countries	Policy document and source
Afghanistan	Digital Foundation Strategy for Afghanistan 2019-2021: https://digital.af/
Azerbaijan	National Strategy for the Development of the Information Society in the Republic of Azerbaijan for 2014-2020: https://president.az/articles/11312
Bangladesh	Vision 2021-2041: Digital Bangladesh: http://oldweb.lged.gov.bd/UploadedDocument/UnitPublication/1/1049/vision%202021-2041.pdf
Bhutan	12th Five-Year Plan 2018-2023: https://www.gnhc.gov.bt/en/wp-content/uploads/2019/05/12FYP-Volume-II-Central-Plans.pdf
Cook Islands	Cook Islands National Information and Communication Technology Policy 2015-2020: https://pafpnet.spc.int/attachments/article/537/Cook%20Islands%20National%20Information%20and%20Communication%20Technology%20Policy.pdf
India	National Policy on Information Technology 2012-2020: https://www.meity.gov.in/writereaddata/files/National_20IT_20Policyt%20_20.pdf
Iran (Islamic Republic of)	Digital Iran: National Roadmap 2020-2025: http://irandigitaltransformation.ir/wp-content/uploads/2020/06/Digital-Iran-Roadmap-Executive-Summary.pdf
Japan	Information and Communications in Japan 2020: https://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/whitepaper/2020/index.html
Kiribati	Kiribati National ICT Policy 2019: https://www.micttd.gov.ki/sites/default/files/National%20ICT%20Policy.pdf
Korea (Republic of)	Korean New Deal 2020-2025: https://english.moef.go.kr/co/fixFileDown.do?orgNm=Korean_New_Deal.pdf
Maldives	Strategic Action Plan 2019-2023: https://erc.undp.org/evaluation/managementresponses/keyaction/documents/download/3556
Micronesia	The Federated States of Micronesia National ICT and Telecommunications Policy 2012: https://fsm-data.sprep.org/system/files/FSM%20National%20Information%2C%20Communication%20%26%20Technology%20Policy%202012.pdf
Mongolia	State Policy on Development of ICT 2017-2025: https://www.cita.gov.mn/wp-content/uploads/2021/01/State-Policy-on-ICT-Development-2025_en.pdf and https://www.cita.gov.mn/en/strategic-policy
Nepal	National Information and Communication Technology Policy 2015-2020: http://www.youthmetro.org/uploads/4/7/6/5/47654969/ict_policy_nepal.pdf
Pakistan	Digital Pakistan Policy: https://moitt.gov.pk/SiteImage/Misc/files/DIGITAL%20PAKISTAN%20POLICY.pdf
Papua New Guinea	PNG Digital Transformation Policy 2020: https://ict.gov.pg/policy/PNG%20Digital%20Transformation%20Policy_21122020_updated.pdf
Philippines	National ICT Ecosystem Framework: http://dict.gov.ph/ictstatistics/wp-content/uploads/resources/NICTEF.pdf
Samoa	Samoa National Broadband Policy 2012: https://mcit.gov.ws/2019/04/04/samoa-national-broadband-policy-2012/
Timor-Leste	Timor-Leste Strategic Development Plan 2011-2030: http://timor-leste.gov.tl/wp-content/uploads/2011/07/Timor-Leste-Strategic-Plan-2011-20301.pdf
Tonga	Tonga Strategic Development Framework 2015-2025: http://extwprlegs1.fao.org/docs/pdf/ton168846.pdf

11 ITU, "National overarching ICT policy or Master plan exists", ITU ICT-Eye: ICT data portal. Available at <https://www.itu.int/net4/itu-d/icteye/#/query> (accessed on 18 June 2021).

12 Abdul-Lateef Balogun and others, "Assessing the Potentials of Digitalization as a Tool for Climate Change Adaptation and Sustainable Development in Urban Centres", Sustainable Cities and Society, vol. 53 (February 2020). Available at <https://www.sciencedirect.com/science/article/pii/S2210670719307267>.

Of these countries that include climate adaptation in their ICT policies or strategies, only 10 are among the top 20 countries most exposed to natural hazards in the region.¹³ Moreover, 4 of the top 10 most exposed countries to natural hazards in the region¹⁴ do not include climate adaptation in their ICT policies or strategies, and only 2 of the 4 countries (China¹⁵ and Indonesia¹⁶) include climate mitigation.

The fact that climate adaptation is not mainstreamed in most ICT policies or strategies indicates the passing over of potential opportunities to leverage digital technologies for building climate resilience. More concerning is the fact that 11 out of 56 of countries in Asia-Pacific do not have an ICT policy or strategy in place.¹⁷ These countries are: American Samoa, French Polynesia, Guam, Marshall Islands, Nauru, Northern Marianas, Palau, Tuvalu, Tajikistan, Turkmenistan and Democratic People's Republic of Korea. As the list shows, these are all CSNs and the majority are Pacific Small Islands Developing States (SIDS).

Generally, CSNs tend to have less capacities to use, adopt and adapt digital and frontier technologies, which threaten to increase inequalities and technological gaps between developed and developing countries.¹⁸

Furthermore, CSNs are the most threatened by climate change and constantly disrupted by natural hazards, which are becoming increasingly frequent and intense. This lack of access to digital technologies and greater climate exposure and vulnerability pose significant constraints on the capacity of these countries to adapt.¹⁹

2.1 Knowledge, awareness and technology constraints

Knowledge, awareness and technology constraints are key barriers to adapting to climate change through the use of digital technologies,²⁰ as highlighted in some Asia-Pacific national ICT policies and strategies reviewed.²¹ According to the IPCC,²² individual, institutional and societal knowledge influences the capacity to develop and use technologies to achieve adaptation objectives. The lack of digital skills also affects the capacity of governments to deliver digital services and contribute to the digital transformation of the respective country.²³

2.2 Financial constraints

Slow economic diversification hinders technological innovation and the ability of countries to adapt,²⁴ resulting in a lack of digital products and their incompatibility with

13 European Commission, "INFORM Risk Index (mid 2021)". Available at <https://drmkc.jrc.ec.europa.eu/inform-index> (accessed on 20 June 2021).

14 The top 10 countries are: The Philippines, Bangladesh, Japan, Myanmar, India, Indonesia, China, Pakistan, Viet Nam and Iran (INFORM Risk Index mid 2021).

15 Hill+Knowlton Strategies, "China's 14th five-year plan (2021-2025) report", 1 April 2021. Available at <https://www.hkstrategies.com/en/chinas-14th-five-year-plan-2021-2025-report/>.

16 Indonesia's Ministry of Industry, "Indonesia's Fourth Industrial Revolution: Making Indonesia 4.0", 2018. Available at [https://kemenperin.go.id/download/18280/Making-Indonesia-4.0--Bahan-AT-Kearney-Sosialisasi-tentang-Industry-4.0-\(update\)](https://kemenperin.go.id/download/18280/Making-Indonesia-4.0--Bahan-AT-Kearney-Sosialisasi-tentang-Industry-4.0-(update)).

17 Or no information was found.

18 United Nations Conference on Trade and Development, *Technology and Innovation Report 2021: Catching technological waves – Innovation with equity* (New York, 2021). Available at <https://unctad.org/webflyer/technology-and-innovation-report-2021>.

19 Richard J.T. Klein and others, "Adaptation Opportunities, Constraints, and Limits", in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects – Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, IPCC (New York, Cambridge University Press, 2014). Available at <https://www.ipcc.ch/report/ar5/wg2/>.

20 Ibid.

21 From Bangladesh, Bhutan and Tonga

22 Richard J.T. Klein and others, "Adaptation Opportunities, Constraints, and Limits", in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects – Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, IPCC (New York, Cambridge University Press, 2014). Available at <https://www.ipcc.ch/report/ar5/wg2/>.

23 Lao People's Democratic Republic's Ministry of Post and Telecommunications, "Digital Transformation in Laos", presentation made at the CICC Online Conference on National Digital Policies and Projects in the New Normal Era, December 2020. Available at http://www.cicc.or.jp/japanese/kouenkai/pdf_ppt/pastfile/r02/201203-05la.pdf.

24 Richard J.T. Klein and others, "Adaptation Opportunities, Constraints, and Limits", in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects – Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, IPCC (New York, Cambridge University Press, 2014). Available at <https://www.ipcc.ch/report/ar5/wg2/>.

the global market.²⁵ Other recurrent barriers mentioned are weak financing mechanisms and scarce sources of funding that further delay the implementation of ICT policies and strategies,²⁶ limiting the access to new technologies.²⁷ According to the IPCC, lack of access to financial capital constrains the implementation of adaptation strategies.

2.3 Structural issues in the governments

Experiences from some countries in Asia-Pacific have seen the absence of coordination between different government ministries and departments across sectors as a hindrance to project implementation.²⁸ This sometimes comes along with a lack of coherence in policies and regulations and lack of collaboration across ministries.²⁹ Multiple studies from both developed and developing nations suggest that the current structure of institutions and regulatory policies may be poorly aligned to achieve adaptation objectives.

2.4 Geographical challenges

Geography is also a great impediment, especially for SIDS to deploy digital infrastructure due to the long distance from oversea markets and isolation.³⁰ Moreover, the geographical location of most CSNs in Asia-Pacific represents a challenge in itself to adapt to climate change, since they face major exposure and vulnerability, which require greater adaptation efforts compared to other countries.

2.5 Lack of ownership

In some cases, there are a lack of awareness, appreciation, confidence or loss of faith in development projects, or a lack of sufficient facilities and infrastructure to carry out certain programmes, which threaten their implementation.³¹

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- 25 Bangladesh's Ministry of Science and Information and Communication Technology, "National Information and Communication Technology (ICT) Policy", 2012.
- 26 United Nations Conference on Trade and Development, *Technology and Innovation Report 2021: Catching technological waves – Innovation with equity* (New York, 2021). Available at <https://unctad.org/webflyer/technology-and-innovation-report-2021>.
- 27 Indonesia's Ministry of Industry, "Indonesia's Fourth Industrial Revolution: Making Indonesia 4.0", 2018. Available at [https://kemenperin.go.id/download/18280/Making-Indonesia-4.0---Bahan-AT-Kearney-Sosialisasi-tentang-Industry-4.0-\(update\)](https://kemenperin.go.id/download/18280/Making-Indonesia-4.0---Bahan-AT-Kearney-Sosialisasi-tentang-Industry-4.0-(update)).
- 28 Nepal's Ministry of Information and Communication, "National Information and Communication Technology Policy", 2015.
- 29 Indonesia's Ministry of Industry, "Indonesia's Fourth Industrial Revolution: Making Indonesia 4.0", 2018. Available at [https://kemenperin.go.id/download/18280/Making-Indonesia-4.0---Bahan-AT-Kearney-Sosialisasi-tentang-Industry-4.0-\(update\)](https://kemenperin.go.id/download/18280/Making-Indonesia-4.0---Bahan-AT-Kearney-Sosialisasi-tentang-Industry-4.0-(update)).
- 30 Tonga, Micronesia, Kiribati, Vanuatu and Maldives.
- 31 Bhutan's Ministry of Information and Communications, "Bhutan e-Government Master Plan", 2014; Korea International Cooperation Agency, "Summary on Cambodian ICT Masterplan 2020", 2014; India's Ministry of Electronics and Information Technology, "National Policy on Information Technology", 2012; Indonesia's Ministry of Industry, "Indonesia's Fourth Industrial Revolution: Making Indonesia 4.0", 2018; and Vanuatu's Prime Ministry, "National Information and Communication Technology Policy", 2013.



03

Digital technologies for climate adaptation – Case studies

Given the urgency to adapt to climate change and in an attempt to minimize the damage to societies, some countries are making use of digital technologies to accelerate adaptation and anticipate the negative consequences of the changing climate to human health, the economy and ecosystems.

3.1 Weather stations for pest control in Florida (United States of America) (since 2011)

According to the IPCC special report on climate change and land,³² there is high confidence that distributions of pests and diseases in agriculture will change, affecting production negatively in many regions due to climate change. Inaction will result in a reduction of yield, affecting global food security. For strawberry production worldwide, anthracnose fruit rot and botrytis fruit rot are two diseases causing significant losses. These diseases favour temperatures greater than 18°C and wet weather (over 12 hours of leaf wetness). Losses due to anthracnose can exceed 50 per cent when conditions favour the development of the disease, even in well-managed fields.³³

The use of data provided by weather stations has allowed climate adaptation of the strawberry sector in Florida, thanks to the development and use of the Strawberry Advisory System, a platform developed by AgroClimate Initiative. This initiative is supported by the Southeast Climate Consortium – a coalition of eight universities in the United States of America (USA) – with

financial support from the National Oceanic and Atmospheric Administration (NOAA) and the United States Department of Agriculture's National Institute of Food and Agriculture.³⁴

AgroClimate is an innovative web-based resource for decision support and learning about the effects of weather and climate on agriculture developed in Florida. It provides interactive tools and climate information to improve resource use efficiency and reduce crop production risk associated with climate variability and change.³⁵ With this aim, the Strawberry Advisory System combines information from weather stations to forecast pests and diseases, and warnings are sent through smartphone, email and short message service (SMS) technologies. These warnings are available during the strawberry season to rapidly provide information to growers and extension agents. The system automatically sends SMS messages and emails to registered users whenever the infection index calculated crosses an established threshold.³⁶

According to a study,³⁷ the use of the Strawberry Advisory System in commercial fields is effective in controlling fruit rot diseases with no reduction in yield while substantially reducing fungicide applications. Results have shown that fungicide applications could be reduced by half in some years by following the recommendations of the system without affecting disease control or fruit quality.³⁸ Given its effectiveness, the phone application is used by over half of the strawberry growers in Florida, according to Dr. Clyde W. Fraisse, Project Director of AgroClimate.

32 Cheikh Mbow and others, "Food Security", in *Climate Change and Land: An IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems*, IPCC (2019). Available at <https://www.ipcc.ch/srccl/>.

33 Willingthon Pavan and others, "The Strawberry Advisory System: A web-based decision support tool for timing fungicide applications in strawberry", Department of Agricultural and Biological Engineering, UF/IFAS Extension, University of Florida, AE450 series, 2017. Available at <https://edis.ifas.ufl.edu/publication/AE450>.

34 AgroClimate, "About AgroClimate". Available at <http://agroclimate.org/about/> (accessed on 10 July 2021).

35 Ibid.

36 Clyde Fraisse, AgroClimate workbook: A guide for climate and agriculture in Southeastern U.S. (IFAS extension of University of Florida, 2016).

37 Leandro G. Cordova and others, "Meta-analysis of a web-based disease forecast system for control of anthracnose and botrytis fruit rots of strawberry in Southeastern United States", *Plant Disease*, vol. 101, no. 11 (November 2017). Available at <https://apsjournals.apsnet.org/doi/full/10.1094/PDIS-04-17-0477-RE>.

38 U.S. Climate Resilience Toolkit, "Strawberry Advisory System: Florida strawberry growers can use this Web-based decision support tool for timing fungicide applications", 8 June 2021. Available at <https://toolkit.climate.gov/tool/strawberry-advisory-system>.

3.1.1 Policies

Contributing to the success of this initiative is policy support to ensure a reliable network of weather stations.³⁹ The USA counts on the Weather Research and Forecasting Innovation Act of 2017,⁴⁰ which aims to improve NOAA's weather research through a focused programme of investment on affordable and attainable advances in observational, computing and modelling capabilities to support substantial improvement in weather forecasting and prediction of high-impact weather events, among others.

3.1.2 Lessons learned

The application and development of this initiative would not have been possible without access to data from the weather stations, and without access to the Internet and mobile phones by the farmers. Furthermore, the coalition of multiple universities pooling human and financial resources, has been key to the successful development of the initiative. Dr. Clyde estimates that including the field research, the total budget for the Strawberry Advisory System amounts to over USD1 million in the last 7-10 years. Government support has been critical, as it helps in funding and implementation of the initiative, and ensuring a reliable network of weather stations.

Other critical success factors mentioned by Dr. Clyde is the well-designed web and mobile phone application, the close interaction and education of growers, and the availability of a dedicated local group providing support to growers.

3.2 IoT for water management in Brazil, Italy and Spain (2017-2020)

Smart water management has become a key policy issue for this century, as a growing number of factors are impacting the delivery of scarce fresh water to millions of people. Economic growth, seasonal climatic conditions and rising population are all affecting the availability of water resources. Moreover, the effects linked to climate change, such as lengthy droughts and extreme weather events, are worsening water availability.⁴¹

The Internet of Things (IoT) has proven to be effective in reducing water consumption and energy costs, as demonstrated in the implementation of the SWAMP project in Brazil, Italy and Spain.⁴² The estimated water saving potential varied from 18-38 per cent depending on the amount of initial water needed for preparation of the field.⁴³

This project was funded by the European Union with EUR1,478,090 to the Finnish company Teknologian Tutkimuskeskus Vtt Oy to coordinate the implementation of the SWAMP project.⁴⁴ The work and innovations behind this project resulted in an open and flexible platform for smart water management for irrigation. Specifically, SWAMP targets the creation of very accurate situational awareness related to soil and crop status.

Multiple sources were used to gather the information needed, some of which represent key project innovations. The technologies

39 Interview with Dr. Clyde W. Fraisse, AgroClimate Project Director.

40 United States of America, Public Law No. 115-25 of 18 April 2017.

41 ITU, "ICT as an Enabler for Smart Water Management", ITU-T Technology Watch Report, October 2010. Available at <https://www.itu.int/en/ITU-T/techwatch/Pages/smartwatermanagement.aspx>.

42 European Commission, "Smart Water Management Platform – Fact Sheet". Available at <https://cordis.europa.eu/project/id/777112> (accessed on 11 August 2021).

43 European Commission, "Smart Water Management Platform –Reporting". Available at <https://cordis.europa.eu/project/id/777112/reporting> (accessed on 11 August 2021).

44 European Commission, "Smart Water Management Platform – Fact Sheet". Available at <https://cordis.europa.eu/project/id/777112> (accessed on 11 August 2021).

used include IoT platforms, applications, sensors, weather stations, actuators, drones, multi-spectral cameras and self-designed module to transmit the images directly to the cloud service, website platforms and mobile phone application, among others.⁴⁵

As a way forward, one of the companies involved in this project, Levertech, plans to use the SWAMP technology to help improve activities in agriculture.

3.2.1 Policies

Relevant to this project is the Europe 2020 Strategy (2010-2020) that recognizes climate change as one of the five national targets and shows commitment to finding solutions to pressing challenges from climate change, not only in the European Union but also worldwide.⁴⁶ Furthermore, the strategy highlights the obligation to combat climate change, as well as strengthen economies' resilience to climate risks, and capacities for disaster prevention and response. Even the measurable targets for 2020 contribute to the fight against climate change.

Another relevant policy that strengthens the use of digital technologies to combat climate change by mitigating and adapting to it is the European Green Deal (2019-2050).⁴⁷ Given that the SWAMP project was funded by the European Union, the project's alignment with the policy helped ensure its smooth implementation.

Other policies from pilot countries also supported the implementation of this project. Both Italy and Spain are under

the European Union Common Agricultural Policy, which financially supports European countries to lessen environmental impacts from the agriculture sector and adapt it to climate change.⁴⁸ Spain, for instance, counts on its National Framework for Rural Development (2014-2022) and the National Rural Development Programme (2014-2020),⁴⁹ which support the modernization of agriculture through smart irrigation systems, among others.⁵⁰ Italy has been applying European Environmental Standards in agriculture through decrees and codes, such as the Environmental Code 2006.⁵¹

In Brazil, its agricultural policy is defined in the annual Agricultural and Livestock Plan administered by the Ministry of Agriculture, Livestock and Food Supply. Some of its policy instruments include agricultural land zoning to facilitate farmers' adaptation to climate change and climate risks through environmental compliance and promotion of biofuels.⁵²

3.2.2 Lessons learned

The implementation of this project would not have been possible without European Union funds. However, this was not the only factor that enabled its implementation. First, it required cooperation between the project leads, farmers and the private sector. The farmers were the ones who had to test and monitor the system, and the private sector helped in the development of digital technologies. For instance, a company (Focknik, in Brazil pilot) supplemented the project with the building of the Variable Rate Irrigation System and 100 sensor probes.

45 European Commission, "Smart Water Management Platform –Reporting". Available at <https://cordis.europa.eu/project/id/777112/reporting> (accessed on 11 August 2021).

46 European Commission, *Europe 2020: A European strategy for smart, sustainable and inclusive growth* (Brussels, 2010). Available at <https://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf>.

47 European Commission, "Delivering the European Green Deal". Available at https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en (accessed on 11 August 2021).

48 Ferdinando Albinis and Roberto Saija, "Agricultural law in Italy: Overview", Thomson Reuters Practical Law, 1 September 2020. Available at <https://content.next.westlaw.com/6-606-7166>.

49 European Commission, "Spain – National Framework and Rural Development Programme". Available at https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/rural-development/country/spain_en (accessed on 11 August 2021).

50 European Commission, "Factsheet on 2014-2022 national framework for rural development in Spain", May 2021. Available at https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/key_policies/documents/rdp-factsheet-spain-national-framework_en.pdf.

51 Ferdinando Albinis and Roberto Saija, "Agricultural law in Italy: Overview", Thomson Reuters Practical Law, 1 September 2020. Available at <https://content.next.westlaw.com/6-606-7166>.

52 Organisation for Economic Co-operation and Development, "Agricultural Policy Monitoring and Evaluation 2020 – Brazil". Available at <https://www.oecd-ilibrary.org/sites/8f4be872-en/index.html?itemId=/content/component/8f4be872-en> (accessed on 11 August 2021).

Second, interest by the participants and the governments was key, as was the case for the Brazilian pilot:

"The SWAMP Project was a success in Brazil due to the significant role that agriculture plays in the country's economy. Farmers from all over the country and several types of specialized media wanted to obtain fresh news from the project during the three years."⁵³

Third, government support was important. As an example, in Cartagena (Spain) they could not fly drones due to regulatory restrictions, which did not allow the team to complete the project. Fourth, human capital was key to the development of the project, since digital applications, platforms, models and forecasting systems had to be developed during the project. Finally, private sector support played a key role in extending the use of the technologies developed beyond the pilot stage of the project.

3.3 Drones for forest fire prevention and management in the Republic of Korea (since 2013)⁵⁴

The risk of forest fires has been increasing dramatically, as global warming is leading to longer, harsher droughts and more extreme weather events.⁵⁵ Drones, together with the use of other technologies, such as geospatial information systems (GIS), global positioning system (GPS), closed-circuit television (CCTV) cameras, smartphone applications

and website portals, have proven to reduce forest fire detection and extinction time. In the Republic of Korea, the implementation of such digital technologies resulted in a reduction from 30 to 5 minutes to detect a forest fire and from 32 to 13 hours to extinguish it.⁵⁶

The initiative started in 2013 when the Korean Forest Service introduced a four-phased plan to develop an integrated system for forest disaster prevention.⁵⁷ Given its success, the Korean Forest Service has been utilizing a scientific and systematic approach since August 2019 through a smart forest disaster response team that actively uses smart technologies for forest management.⁵⁸ In 2020, the government established a new comprehensive forest fire prevention plan. The plan focuses on the provision of a system for forest fire prevention, response and suppression based on science and technology in line with the Fourth Industrial Revolution. This plan also strengthens the monitoring and control of forest disease and pests with smart technologies.⁵⁹

Having experienced several large forest fires, the Korean government recognized the need for a dedicated organization and system to quickly respond to forest fires. This recognition led to the formation of a central organization in charge of forest fires under the Korea Forest Service and a network of organizations responsible for forest fires in local governments and regional Forest Service Offices, which are currently operating to complement one another.⁶⁰ Some of the

53 European Commission, "SWAMP Smart Water Management Platform: D5.6 Pilot evaluation report", 16 December 2020, p. 33. Available at <https://ec.europa.eu/research/participants/documents/downloadPublic?documentId=080166e5d73fda25&apId=PPGMS>.

54 Global Delivery Initiative, "Case Study – Smart Forest Fire Management in the Republic of Korea: Creating a Data-Driven and User-Oriented Wildfire Prediction and Monitoring System", February 2021. Available at https://www.effectivecooperation.org/system/files/2021-06/gdi_case_study_smart_forest_fire_management_in_korea_0.pdf.

55 World Economic Forum, "The climate loop: 6 ways global warming is fuelling US fires", 24 September 2020. Available at <https://www.weforum.org/agenda/2020/09/climate-feedback-climate-change-forest-fires>.

56 Global Delivery Initiative, "Delivery Note – Smart Forest Fire Management in the Republic of Korea: Creating a Data-Driven and User-Oriented Wildfire Prediction and Monitoring System", June 2021. Available at https://www.effectivecooperation.org/system/files/2021-06/gdi_delivery_note_on_smart_forest_fire_management_in_the_republic_of_korea.pdf.

57 Ibid.

58 Baek Byung-yeul, "Korea Forest Service adopts ICT to prevent bushfires", The Korea Times: Biz & Tech, 30 March 2020. Available at https://www.koreatimes.co.kr/www/tech/2021/09/133_287041.html.

59 Korea Forest Service, "Forest Fire Management Policy and Technology in Korea: Modularization of Korea's Development Experience in Forestry Field", 2020. Available at https://english.forest.go.kr/kfswb/cop/bbs/selectBoardArticle.do?nttlId=3154714&bbsId=BBSMSTR_1057&pageIndex=1&pageUnit=10&searchTitle=title&searchCont=&searchKey=&searchWriter=&searchDept=&searchWrd=&ctgryLrcls=&ctgryMdcls=&ctgrySmcls=&ntcStartDt=&ntcEndDt=&orgId=&mn=UENG_04_05.

60 Ibid.

organizations include: the National Institute of Forest Science (conducts research on fire prediction and launched a fire danger rating system), the Korean Forestry Promotion Institute (promotes forestry technologies and creates global forestry value for combating climate change),⁶¹ and the Korean Forest Fire Management Service Association (develops policies and promotes forest fire prevention technologies).⁶²

In order to prevent and suppress forest fires, the Korean government utilizes considerable financial resources (USD 228 million) and manpower, equipment and systems to carry out fire prevention activities.⁶³

3.3.1 Policies

Before implementation of the four-phased plan for forest disaster prevention in 2013, there was the National Informatization Basic Plan (2008-2012) and the Smart E-Government Plan (2011-2015). The plans resulted in 5 areas, 21 agendas, and 72 informatization activities. Among them, the e-government project is the fourth area with 4 agendas and 19 activities.⁶⁴ The agendas are aligned with the goals of this forest fire prevention initiative, which was a need recognized from the government.

Today, under the Korean New Deal, the Republic of Korea explicitly supports the use of digital technologies for climate adaptation, with one of its focus areas being the green transition of infrastructures through the restoration of terrestrial, marine and urban ecosystems, among others.⁶⁵

3.3.2 Lessons learned

For the successful implementation of this forest fire monitoring system, interagency cooperation efforts are highlighted. Those that facilitated communication among first responders, combined with real-time situational information from the smart forest fire prediction and monitoring system, improved forest fire preparedness dramatically. Furthermore, the forest service officials worked closely with multiple partners across different levels of government as well as with academics and private sector experts on forest science and wildfire research. Such collaborations helped the forest service keep the underlying datasets up to date, and enabled faster emergency communication and response.⁶⁶ The prompt availability of data from diverse sources supported informed decision-making during wildfire emergencies.⁶⁷

User-friendly mobile application and system were essential to ensure that forest fire prevention and control division officials switch from their old system to this new one. In this case, the results of online user polls and feedback from user interviews were incorporated in the design of the application and system. Trust between the developers in the ICT division team and the forest fire prevention and control division officials was critical to ensure the effective use of the new system.

Last but not least, this initiative would not have been possible without the government's strong awareness and commitment to

61 Climate Technology Centre and Network, "Korea Forestry Promotion Institute". Available at <https://www.ctc-n.org/network/network-members/korea-forestry-promotion-institute>.

62 Korea Forest Fire Management Service Association, "About Us". Available at <http://www.kffmsa.kr/eng/index.html> (accessed on 29 August 2021).

63 Korea Forest Service, "Forest Fire Management Policy and Technology in Korea: Modularization of Korea's Development Experience in Forestry Field", 2020. Available at https://english.forest.go.kr/kfswb/cop/bbs/selectBoardArticle.do?nttlId=3154714&bbsId=BBSMSTR_1057&pageIndex=1&pageUnit=10&searchTitle=title&searchCont=&searchKey=&searchWriter=&searchDept=&searchWrd=&ctgryLrclIs=&ctgryMdclIs=&ctgrySmclIs=&ntcStartDt=&ntcEndDt=&orgId=&mn=UENG_04_05.

64 Choong-Sik Chung, "The Introduction of e-Government in Korea: Development Journey, Outcomes and Future", *Gestion et Management Public*, vol. 3, no. 4 (2015), pp. 107-122. Available at <https://www.cairn.info/revue-gestion-et-management-public-2015-2-page-107.htm>.

65 Government of the Republic of Korea, "National Strategy for a Great Transformation: Korean New Deal", July 2020. Available at https://english.moef.go.kr/co/fixFileDownload.do?orgNm=Korean_New_Deal.pdf.

66 Global Delivery Initiative, "Case Study – Smart Forest Fire Management in the Republic of Korea: Creating a Data-Driven and User-Oriented Wildfire Prediction and Monitoring System", February 2021. Available at https://www.effectivecooperation.org/system/files/2021-06/gdi_case_study_smart_forest_fire_management_in_korea_0.pdf.

67 Ibid.

improve crisis response. This facilitated interagency cooperation and resulted in the establishment of an interagency fire operations centre in 2018,⁶⁸ which, to date, continues to improve its monitoring system.⁶⁹

3.4 Satellites for flood forecasting in Bangladesh and India (since 2018)

Flooding is the most common natural disaster on the planet, affecting the lives of hundreds of millions of people worldwide and causing around USD10 billion in damages every year.⁷⁰ Satellites, together with the use of other complementary technologies such as stream gauging stations, electronic sensors, GIS and GPS technologies, computers, and smartphones⁷¹ have saved many lives with earlier warnings of imminent flooding.⁷² Moreover, the information from high resolution elevation maps developed with data from digital technologies enables decision makers to take informed planning decisions, based on full details of the flood risks.

The Google Flood Forecasting Initiative is a Google.org-funded initiative that aims to improve flood forecasting by providing unprecedented lead time, accuracy and clarity worldwide.⁷³ This has been possible with automated river gauges that report water levels in real time; satellites providing images that contribute to flood mapping and modelling for location-specific warnings; smartphones for the dissemination of early warnings; and AI such as machine learning to make more accurate predictions.⁷⁴

Starting with Bangladesh and India, the most flood prone areas in the world, Google.org's initiative is providing people with information about flood depth – when, where and how much floodwaters are likely to rise. In areas where it is possible to produce depth maps throughout the floodplain, they are sharing information about depth in the user's village or area. The recent improvement to the forecasting model has doubled the lead time of many of their alerts – providing more notice to governments and giving tens of millions of people an extra day or so to prepare.⁷⁵

Although this initiative is led and funded by Google.org, it required the collaboration of government agencies, such as the Indian Central Water Commission and the Bangladesh Water Development Board, in order to expand warnings and improve services. This initiative also collaborated with Yale University to better understand what information people need, how they use it to protect themselves, and what to do to make that information more accessible; and with the International Federation of Red Cross and Red Crescent Societies to build local networks that can get disaster alert information to people who would not otherwise receive smartphone alerts directly.⁷⁶ The initiative's satellite partners include Airbus, Maxar and Planet.⁷⁷

3.4.1 Policies

Google.org aims to expand this initiative globally, increasing the potential benefits of such initiative. Even though it is a global initiative from the private sector, Google.org still needs the support from governments.

68 Ibid.

69 Baek Byung-yeul, "Korea Forest Service adopts ICT to prevent bushfires", The Korea Times: Biz & Tech, 30 March 2020. Available at https://www.koreatimes.co.kr/www/tech/2021/09/133_287041.html.

70 Sella Nevo, "The Technology Behind our Recent Improvements in Flood Forecasting", Google AI Blog, 3 September 2020. Available at <https://ai.googleblog.com/2020/09/the-technology-behind-our-recent.html>.

71 Ibid.

72 Abhishek Modi and Karan Agarwal, "Google's Flood Forecasting Initiative: Sounding the Alarm in India and Beyond", presentation by Google. Available at <https://thedocs.worldbank.org/en/doc/500781574707911439-0310022019/render/AbhishekModi.pdf>.

73 Sella Nevo, "The Technology Behind our Recent Improvements in Flood Forecasting", Google AI Blog, 3 September 2020. Available at <https://ai.googleblog.com/2020/09/the-technology-behind-our-recent.html>.

74 Ibid.

75 INDIAai, "Using AI to predict floods and save lives", 4 December 2020. Available at <https://indiaai.gov.in/case-study/using-ai-to-predict-floods-and-save-lives>.

76 Yossi Matias, "A big step for flood forecasts in India and Bangladesh", Google, 1 September 2020. Available at <https://blog.google/technology/ai/flood-forecasts-india-bangladesh/>.

77 Sella Nevo, "The Technology Behind our Recent Improvements in Flood Forecasting", Google AI Blog, 3 September 2020. Available at <https://ai.googleblog.com/2020/09/the-technology-behind-our-recent.html>.

In India, there is the National Policy on Information Technology (2012-2020)⁷⁸ and Digital India,⁷⁹ the national flagship programme to transform India into a digitally empowered society and knowledge economy. They both support this initiative, leveraging GIS for decision-support systems and development.

In Bangladesh, one of the strategic goals and milestones of the “Making Vision 2041 a Reality: Perspective Plan of Bangladesh 2021-2041” is to build a resilient Bangladesh to climate change and other environmental challenges.⁸⁰ The plan recognizes the existing challenges in implementing the many laws and regulations that support climate adaptation (page 200), and this initiative contributes to advancing climate adaptation in more vulnerable and flood-prone areas.

3.4.2 Lessons learned

The capital needed for the implementation of this initiative is not known, but Google.org has granted USD200 million for social initiatives and non-governmental organizations worldwide.⁸¹ An initiative like this one requires huge investments for the development of forecasting models and machine learning. In addition to financial capital, machine learning expertise (human capital), computational resources, access to global data and the scalability of the project are determinants of its success.⁸² Collaboration is also a key component for this initiative, as well as government support.

3.5 Satellites for coral reef conservation in Australia (since 2012)

Coral reefs are important ecosystems for fisheries, and protect coastal areas against disasters. However, due to increasing temperatures in the ocean, coral reefs are disappearing. For this reason, many countries have begun monitoring coral bleaching and reef health. Remote sensing techniques (satellites) using the sea surface temperature provide a quick, broad way to assess the risk of coral reef bleaching.⁸³

Australia’s eReefs portal is a publicprivate collaboration project that started in 2012, combining government’s commitment to reef protection, world-class science innovation and contributions from leading Australian businesses.⁸⁴

The eReefs portal combines an array of data, including sea surface temperature and chlorophyll concentration, to monitor the water quality and coral reef health of the Great Barrier Reef.⁸⁵ It produces powerful visualizations, communication and reporting tools, benefiting government agencies, reef managers, policymakers, researchers, industries and local communities.⁸⁶ The impacts generated from the implementation of this initiative are large, from more efficient decision-making to improved water quality, improved marine bio-ecosystems and reduced likelihood of serious environmental damage.⁸⁷ The economic benefits from this

78 NeoStencil, “National Policy on Information Technology”. Available at <https://neostencil.com/upsc-science-tech-national-policy-on-information-technology> (accessed on 6 October 2021).

79 India’s Ministry of Electronics and Information Technology, “Digital India: Power to Empower – Vision and Vision Areas”. Available at <https://www.digitalindia.gov.in/content/vision-and-vision-areas> (accessed on 23 Sept 2021).

80 Bangladesh’s Ministry of Planning, “Making Vision 2041 a Reality: Perspective Plan of Bangladesh 2021-2041”, March 2020. Available at <http://oldweb.lged.gov.bd/UploadedDocument/UnitPublication/1/1049/vision%202021-2041.pdf>.

81 Google, “Our Approach”. Available at <https://www.google.org/our-approach/> (accessed on 29 August 2021).

82 Abhishek Modi and Karan Agarwal, “Google’s Flood Forecasting Initiative: Sounding the Alarm in India and Beyond”, presentation by Google. Available at <https://thedocs.worldbank.org/en/doc/500781574707911439-0310022019/render/AbhishekModi.pdf>.

83 ESCAP, *Geospatial Practices for Sustainable Development in Asia and the Pacific 2020: A Compendium* (Bangkok, 2020). Available at <https://www.unescap.org/publications/geospatial-practices-sustainable-development-asia-and-pacific-2020-compendium>.

84 Great Barrier Reef Foundation, “eReefs”. Available at <https://ereefs.org.au/ereefs/about> (accessed on 29 August 2021).

85 ESCAP, *Geospatial Practices for Sustainable Development in Asia and the Pacific 2020: A Compendium* (Bangkok, 2020). Available at <https://www.unescap.org/publications/geospatial-practices-sustainable-development-asia-and-pacific-2020-compendium>.

86 Acil Allen Consulting, “Ereefs Case Study”, April 2016. Available at <https://www.csiro.au/-/media/About/Files/Impact-assessment/2016/Impact-evaluation-eReefs.pdf>.

87 Ibid.

initiative are also important, with net present value of benefits to 2025-26 of USD80.8 million, coming from tourism and the reduction of the probability of a catastrophic event.⁸⁸

3.5.1 Policies

Australia's commitment to protect the Great Barrier Reef can be seen through a number of acts and management plans, such as the Environment Protection and Biodiversity Conservation Act 1999, which allows rigorous environmental assessments of the Great Barrier Reef, and the Reef 2050 Long-Term Sustainability Plan, which includes actions to boost the health and resilience of the reef to cope with pressures, including the effects of climate change.⁸⁹ This plan includes the use of digital technologies, such as satellites, for the monitoring of the Great Barrier Reef and marine ecosystems. Other laws and agreements also target its protection.⁹⁰

3.5.2 Lessons learned

The success behind the protection of the Great Barrier Reef can be partly explained by the strong commitment of the Australian Government, which is supported by the implementation of policies described. Apart from the many regulations, plans and funding that have created an enabling environment for its success, collaboration has also been at the core of the initiative to pool human and financial resources.⁹¹

3.6 Summary of digital technologies for climate adaptation

In this working paper, 15 digital technologies have been discussed. These include: weather/stream gauging stations, online platforms/web portals, GIS, GPS, smartphone applications, email, SMS, sensors, IoT, AI,

actuators, drones, satellites, CCTV cameras and computers. The most used digital technologies across the case studies are weather or stream gauging stations, online platforms, GIS and GPS technologies, computers, and smartphone applications.

Weather or stream gauging stations, smartphone applications, sensors, drones, satellites, IoT, actuators and CCTV cameras provide powerful tools for data collection, which serve as inputs for forecasting models, as shown in the US, Australian and Google.org case studies. These digital technologies are also important for monitoring and control, as shown in the Korean case, and for the enhancement of processes, as shown in the SWAMP pilot project.

Online platforms, smartphone applications, email and SMS technologies are common channels for disseminating information on imminent disasters and have enabled people to anticipate the damages by taking precautionary actions. In the case of the Google.org initiative, for example, early receipt of warning messages allows more time for evacuation. GIS and GPS technologies and AI have enhanced the precision of the data represented, further minimizing damages and losses from disasters and climate change.

Finally, computers have been essential to run programs for the resulting forecasting models, for instance, in the Australian case.

Other technologies that help advance climate adaptation are dykes and sluice gates for coastal protection, insurance tools to protect farmers or people living in flood prone areas from losses incurred from floods or other climate impacts, and spray mechanisms that water roads to lower temperatures.⁹² These technologies and tools are increasingly being enhanced with digital technologies.

88 Commonwealth Scientific and Industrial Research Organisation, "Ensuring a vital future for the Great Barrier Reef: eReefs platform transforming our ability to manage and protect the Great Barrier Reef for the long term". Available at <https://www.csiro.au/en/research/natural-environment/oceans/ereefs-management-system> (accessed on 29 August 2021).

89 Australia's Department of Agriculture, Water and the Environment, "What Australia is doing to manage the Great Barrier Reef", June 2015. Available at <http://www.environment.gov.au/marine/gbr/publications/what-australia-doing-manage-great-barrier-reef>.

90 Australia's Great Barrier Reef Marine Park Authority, "Legislation, regulations, agreements and policies". Available at <https://www.gbrmpa.gov.au/about-us/legislation-regulations-and-policies>.

91 Australia's Department of Agriculture, Water and the Environment, "Managing and Protecting the Great Barrier Reef". Available at <https://www.awe.gov.au/parks-heritage/great-barrier-reef/protecting-the-reef>.

92 Other interesting examples can be found in: Hyejung Kim, *Technologies for adapting to climate change: A case study of Korean cities and implications for Latin American cities* (Santiago, United Nations Economic Commission for Latin America and the Caribbean, 2021). Available at https://repositorio.cepal.org/bitstream/handle/11362/46992/1/S2100001_en.pdf.

Table 2. Overview of case studies assessed

Case study	Climate-related challenges	ICT interventions	Climate adaptation outcomes	Integration of climate adaptation and ICTs at the policy level
Weather stations for pest control in Florida, USA	Distributions of pests and diseases in agriculture will change, affecting production negatively in many regions due to climate change. Inaction results in a reduction of yield, affecting global food security.	Weather stations (data collection), platforms (dissemination of data), smartphones, email and SMS technologies (early warning dissemination).	Effective in controlling fruit rot diseases with no reduction in yield while substantially reducing fungicide applications.	Weather Research and Forecasting Innovation Act of 2017.
IoT for water management in Brazil, Italy and Spain	Smart water management has become a key policy issue for this century as a growing number of factors are impacting the delivery of scarce fresh water to millions of people.	IoT platforms, applications, sensors, actuators, drones, multi-spectral cameras (to gather information) and self-designed module (to transmit the images directly to the cloud service), website platforms and mobile phone application (early warning).	The estimated water saving potential varied from 18-38 per cent depending on the amount of initial water needed for preparation of the field.	Europe 2020 Strategy, European Green Deal, EU Common Agricultural Policy and Brazil's Agricultural and Livestock Plan.
Drones for forest fire prevention and management in the Republic of Korea	The risk of forest fires has been increasing dramatically as global warming is leading to longer, harsher droughts and more extreme weather events.	Drones and CCTV cameras (for health monitoring and control of forest fires), GIS and GPS (for development of risk maps), smartphone application (for users to communicate and as early warning system) and website portal (for awareness raising of forest fire risk).	An improvement in efficiency of forest fire management, reducing up to 6 times the time to detect a forest fire and 2.5 times to extinguish it.	National Informatization Basic Plan, Smart E-Government Plan and Korean New Deal.
Satellites for flood forecasting in Bangladesh and India	Flooding is the most common natural disaster on the planet, affecting the lives of hundreds of millions of people worldwide and causing around USD10 billion in damages every year.	Automated river gauges that report water levels in real time; satellites providing images that contribute to flood mapping and modelling for location-specific warnings; smartphones for dissemination of early warning; and AI such as machine learning to make more accurate predictions.	This has doubled lead time – providing more notice to governments and giving tens of millions of people an extra day or so to prepare.	Digital India and Making Vision 2041 a Reality: Perspective Plan of Bangladesh 2021-2041.
Satellites for coral reef conservation in Australia	Coral reefs are important ecosystems for fisheries and protect coastal areas against disasters. However, due to increasing temperatures in the ocean, coral reefs are disappearing.	Remote sensing techniques (satellites) to assess the risk of coral reef bleaching, and platforms to increase awareness and provide detailed information on health status of the coral reef, among others.	More efficient decision-making, improved water quality, improved marine bio-ecosystems and reduced likelihood of serious environmental damage. The economic benefits include a net present value of benefits to 2025-26 of USD80.8 million, coming from tourism and for the reduction of the probability of a catastrophic event.	Reef 2050 Long-Term Sustainability Plan.



04

Key findings from good policies and practices

The current status of digital technology applications for climate adaptation is marked by intense and constant research and improvement of ongoing or new projects, supported by national ICT and development policies. However, many projects are pilots and are not continued or scaled, while the technologies used are mostly simple and not necessarily expensive. These findings show that the factors determining the success of such initiatives go well beyond the use of digital technologies.

4.1 Climate adaptation mainstreamed in ICT policies

ICT policies that mainstream climate adaptation have enabled governments to support different initiatives that use digital technologies for climate adaptation. This is the case, for instance, in the Republic of Korea, which through the National Informatization Basic Plan (2008-2012) and the Smart E-Government Plan (2011-2015), and later, with the Korean New Deal, could develop and support the continuation of the use of digital technologies for monitoring forest fires.

The existence of ICT and development policies that mainstream both climate adaptation and the use of digital technologies, not only strengthens governments' commitment to adapt to climate change through the use of digital technologies, but also ensures that these projects are prioritized to receive funding and human capital for their successful implementation.⁹³

4.2 Sustained cross-sectoral collaboration

When governments cannot support the continued implementation of a pilot, private sector support has proven to be an effective solution to push pilots further. This is the case of the SWAMP pilot project, where Levertech (in Brazil) plans to scale the technology developed in the pilot.

Another recurrent point in the case studies is the importance of collaboration between different entities – governments, private sector and research institutions (also known as the Triple Helix model of innovation).⁹⁴ Through these collaborations, entrepreneurship, innovation and economic growth are fostered.⁹⁵ This enables the pooling of human and financial resources, and the overcoming of some of the barriers that are usually present when implementing technically complex and costly projects.

There has also been collaboration with humanitarian organizations, such as with the International Federation of Red Cross and Red Crescent Societies in the case of Bangladesh and India. This has proven to be an effective way to overcome digital gaps when implementing ICT projects for climate adaptation in more vulnerable and remote areas.

4.3 Public data sharing

This collaboration, however, needs to be sustained across time with constant communication and support across the agencies, as shown in the Korean and US cases. Moreover, access to data has been key for all case studies to be able to produce models and forecasts. Public data sharing by organizations has helped advance climate adaptation. For example, the innovations and lessons learned from the SWAMP project have allowed Levertech to keep pushing for this initiative, instead of starting from scratch.

4.4 Close interaction with end users and the population

Finally, user-friendly platforms and mobile applications have ensured the effectiveness of communication between developers and users. Even if the end users do not have access to digital devices, collaboration with local non-governmental organizations to build local networks to access information is a good alternative, as illustrated in the Google.org case study.

⁹³ Kathleen Mogelgaard and others, "From planning to action: Mainstreaming climate change adaptation into development", World Resources Institute Working Paper, September 2018. Available at <https://www.wri.org/research/planning-action-mainstreaming-climate-change-adaptation-development>.

⁹⁴ IGI Global Publisher of Timely Knowledge, "What is Triple Helix". Available at <https://www.igi-global.com/dictionary/triple-helix/40797> (accessed on 10 September 2021).

⁹⁵ Ibid.

4.5 Key barriers for CSNs

The existing barriers in CSNs, however, give rise to additional challenges that hinder the promotion of digital applications to adapt to climate change.

4.5.1 Lack of climate change data availability and access, and lack of data analysts

The lack of climate-related data availability and access, and the lack of data analysts to process and generate insights from the data, present a big obstacle for development organizations and governments to assess and tackle climate risks. As observed in the case studies, data availability and access and the models developed are key foundations to advance and guide actions and prevent losses due to climate change. For example, a good network of weather stations in Florida, USA has enabled the availability and access to key weather data, and the creation of an early warning system through a model to control and reduce losses from pests.

In cases where countries do not have capacity and urgent action is needed, the private sector has intervened. The Google.org initiative represents an advancement in filling data gaps in the most vulnerable and flood prone areas in Asia and the Pacific, and has managed to improve early warning and save lives. However, data availability on its own is insufficient. In order to avoid dependency issues with the private sector in the long term, the data and forecasting models should be publicly accessible (see Section 4.5.4).

4.5.2 Lack of funding for climate adaptation initiatives that involve the use of digital technologies

CSNs face chronic shortages of financial resources⁹⁶ that not only impede their access to digital technologies,⁹⁷ but also

their implementation of climate adaptation projects. The inherent lack of access to digital technologies affects their digital literacy, which further challenges climate adaptation through ICTs.

However, there are multiple funds that can help in the advancement of climate adaptation. Some of them are the Adaptation Fund,⁹⁸ which has committed USD850 million to climate adaptation projects since 2010; the Green Climate Fund,⁹⁹ considered the largest global fund to help fight climate change; and the Official Development Assistance,¹⁰⁰ which is the main source of financing for development aid.

One of the downsides of international funds is that they cannot cover all projects, which results in a further delay of climate adaptation. The development of new financing mechanisms or the strengthening of existing ones that CSNs could leverage for climate adaptation would be important to consider.

4.5.3 Lack of ICT policies that mainstream climate adaptation

In all cases analysed, there are policies and other regulatory mechanisms that strengthen the role, mandate and commitment of governments to advance climate adaptation through digital technologies. However, 11 countries in Asia-Pacific, all of which are CSNs, still do not have an ICT policy or strategy. This is of concern since these countries are generally more vulnerable to the effects of climate change, and the absence of an overarching policy or strategy to guide and coordinate efforts could result in missed opportunities to harness the potential of digital technologies for climate adaptation.

Taking the Europe-funded pilot project as an example, the European Union had the mandate and commitment to adapt the

96 ESCAP, *Asia-Pacific Countries with Special Needs Development Report 2021: Strengthening the resilience of least developed countries in the wake of the coronavirus disease pandemic* (Bangkok, 2021). Available at <https://www.unescap.org/kp/2021/CSNDR2021>.

97 United Nations Conference on Trade and Development, *Technology and Innovation Report 2021: Catching technological waves – Innovation with equity* (New York, 2021). Available at <https://unctad.org/webflyer/technology-and-innovation-report-2021>.

98 Adaptation Fund, "About the Adaptation Fund". Available at <https://www.adaptation-fund.org/about/> (accessed on 20 September 2021).

99 Green Climate Fund, "About GCF". Available at <https://www.greenclimate.fund/about> (accessed on 20 September 2021).

100 Organisation for Economic Co-operation and Development, "Official Development Assistance (ODA)". Available at <https://www.oecd.org/dac/financing-sustainable-development/development-finance-standards/official-development-assistance.htm> (accessed on 20 September 2021).

agriculture sector to climate change using digital technologies, thanks to existing strategies during the implementation of the project, such as the Europe 2020 Strategy and the European Green Deal. Moreover, the project counted on the support of national policies from the pilot countries. In Spain for example, the project could not be fully implemented due to a regulation that did not allow the use of drones – further highlighting the importance of policy and regulatory support.

4.5.4 Lack of government-owned climate adaptation projects that advance digital development

Despite growing political attention and tools to support the mainstreaming of climate adaptation in ICT policies, an implementation gap persists. Efforts to mainstream adaptation into development policies and plans have been slow to translate into robust actions at national and subnational levels, undermining the ability to prepare the world's most vulnerable communities for the climate impacts that lie ahead.¹⁰¹

In cases where governments are committed but do not have sufficient resources for implementation, an external entity may play the coordinating role like in the Google.org initiative. However, clear responsibilities and terms need to be stated in the partnership, particularly regarding governments' access to the flood forecasting service and their ability to evaluate proprietary AI algorithms applied to the flood forecasting system. Measures must also be in place to safeguard data privacy and security.

While Google.org does not charge a fee for the flood forecasting information, it is possible for Google.org to shut down the system at any point, leaving governments

that had become reliant on it completely unattended. Hence, while in the short term, cost and capacity constraints do not apply; in the longer term, dependency may result.

4.5.5 Lack of regional cooperation

Both climate change and digital development are cross-boundary issues that not only require the involvement of many stakeholders across sectors, but also the cooperation, coordination and support from different regions and countries. In relation to the issues discussed in this working paper, regional cooperation on digitalization for climate adaptation is still not fully exploited.

Despite the existence of some regional cooperation platforms for climate adaptation, such as the Central Asian Climate Information Platform,¹⁰² Association of Southeast Asian Nations (ASEAN) Climate Resilience Network¹⁰³ and Regional Climate Consortium for Asia and the Pacific,¹⁰⁴ member States are only partners and do not lead the platforms or, in some cases, the platforms are led by just one country. This raises the issue of lack of ownership and awareness by the member countries, leading to the reduced effectiveness of these platforms.

Furthermore, most of these platforms do not include all countries from the Asia-Pacific region, rather, they are often subregional; and not all of them focus on general adaptation, but in specific sectors (such as data or agriculture), not taking a holistic approach. On this point, digital technologies are only emphasized in data collection and in the models used, ignoring other potential applications as discussed in this working paper. Lastly, in some cases, financial support is not mentioned, even though it is one of the main barriers for many countries that are being left behind in terms of digital development and climate adaptation.

101 Kathleen Mogelgaard and others, "From planning to action: Mainstreaming climate change adaptation into development", World Resources Institute Working Paper, September 2018. Available at <https://www.wri.org/research/planning-action-mainstreaming-climate-change-adaptation-development>.

102 Regional Environmental Centre for Central Asia, "Information Portal on Climate Adaptation and Mitigation in Central Asia". Available at <https://ca-climate.org/eng/cacip.php> (accessed on 20 September 2021).

103 ASEAN Climate Resilience Network, "About us". Available at <https://asean-crn.org/asean-climate-resilience-network-asean-crn-platform-regional-exchange/> (accessed on 20 September 2021).

104 Regional Climate Consortium for Asia and the Pacific, "About RCCAP". Available at <https://www.rccap.org/about-rccap/> (accessed on 20 September 2021).



05

Policy recommendations

In light of the assessment in this working paper, five key policy recommendations are put forward to accelerate the use of digital technologies for climate adaptation, especially in CSNs from the Asia-Pacific region.

5.1 Build capacity to bridge climate change data gaps

As observed in the cases analysed and in the context of increasing extreme weather events and a climate crisis, reliable, real-time access to observational data is critical for high quality weather forecasts and climate analyses.

While some regions provide a good and robust supply of surface-based observations, some areas of the world, notably SIDS and least developed countries, significantly lack the infrastructure and financial and human capacity to do so. These countries fail to meet the World Meteorological Organization's Global Basic Observing Network (GBON) requirements,¹⁰⁵ which allow network integration and partnership outreach for global space- and surface-based observations and predictions.¹⁰⁶ This adversely impacts the accuracy of weather and climate products, both locally and in areas far from the missing data.

As a way forward, capacity building trainings should be offered to countries in Asia-Pacific that do not have the relevant skills and competencies to collect, understand and process climate-related data, prepare metadata, and establish mechanisms for collaboration with data providers, among others.¹⁰⁷

5.2 Explore financial alternatives to fund digital climate adaptation projects

CSNs cannot wait to replicate the projects that use digital technologies for climate adaptation, since most of those are still in development or under constant improvement. Waiting to adapt to climate change may be too late and threatens the development of the most vulnerable countries.

However, CSNs often face financial and economic constraints, which hinder the realization of such capital intensive projects. Global funds cannot always finance the projects. Financial alternatives or other forms of collaboration, such as the one presented by the Triple Helix, provide effective ways to overcome financial constraints.

Other forms of financing that governments could consider include incentivizing the private sector to invest in climate adaptation and mitigation options, through tax incentives, for example. Crowdsourcing mechanisms to collect weather data, and the ability to collate user-provided weather/climate data at the local/national levels to help in the development of risk maps and early warning systems are also effective. In countries where agriculture or fisheries is a major industry, farmers can be incentivized to invest in micro weather stations that can feed into the national dataset – helping to make better informed decisions over time.

5.3 Strengthen governance and institutional capacity to mainstream climate adaptation into ICT policies

Regulatory barriers, such as bureaucratic delay, the slow pace of the legal process and existing corruption in the ecosystem

¹⁰⁵ Systemic Observations Financing Facility, "The gaps in the Global Basic Observing Network (GBON)", October 2020. Available at https://library.wmo.int/doc_num.php?explnum_id=10377.

¹⁰⁶ World Meteorological Organization, "WMO Integrated Global Observing System (WIGOS)". Available at <https://public.wmo.int/en/about-us/vision-and-mission/wmo-integrated-global-observing-system> (accessed on 25 September 2021).

¹⁰⁷ ESCAP, *Asia-Pacific Guidelines to Data Integration for Official Statistics* (Bangkok, 2020). Available at https://www.unescap.org/sites/default/d8files/knowledge-products/Data_Integration_Guidelines_ESCAP.pdf.

are present in some countries and further challenge the implementation of ICT policies and strategies, as well as undermine adaptation processes.

There is the need to review existing ICT policies and regulations at the national and regional levels and enhance collaboration across ministries, with the aim to ensure that they support climate adaptation and are aligned with adaptation objectives. Some countries with ICT policies that mainstream climate adaptation, such as Iran, are already contemplating its development.¹⁰⁸

As a way forward, developing national overarching vision documents that clearly outline the linkages between ICT policies and climate adaptation can advance climate adaptation mainstreaming into ICT policies.

5.4 Accelerate the development and implementation of digital climate adaptation projects

In many cases, CSNs have neither the technical capacity nor the financial capacity to develop and implement projects of this nature. Governments alone face many challenges for a project to be successfully implemented and maintained through time. However, human and financial resources can be pooled when governments collaborate with the private sector and academia, and even humanitarian organizations – as evidenced in the case studies reviewed.

The collaboration of multiple stakeholders in projects that require technical knowledge and substantial investment, such as the Triple Helix model of innovation, has proven to be effective to overcome financial, human and economic constraints. This, however, may require some changes to the structure of institutions and regulatory policies to accelerate the development and deployment of projects.

5.5 Include climate adaptation projects in regional cooperation platforms that advance digital development

Despite existing cooperation platforms that advance climate adaptation, these do not manage to fully exploit the use of digital technologies for climate adaptation in a holistic way. Furthermore, most have their own limitations – geographically and in scope.

The Asia-Pacific Information Superhighway (AP-IS)¹⁰⁹ provides a unique platform for stakeholders in the region to work together, share lessons learned and strengthen cross-sectoral collaboration with the aim to advance digital development at the regional level. The mainstreaming of climate adaptation projects, as well as technology transfer to CSNs, into the platform prove essential for the increased protection of the most vulnerable and for the inclusive advancement of the Sustainable Development Goals.

The inclusion of climate adaptation projects to the AP-IS would not only increase policy knowledge based on practical case studies from countries in the Pacific and other CSNs, but would also strengthen the current understanding of and preparedness to climate change, as knowledge gaps would be filled with the implementation of more digital climate adaptation projects in the most vulnerable areas from the region, particularly in countries that do not have digital adaptation projects. The lessons learned from projects implemented with CSNs could help other countries with more resources fill knowledge gaps before implementing certain projects or policies, and explore alternative cost-effective mechanisms or funding mechanisms to implement such projects.

108 Iran's Ministry of Information and Communications Technology, "Digital Iran: National Roadmap Executive Summary 2020-2025", 2020. Available at <http://irandigitaltransformation.ir/wp-content/uploads/2020/06/Digital-Iran-Roadmap-Executive-Summary.pdf>.

109 ESCAP, "ICT and Disaster Risk Reduction: The Asia-Pacific Information Superhighway Platform". Available at <https://www.unescap.org/our-work/ict-and-disaster-risk-reduction/asia-pacific-information-superhighway-platform>.

Climate adaptation projects should be included in the scope of work of the AP-IS to advance digitally-enabled climate adaptation in CSNs in Asia and the Pacific.

5.6 Future research

Further research is needed on the use of digital technologies for the most pressing challenges that climate change poses to the most vulnerable in the Asia-Pacific region. While digital technologies are key to the development of all the case studies analysed, the technologies are continuously

evolving and are not accessible to everyone. This raises key questions that can affect the development of the most vulnerable:

How the lack of access to digital technologies is affecting and will affect climate adaptation and vulnerability in CSNs and vice versa?

How an efficient, effective and fair system or platform of technology transfer and cooperation among countries in the Asia-Pacific region could look like? Would it be feasible? Could it be supported within the AP-IS initiative?

Annex

Annex 1: Linkages of ICT policies and strategies with climate adaptation in Asia and the Pacific

Legend:

ICT policies or strategies linked with climate change adaptation

ICT policies or strategies found but with no link to climate change adaptation

ICT policies or strategies not found

Country	Link	Comments
Azerbaijan	National Strategy for the Development of the Information Society in the Republic of Azerbaijan for 2014-2020: https://president.az/articles/11312	Climate adaptation linkage: Through environment (climate change mitigation, environmental problems)
Japan	ICT Policy in Japan 2020: https://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/whitepaper/2020/index.html (Chapter 6 - ICT policy directions) Beyond 5G Promoting Strategy: https://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/presentation/pdf/200414_B5G_ENG_v01.pdf	Climate adaptation linkage: Methods of maintaining and managing disaster-resilient communications infrastructure, among others
Pakistan	Digital Pakistan Policy: https://moitt.gov.pk/SitelImage/Misc/files/DIGITAL%20PAKISTAN%20POLICY.pdf	Climate adaptation linkage: e-Agriculture
Iran	Digital Iran – National Roadmap 2020-2025: http://irandigitaltransformation.ir/wp-content/uploads/2020/06/Digital-Iran-Roadmap-Executive-Summary.pdf	Climate adaptation linkage: ICT use to solve water crisis (water shortages)
Papua New Guinea	PNG Digital Transformation Policy 2020: https://ict.gov.pg/policy/PNG%20Digital%20Transformation%20Policy_21122020_updated.pdf	Climate adaptation linkage: The policy is aligned with PNG Strategy for the Development of Statistics 2018-2027 that is designed to strengthen Papua New Guinea's statistical system and support the country's development agenda by fostering greater use of evidence in policymaking and development planning
Republic of Korea	Korean New Deal 2020-2025: https://english.moef.go.kr/co/fixFileDown.do?orgNm=Korean_New_Deal.pdf	Climate adaptation linkage: By conducting a comprehensive diagnosis on climate and environmental challenges of a city, and customized solutions based on environmental technology and ICT will be introduced in 25 regions by 2022 To support the training of 20,000 individuals in green-integrated fields, specialized graduate schools in the fields of climate change and green engineering, and job training in the environmental industry will be provided
Maldives	Strategy Action Plan 2019-2023: https://erc.undp.org/evaluation/managementresponses/keyaction/documents/download/3556	Climate adaptation linkage: Improved health care, biodiversity conservation, open data, etc.

Country	Link	Comments
Bangladesh	Vision 2021-2041 – Digital Bangladesh: http://oldweb.lged.gov.bd/UploadedDocument/UnitPublication/1/1049/vision%202021-2041.pdf	Climate adaptation linkage: Better climate information, innovative research for the development of heat-tolerant, salinity-tolerant crop varieties and climate smart production technologies, efficient water-saving irrigation practices and early forecasting/warning systems
Mongolia	State Policy on Development of ICT 2017-2025: https://www.cita.gov.mn/wp-content/uploads/2021/01/State-Policy-on-ICT-Development-2025_en.pdf	Climate adaptation linkage: Support activities to maintain environmental and ecosystem balance, and protect nature through ICT advancement
Tonga	Tonga Strategic Development Framework 2015-2025: http://extwprlegs1.fao.org/docs/pdf/ton168846.pdf	Climate adaptation linkage: Effective land and environmental management and resilience to climate; specialized hazards maps and detailed analysis in place
Afghanistan	Digital Foundation Strategy for Afghanistan: https://digital.af/ ; https://digital.af/strategic-pillar-3/strategic-objective-three	Climate adaptation linkage: Integrate geospatial data into planning, monitoring and reporting activities
Nepal	National Information and Communication Technology Policy 2015-2020: http://www.youthmetro.org/uploads/4/7/6/5/47654969/ict_policy_nepal.pdf	Climate adaptation linkage: Special measures will be taken to develop innovative approaches to climate change adaptation through the integration of traditional and emerging ICTs, including the development of e-adaptation applications. Such measures will also be geared towards supporting specific sectoral strategies on key areas affected by climate change such as water, food security, health, disasters, etc.
Timor-Leste	Timor-Leste Strategic Development Plan 2011-2030: http://timor-leste.gov.tl/wp-content/uploads/2011/07/Timor-Leste-Strategic-Plan-2011-20301.pdf	Climate adaptation linkage: Encourage technology innovation to address climate change adaptation and mitigation. As a small island developing state, Timor-Leste will seek support from developed countries to assist with climate change research, adaptation and mitigation.
Micronesia	The Federated States of Micronesia National ICT and Telecommunications Policy 2012: https://fsm-data.sprep.org/system/files/FSM%20National%20Information%2C%20Communication%20%26%20Technology%20Policy%202012.pdf	Climate adaptation linkage: Relation between ICT use and climate adaptation and mitigation
Cook Islands	Cook Islands National Information and Communication Technology Policy 2015-2020: https://pafpnet.spc.int/resources/537-cook-is-national-ict-policy-2015-2020#:~:text=The%20focus%20of%20the%20National,the%20local%20and%20global%20economy	Climate adaptation linkage: ICTs are critical tools used to monitor climate change activities, mitigate and adapt to its effects, and assist in transitioning towards a green economy (page 10). Government will strive to raise awareness of the role of ICTs in addressing key challenges related to climate change and sustainable development, to ensure public safety
Bhutan	12th Five-Year Plan 2018-2023: https://www.gnhc.gov.bt/en/wp-content/uploads/2019/05/12FYP-Volume-II-Central-Plans.pdf	Climate adaptation linkage: Linkage of ICT with climate mitigation, environmental awareness and disaster management (pre-warning and post-disaster)
India	National Policy on Information Technology 2012-2020: https://www.meity.gov.in/writereaddata/files/National_20IT_20Policyt%20_20.pdf	Climate adaptation linkage: The policy mentions the development of a GIS platform for facilitating location-based planning, service delivery, information availability and disaster management
Kiribati	Kiribati National ICT Policy 2019: https://www.micttd.gov.ki/sites/default/files/National%20ICT%20Policy.pdf	Climate adaptation linkage: Related with national disaster management (early warning systems and well-established communications)

Country	Link	Comments
Samoa	Samoa National Broadband Policy 2012: https://mcit.gov.ws/2019/04/04/samoa-national-broadband-policy-2012/	Climate adaptation linkage: Policy linked with disaster communication systems
Philippines	Philippines National ICT Ecosystem Framework: http://dict.gov.ph/ictstatistics/wp-content/uploads/resources/NICTEF.pdf	Climate adaptation linkage: This framework mainly addresses climate mitigation, but also relates climate change and disaster risks with artificial intelligence and smart cities, among others
Armenia	https://unidir.org/cpp/en/states/armenia ; https://www.trade.gov/country-commercial-guides/armenia-information-and-telecommunication-technology ; https://www.privacyshield.gov/article?id=Armenia-information-technology	The original documents of the strategies could not be found – only articles talking about them
Niue	Niue National Strategic Plan 2016-2026: https://policy.asiapacificenergy.org/sites/default/files/Niue%20National%20Strategic%20Plan.pdf	The plan addresses the infrastructure, but not specifically the ICT infrastructure and does not link ICT with climate adaptation. The plan was only found in the local language
Vanuatu	Strategic Plan 2019-2021: https://www.trbr.vu/attachments/article/770/trbr_strategic_plan_2019_2021.pdf	
Australia	Digital Economy Strategy: https://pmc.gov.au/domestic-policy/digital-technology-taskforce	
Brunei Darussalam	Brunei Digital Government Strategy 2015-2020: http://www.digitalstrategy.gov.bn/Themed/index.aspx Digital Economy Masterplan 2025: http://www.mtic.gov.bn/DE2025/documents/Digital%20Economy%20Masterplan%202025.pdf	
Cambodia	Cambodian ICT Masterplan 2020: https://www.trc.gov.kh/wp-content/uploads/2016/10/Cambodian-ICT-Masterplan-2020-%E1%84%8B%E1%85%AD%E1%84%8B%E1%85%A3%E1%86%A8%E1%84%87%E1%85%A9%E1%86%AB%E1%84%8B%E1%85%A7%E1%86%BC%E1%84%86%E1%85-AE%E1%86%AB.pdf	Linkage with climate mitigation but not adaptation: While operating the refurbishment centre of second-hand computers, Cambodia has to operate the recycling centre that collects and recycles second-hand computers in an environmentally friendly manner
China	China's 14th Five-Year Plan: https://merics.org/en/report/chinas-digital-rise http://www.caict.ac.cn/english/research/whitepapers/202007/P020200728343679920779.pdf https://www.hkstrategies.com/en/chinas-14th-five-year-plan-2021-2025-report/	Linkage with climate mitigation but not adaptation
Fiji	Digital Fiji: https://www.fiji.gov.fj/digitalFIJI Five-Year and Twenty-Year National Development Plan: Transforming Fiji 2017-2036: https://www.fiji.gov.fj/getattachment/15b0ba03-825e-47f7-bf69-094ad33004dd/5-Year-20-Year-NATIONAL-DEVELOPMENT-PLAN.aspx	
Georgia	Digital Transformation Strategy of Georgia 2021-2024: https://unu.edu/projects/digital-transformation-strategy-of-georgia-2021-2024.html	In progress but does not include climate change

Country	Link	Comments
Indonesia	Making Indonesia 4.0: https://kemenperin.go.id/download/18280/Making-Indonesia-4.0---Bahan-AT-Kearney-Sosialisasi-tentang-Industry-4.0-(update) ; https://www.kemenperin.go.id/download/19347	Linkage with climate mitigation but not adaptation
Kazakhstan	Digital Kazakhstan 2018-2022 Programme: https://www.trade.gov/country-commercial-guides/kazakhstan-information-and-communication-technologies	
Kyrgyzstan	Digital Kyrgyzstan 2019-2023: https://www.trade.gov/country-commercial-guides/kyrgyz-republic-information-and-communication-technology-ict	
Lao PDR	Lao Digital Transformation Plan: http://www.cicc.or.jp/japanese/kouenkai/pdf_ppt/pastfile/r02/201203-05la.pdf Law on Information and Communication Technology Lao 2016: https://www.slideshare.net/iotcloudserve_tein/20181214-digital-technology-and-development-in-the-lao-pdr-by-prof-keonakhone-ministry-of-science-and-technology National ICT Development Strategy for 2016-2025: file:///C:/Users/crist/Downloads/Lao_People's_Republic.pdf (not translated into English)	No evidence of ICT use for environment, climate change adaptation or mitigation
Malaysia	Public Sector ICT Strategic Plan 2016-2020: https://www.malaysia.gov.my/portal/content/130 https://www.trade.gov/country-commercial-guides/malaysia-information-communications-technology National Policy on Science, Technology and Innovation 2013-2020: https://www.pmo.gov.my/2019/07/national-policy-on-science-technology-innovation-npst/ National Policy on Industry 4.0 (2018): https://www.miti.gov.my/index.php/pages/view/4832	No evidence that the plan includes the use of ICT for climate adaptation although environment and climate change are mentioned once in the plan
Myanmar	Myanmar Digital Economy Roadmap: https://myanmar.gov.mm/documents/20143/9096339/2019-02-07+DEDC+RoadMap+for+Websites.pdf	
New Caledonia	The Strategic Plan for the Digital Economy: https://numerique.gouv.nc/strategies-numeriques/le-plan-strategique-pour-leconomie-numerique-psen	The plan includes strategies for digital economy and electronic administration master plan, but there is no mention of linkage between ICT and climate adaptation
New Zealand	New Zealand Digital Transformation: https://www.digital.govt.nz/digital-government/about-digital-government/introduction-to-nzs-digital-transformation/	
Russian Federation	ICT in Russia: https://digital.gov.ru/en/activity/statistic/rating/ikt-v-rossii/	No linkage between ICT and climate change

Country	Link	Comments
Singapore	Strategic National Project Singapore: https://www.tech.gov.sg/digital-government-transformation/ ; https://www.tech.gov.sg/media/technews/5-national-projects-for-1-smart-nation ; https://www.tech.gov.sg/media/media-releases/2021-06-23-increased-ict-spending-in-fy2021-to-accelerate-government-digitalisation	
Solomon Islands	Five-Year ICT Strategic Plan 2019-2023: https://solomons.gov.sb/wp-content/uploads/2020/02/SIG-Five-Year-ICT-Strategic-Plan_Low-Res.pdf	The plan is more focused on improved services and 5G for everyone, but no linkage with climate adaptation
Sri Lanka	National Digital Policy: https://www.icta.lk/policy-framework/#:~:text=The%20National%20Digital%20Policy%20outlines,Government%20and%20a%20Digital%20Economy	No linkage to climate change, adaptation or the environment
Thailand	Digital Strategy: http://www.cicc.or.jp/japanese/kouenkai/pdf_ppt/pastfile/h28/161026-10th.pdf ; https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/Documents/Events/2016/Apr-Digital2016/S2_Present_Pansak_Siriruchatapong.pdf	No linkage to climate change, adaptation or the environment
Turkey	Turkish Strategy Document: https://www.sanayi.gov.tr/assets/pdf/SanayiStratejiBelgesi2023.pdf (in Turkish); https://stip.oecd.org/stip/policy-initiatives/2019%2Fdata%2FpolicyInitiatives%2F26204 and http://gokce.av.tr/wp-content/uploads/2019/10/The-Fine-Print_Ekim_2019_Ing.pdf	
Uzbekistan	Strategy for Innovative Development 2019-2021: https://ai4da.com/uzbekistan-the-dawn-of-an-innovation-driven-economy/ Strategy Digital Uzbekistan – 2030*: https://www.un.org/development/desa/cdpmo/node/3492	Nothing found in the official website: https://mitc.uz/en No linkage to climate change, adaptation or the environment
Viet Nam	The new national strategy on developing the digital economy and society is under development: https://opengovasia.com/vietnam-to-formulate-national-strategy-on-digital-economy/	Many other laws, strategies and action plans: https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/Documents/Events/2017/Sep-SCEG2017/SESSION-2-Vietnam_Mr_Lap_Hien_Do.pdf No linkage to climate change, adaptation or the environment
Democratic People's Republic of Korea		
French Polynesia		No strategy/policy found but they have this initiative: https://www.tech4islands.com/en/
Guam		
Marshall Islands		
Nauru		
Northern Marianas		

Country	Link	Comments
Palau		
Tajikistan		
Turkmenistan		https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Turkmenistan.pdf
Tuvalu		National Strategy for Sustainable Development 2021-2030: https://australiaawardsfijiandtuvalu.org/wp-content/uploads/2021/01/Te-Kete-2021-2030-National-Development-Strategy.pdf But they do not have ICT policy or strategy
American Samoa		US project about American Samoa Territorial Broadband Strategy: http://amsamoatbs.uhtasi.org/ Focus areas: Leverage broadband across all industries and sectors, educate and inform the public about new resources and opportunities, close digital divide

Annex 2: Survey questionnaire

For Strawberry Advisory System

Survey questionnaire answered by Clyde William Fraisse, Professor and Extension Specialist from the Agricultural and Biological Engineering Department, University of Florida

1. Is this service widely used by farmers? Approximately, how many users use the app and services offered?

It is used by a significant number of farmers in Florida. Not sure about the numbers. I would estimate that over half of the strawberry growers in Florida use the app. Outside Florida I wouldn't know.

2. Approximate cost of development of such initiative?

It depends on what you consider as cost. If we include the field research it certainly goes over USD1 million during the last 7-10 years.

3. What are the key success factors that you would highlight that have allowed the implementation of this initiative?

Two main factors, well-designed web and mobile phone app together with a close interaction and education of growers.

4. Are there any barriers of implementation? Could you elaborate on the key ones?

Not many barriers, the main thing is to have a dedicated local group providing support to growers.

5. How ICT policies in the USA or others influence in the success of this initiative?

What is important is to have a reliable network of weather stations.

6. Could this initiative be developed by a low- or low-middle income country? Why? What pre-existing conditions need to be in place?

The challenges are the network of stations with good sensors that have good maintenance (this is the major challenge). Also, you need communication (cell phone, Internet) to gather data and distribute alerts.

