Climate Change Management

Walter Leal Filho
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Handbook of Climate Services

Springer

Climate Change Management

Series Editor

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Handbook of Climate Services

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Preface

The provision of climate services, by means of customised tools, products and information based on climate data, is a growing trend. There are, however, some problems associated with it. One of them is the fact that even though climate services are important, they are not as widely used as they could—or should—be. In addition, information on climate services is often not widely available. Moreover, there are many modalities of climate services which are not duly documented or disseminated. Finally, the quality of some quality services is sometimes not as good as it should be. This state of affairs means that many good opportunities to use climate services in support of projects, investments or in future policies and decision-making, are being lost.

Based on the perceived need to promote and disseminate information on climate services, the *Handbook of Climate Services* has been produced. This volume presents information, experiences, practical initiatives and projects around the subject matter of climate services, making it available to a wide audience. It is expected that this publication will make the many benefits of climate services clearer and, inter alia, lead to an increase in the demand for such important services.

This volume contains contributions from across various areas related to climate services. These include:

i. Theory and practice of climate services
ii. Provisions of climate services
iii. IT-based approaches and methods to deliver climate services
iv. Case studies in climate services
v. Community-based climate services
vi. Using climate services in support of policies and decision-making
vii. Collaboration and co-delivery of climate services
viii. Raising demand for climate services
ix. Market for climate services
x. Using climate services to meet mitigation and adaptation needs.

Structurally, the book consists of two parts. Part I presents an overview of the principles, philosophy and applications of climate services. Part II presents a set of case studies, which illustrate how climate services may be deployed in practice.

Thanks to its scope, this book will not only provide essential scientific information, but also describes facts, trends and case studies from various geographical regions.

We would like to thank the authors for their willingness to share their experiences and the reviewers for supporting us with the development of the manuscripts. We hope this book will foster a broader understanding of the subject matter of climate services and will support their promotion and dissemination across the world.

Hamburg, Germany

Walter Leal Filho
Daniela Jacob

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Part I
Principles, Philisophy and Applications of Climate Services

Chapter 1
Introducing Climate Services and Their Applications

Walter Leal Filho

Abstract This introductory chapter defines climate services and outlines their nature, as processes which deliver climate information to a wide range of users. It also describes some application and the barriers experienced in the dissemination of climate services, and introduces the chapters of this book.

Introduction

Knowledge about climate change plays a crucial role in guiding both, mitigation and adaptation processed. The pressures posed by climate change on the one hand, and the advancement in climate science on the other, have led to the prioritizing the development and provision of Global Climate Services by public and private organisations and specialist institutions (Jancloes et al. 2014). Climate services are defined as those related to the generation, interpretation, transmission and application of climate knowledge and information for the decision making and further planning. Climate services provide the most recent knowledge about climate science, in support of adaptation strategies for agriculture, water, health and other sectors (Climate Services Partnership 2015). The difference between climate service from climate research is that it focuses at serving user requirements which later helps in the understanding of climate systems. Apart from helping to prepare to manage the effects of climate change, one of the mains aim of climate services is to provide up to date climate-related knowledge and information which can be further used to reduce climate related disaster risks, and to improve welfare (Vaughan and Dessai 2014; WMO 2012, 2019).

One of the features of climate services is that the climate information processed is provided in a suitable format which allow it to be used by a variety of groups. These include:

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W. Leal Filho and D. Jacob (eds.), *Handbook of Climate Services*, Climate Change Management, https://doi.org/10.1007/978-3-030-36875-3_1

(a) policy-makers,
(b) planners,
(c) investors,
(d) other user groups (e.g. farmers).

The data required, be it in respect of temperature, rainfall, wind or soil moisture, among others, is provided in the ways required by the users. If needed, long-term historical averages of these parameters, with vulnerability maps and risk analysis may also be provided. Climate data may also be combined with non-climate data i.e. health trends, agriculture production, population distribution in high-risk areas, and other socio-economic variables, depending on users´ requirement (GFCS 2012).

The list of climate service providers, which act in the nexus climate science, policy and process. Include a variety of organisations (Vaughan and Dessai 2014) such as:

- International Service Structures—World Meteorological Organization Climate Service
- National Climate Service Providers—NOAA Climate Services, Climate Service Center, Germany
- Regional Climate Services—Australia National Climate Center
- Research Institutes—The Climate Impacts Group (CIG) of the University of Washington
- Private Sector Services—Climate Risk Analysis, Predictia, and Climpact
- Climate Services across Scales.

There are also organisations, such as meteorological services, which offer climate services. Table 1.1 shows a list of climate services around the world.

Figure 1.1 provides a framework of climate services. It shows that it consists of information provision based on the availability of good quality data, which may allow an interpretation of trends. All these elements interact. Combined, they may ultimately lead to improved decision-making.

There are many factors which speak for the use of climate services. These include:

(a) The pressures posed by a changing climate which leads to a greater demand for timely, reliable and technically sound information
(b) The multiple uses of data, from support to mitigation efforts, to a concrete use in adaptation efforts
(c) The multi-stakeholder dimension, which enables the mobilisation of a variety of users
(d) The concrete support to cope with extreme events
(e) The provision of support to administrations, enterprises and other organisations which need climate information.

One further characteristic of climate services is the existence of various modalities of applications. Figure 1.2 illustrates some of them.

Unlikely widely believed, the provision of climate services is not solely related to the availability of information on weather and climate. Rather, climate services encompass also support to the identification of possible (or likely) risks, proving

Table 1.1 Some existing climate services providers

Climate services	Country	Website
World Meteorological Organization Climate Services	International	http://www.wmo.int/pages/themes/climate/climate_services.php
Food and Agriculture Organization of United Nations—climate change resources	International	http://www.fao.org/climatechange/59898/en/
Red Cross Climate Center	International	http://climatelab.org/Red_Cross_Red_Crescent_Climate_Centre
NOAA (National Oceanic and Atmospheric Administration) Climate Services Portal	USA	http://www.ncdc.noaa.gov/oa/climate/regionalclimatecenters.html
Australia National Climate Centre	Australia	http://www.bom.gov.au/climate/
China Meteorological Administration (CMA) Climate	China	http://www.cma.gov.cn/en2014/
Caribbean Community Climate Change Centre (CCCCC)	Caribbean Community	http://www.caribbeanclimate.bz
Fiji Meteorological Services—Climate Services	Fiji	http://www.met.gov.fj/
Southern African Development Community—Climate Services Centre (SADC CSC)	South Africa	https://www.sadc.int
Climate Service Center, Germany	Germany	https://www.climate-service-center.de/
UK MET Office—Climate Services	UK	https://www.metoffice.gov.uk/services/research-consulting/climate-service
KNMI Climate Services	Netherlands	https://www.knmi.nl/research/climate_services/
Météo-France Climate Section	France	http://www.meteofrance.com/accueil

Source Modified from Medri et al. (2012)

valuable information which may be deployed in support of investment decisions or policies.

But despite the relevance of and the need for climate services, there are some barriers which hinder their deployment. These are described in Table 1.2.

This list is by no means exhaustive. Other barriers which may be added include possible problems related to the lack of quality regarding the information offered by the scientific community, as cross-checked against the needs of diverse potential users (Brasseur and Gallardo 2018). In some developing countries, up to date weather information may not be available, which would make it difficult to deploy climate

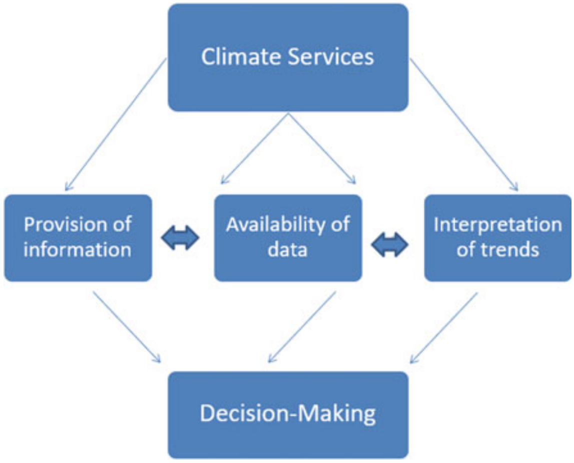

Fig. 1.1 Framework of climate services

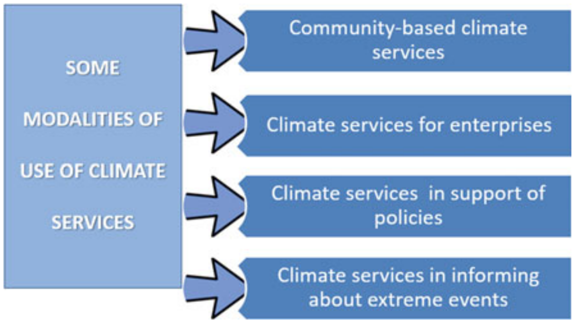

Fig. 1.2 Some modalities of climate services

Table 1.2 Some of the barriers to the dissemination of climate services

Barrier	Impact
Limited access to technology	Limits the options and access to up to date information in some contexts (e.g. developing countries)
Low levels of awareness	Limited information about the benefits of climate services
Restricted data availability	Reduces the scope of use of climate services
Need for multi-stakeholder engagement	Adds complexity to the design and use of climate services
Lack of frameworks	Unsystematic use of climate services

services. Moreover, the key issue in integrating climate services is budgeting should be mentioned, since government budgets are usually assigned sectorally (Bettencourt 2015), which may make inhibit the allocation of specific funding for climate services.

But despite the barriers, climate services do offer various benefits at the community level, at the individual level, and to the environment as well. For instance, in agriculture, climate services can enhance awareness regarding the possible climate risks and help farmers in deciding on particular crops, plantation timing, and fertilizers' application to mitigate the impact of climate risk on agriculture (Vaughan and Dessai 2014). Moreover, disaster risk reduction can be pursued, by prior information obtained from climate services. The broadcasting of warnings related to hazards can help appropriate preparedness measures, and ultimately protect lives. In addition, data observation on extreme weather events can help increase livelihood's security (Dutton 2002; WMO 2012). Moreover, climate services may be used to raise awareness regarding the patterns and burdens of many diseases related to the environment, which may prevent the population from getting infected (Global Framework for Climate Services 2012). Indeed, the inclusion of climate information in health planning is one of the promising areas of climate services, which may assist the health community (Shafer 2008).

Another advantage of climate services is the support of sustainable tourism development, and adaptation to climate change as a whole. The use of historical climate information can be beneficial for infrastructure planning for tourism, location analysis for new resorts, architectural and landscape designs (Scott et al. 2011). Overall, climate services may be helpful tools to climate change resilience (Leal Filho 2019) and may contribute towards achieving it.

Experiences from This Book

This book encompasses a set of papers, which explore the different dimensions of climate services. Saleem Khan and Amsad Ibrahim Khan for instance, introduce "BASIEC", a coastal climate service framework for community-based adaptation to rising sea-levels. Abbadi Girmay Reda describes some methods for geospatial climate change detection and resilience through nature conservation in Ethiopia. Jahir Anicama Diaz discusses a state of the art socio-economic valuation tools for climate services.

Haile Arefayne Shishaye provides an overview of nitrous oxide emissions from agricultural farms and how this contributes to global warming.

Markus Groth outlines some business strategies and climate change, with a prototype development, as well as testing of a user specific climate service product for companies, whereas Steffen Bender describes why there is more to adaptation than creating a strategy.

Saleem Khan tackles, with the paper "COREDAR: A coastal climate service framework on sea-level rise risk communication for adaptation policy planning", issues related to climate change services focusing on sea-level rise.

Esther Hoffmann provides an overview of what users expect from climate adaptation services, whereas Karianne de Bruin outlines the links between physical climate risks and the financial sector. Åshild Hauge discusses the role of public-private cooperation for climate adaptation, providing insurance loss data to the municipalities. The need to assess climate services was analysed by Maida Zahid, who looked at how to enable users to assess the quality of multi-model climate projections and derived products. Marcela Scarpellini outlines the need for science-based information, describing a requirement for top-down and bottom-up decision-making processes, whereas Hannah Helmke describes the provision of climate services and the XDC Model.

At a case study level, Busuttil and Galdies describes a climatological global solar UV index, with a measurement and link with health issues in Malta, whereas Michael Addaney outlines climate change risk and insurance as an adaptation strategy, with an inquiry into the regulatory framework of Ghana and South Africa.

Sajal Roy writes on the impacts of climatic disasters in the coastal area of Bangladesh, using 'Climate Services' as a way-forward. Andrea Rossa, in turn, outlines trends towards more resilient food systems for smallholder farmers in the Peruvian Altiplano. Perdinan, on the other hand, outlines how weather services are used for forecast based early actions in Indonesia. Other case studies are from:

(a) Uganda: appraising climate services and impacts on adaptation and mitigation to climate change (Mwangu Alex Ronald)
(b) Bangladesh: climate information services and their potential on adaptation and mitigation (Muhammad Abdur Rahaman)
(c) Nigeria: communicating Climate Change impacts as manifested in extreme weather (Ayansina Ayanlae)
(d) Sri Lanka: climate-indexed insurance as a climate service to drought-prone farmers (Pahan Prasada)
(e) Ethiopia: Geospatial Climate Change Detection and Resilience through Nature Conservation in Ethiopia (Abbadi Girmay Reda) and Food security in the face of a climate change at Kafa Biosphere Reserve (Teowdroes Kassahun)
(f) Zimbabwe: A participatory approach to developing community based climate services (Juliet Gwenzi)
(g) Serbia: Climate services for climate resilient planning of natural and cultural heritage (Tijana Crnčević).

Both, individually and combined, the experiences from the authors illustrate the fact that engagement and collaboration are very useful on how to best prepare for and provide climate services.

Conclusions

Climate services offer reliable support in efforts towards climate change mitigation and adaptation. As the subsequent chapters of this book show, climate services can offer effective support to decisions which can increase the resilience of sites, cities or regions, making them better prepared to manage the effects of climate change and extreme events.

But in order to yield maximum benefits, climate services should ideally follow the principle of co-production, meaning that apart from weather and climate data, they need to also take into account traditional and local knowledge, hence providing a basis for climate smart practices, from agriculture to pastoralism, especially in the developing world.

Apart from the key role they can play in decision-making, one of the major advantages of climate services is their proven support in the better understanding—and often anticipation—of disaster and risks, helping to reduce the uncertainties related to climate change.

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Chapter 2
BASIEC: A Coastal Climate Service Framework for Community-Based Adaptation to Rising Sea-Levels

A. Saleem Khan, M. Sabuj Kumar, R. Sudhir Chella and B. Devdyuti

Abstract Climate change induced sea-level rise poses serious threats to coastal regions across the world and the communities in the low-lying coastal regions are at high risk. Building capacities of coastal communities to adapt to sea-level rise are increasingly high priorities for low-lying coastal regions. Climate services are believed to be a powerful mechanism to build capacities of communities, particularly at the local level. It focuses on the connection between climate science and public demand for information and services. In this context, this chapter emphasizes the importance of community-based climate services that build the capacities of local communities to prepare, manage and adapt to rising sea-levels. This study has put forth three research questions such as (1) what services do the coastal communities require; (2) how these services need to be delivered; (3) what are all the roles of climate services that can help in building capacities of coastal communities and involve them in the community-based adaptation decision-making process? This study has adopted the methodology following the recommendations and guidelines of the UNFCCC, the Global Framework for Climate Services (GFCS) and Fifth Assessment Report of IPCC, on climate information and services. As a result, this study has introduced BASIEC (Building capacities for Adaptation to Sea-level rise through Information, Education and Communication for coastal communities), a coastal climate service framework for community-based adaptation to rising sea-levels. The framework emerges from theoretical and empirical knowledge of community-based climate services and offers a holistic approach for integrating information, communication and education through the lens of climate change and sea-level rise. Thus, it provides a systematic starting point and guidance for local level coastal climate policy planners, decision-makers, researchers, local communities and others who hold a stake on coastal climate services for community-based adaptation to changing climate in general and sea-level rise in particular.

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Introduction

The Paris Agreement sets a long-term temperature goal of holding the global average temperature increase to well below 2 °C, and pursuing efforts to limit this to 1.5 °C above pre-industrial levels (Schleussner et al. 2016). Even if greenhouse gas emissions were stabilized in the near future, thermal expansion and melting of glaciers would continue to raise the sea level for many decades (Natesan and Parthasarathy 2010). Sea-Level Rise (SLR) in this case has been defined as the combination of climate induced rising sea-levels, intensified storm surges, frequent cyclones, extreme flood events etc. The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) has projected SLR for all four Representative Concentration Pathways (RCPs), based on CMIP5 climate projections. Global mean SLR for 2081–2100 relative to 1986–2005 will likely be in the range of 0.26–0.55 m for RCP 2.6, 0.32–0.63 m for RCP 4.5, 0.33–0.63 m for RCP 6.0, and 0.45–0.82 m for RCP 8.5 (Church et al. 2013; IPCC 2013; Ramachandran et al. 2017; Khan et al. 2018). It is virtually certain that in the coming decades, the expected acceleration of SLR in response to continuing global warming will exacerbate the vulnerability of many low-lying, densely populated coastal regions of the world, and very likely will become a major threat in the near future for a significant fraction of human beings (Cazenave and Cozannet 2013). Globally, each year, millions of people experience coastal flooding, often leading to inequalities for vulnerable populations. It is in these communities that the adverse effects will be the most prominent (Moth 2008). However, SLR poses an ominous threat because 10% of the world's population (634 million people) lives in low-lying coastal regions within 10 m elevation of sea level (McGranahan et al. 2007; Fitz Gerald et al. 2008). This threatened population is growing significantly (McGranahan et al. 2007), and it will almost certainly increase in the coming decades, especially if the strong tendency for coastward migration continues (Nicholls 2011). However, the vulnerability of coastal communities to SLR depends on their exposure to climatic hazards such as storms, floods and cyclones, erosion, ecosystem changes, and saltwater intrusion. These types of events are likely to become more frequent and intense as sea level rises (Tol et al. 2008).

Adaptation is one of the significant measures that reduce vulnerability to actual or expected climate-change effects (Khan et al. 2012). It enables coastal communities to limit their vulnerability by averting or reducing potentially negative consequences of SLR while benefiting from potentially positive consequences (Tol et al. 2008). IPCC in its Fifth Assessment Report defines adaptation as "the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects" (IPCC 2014). However, until recently, most adaptation efforts have been top-down, and little attention has been paid to communities' experiences of climate change and their efforts to cope with their changing environments (Reid et al. 2009). Emphasis was placed on applying 'bottom-up' participatory processes to identify the climate change problem and appropriate local responses to this problem (Ayers and Forsyth

2009). Also, providing a means to overcome uncertainties relating to climate vulnerability and impacts, Community-based adaptation (CBA) has increasingly gained traction among national governments and international non-government organization (Reid and Huq 2014; Jamero et al. 2018). It is defined as ‘a community-led process, based on communities’ priorities, needs, knowledge, and capacities, which should empower people to plan for and cope with the impacts of climate change’ (Reid and Huq 2014). It focuses attention on empowering and promoting the adaptive capacity of communities. It is an approach that takes context, culture, knowledge, agency, and preferences of communities as strengths (IPCC 2014).

Capacity building has long been accepted as a critical element for improving responses to climate change (both mitigation and adaptation) at the local, urban and national level (Archer and Dodman 2015). It is a key issue for climate adaptation measures (Hartmann and Spit 2014) and it is one of the most urgent requirements for addressing climate risk, such as SLR, particularly at the local level (IFRC 2009; Khan 2017). It is defined as the practice of enhancing the strengths and attributes of, and resources available to, an individual, community, society, or organization to respond to change (IPCC 2014). Thus, it is important to engage in community mobilization and awareness raising through designing activities that are tailored to local practices and establish strong relationships with the communities to enable sustainable actions to involve the key stakeholders in adaptation action and enhance capacity building (Khan 2017). However, not all stakeholders are aware and informed about their vulnerability and the measures they can take to pro-actively adapt to climate change. Awareness raising is therefore an important component of the adaptation process to manage the impacts of climate change, enhance adaptive capacity, and reduce overall vulnerability (EEA 2015). Thus, understanding the challenges and raising awareness of the action required is key to improving the region’s resilience and capacity to take advantage of the opportunities (South West 2008).

Climate services are an influential mechanism to build capacity to different stakeholders in general and local communities in particular by creating awareness about the changing climate and enhance their capacity to respond to the challenges. Climate services may be defined as scientifically based information and products that enhance users’ knowledge and understanding about the impacts of climate on their decisions and actions (AMS 2012). In other words, it is a decision aide derived from climate information that assists individuals and organizations in society to make improved ex-ante decision-making. It requires appropriate and iterative engagement to produce a timely advisory that end-users can comprehend and which can aid their decision-making and enable early action and preparedness (WMO 2013). Thus, touted as an important part of the adaptation agenda, climate services have received a great deal of attention in recent years. Improving our understanding of the role and relative contribution of climate services is thus a critical step in enhancing our ability to manage climate-related risk (Vaughan and Dessai 2014), in this case risk due to rising sea-level. Unfortunately, the relation between climate services and potential stakeholders remains weak or ad hoc in many cases and the reason could be the insufficient awareness by some societal actors of their vulnerability to future climate change (Brasseur and Gallardo 2016). However, there are a number of climate services available across the globe and some of them are (i) NOAA Climate Services (USA): It is a source of timely and authoritative scientific data and information about climate. The main goal is to promote public understanding of climate science and climate-related events, to make data products and services easy to access and to serve people making climate-related decisions with tools and resources that help them answer specific questions (NOAA 2019); (ii) Climate Service Centre (Germany): It functions as a think tank for climate services and develops prototype products in the area of climate services, it also offers advisory services and decision-relevant information in order to support government, administration and business in their efforts to adapt to climate change (GERICS 2019); IMD Climatological Services (India): Indian Meteorological Department provides climate products that include real-time climate monitoring and publication of Climate Diagnostics Bulletins for the Indian region and reporting of major anomalous climate events were generated and supplied to researchers (MoES 2019) and likewise many other examples of climate services are available.

In this purview, this chapter explores community-based coastal climate services through the lens of an SLR and put forth three research questions such as (1) what services do the coastal communities require; (2) how these services need to be delivered; (3) what are all the roles of climate services that can help in building capacities of coastal communities and involve them in community-based adaptation decision-making process?. Thus, the aim of this chapter is to address the importance of community-based climate services that build the capacities of local communities to prepare, manage and adapt to rising sea-levels. The chapter sets its objective to create climate awareness by evolving a framework that outlines as (1) to collect coastal climate (SLR) information, (2) to communicate the impact and vulnerability of changing climate (SLR) and (3) to educate coastal communities to respond to changing climate (adaptation to SLR) following the guiding principles of the UNFCCC (United Nations Framework Convention on Climate Change) and GFCS (Global Framework for Climate Services) to build the capacity of coastal communities.

Rationale and Guiding Principle

UNFCCC emphasizes the need to educate people about climate change. Improving awareness and understanding of climate change, and creating solutions to facilitate access to information on climate change is key to winning public support for climate-related policies (UNFCCC 2018). The New Delhi Work Programme on Article 6 of the UNFCCC stipulates the promotion of education, training and public awareness on climate change (REC 2008). Similarly, Article 10 of the Kyoto Protocol provides for strengthening of research capacity, education and training of personnel and institutional strengthening in developing countries. Article 11 of the Paris Agreement creates the Paris Committee on Capacity Building (PCCB), to oversee a work plan for the period 2016–2020; Article 12 on the promotion of education, training, and public awareness and Article 13 on the Capacity Building Initiative on Transparency (ECBI

2018). However, the Paris Agreement has elevated capacity building and education to new heights as important avenues toward climate action. It creates an opportunity to foster enhanced, strategic and sustained approaches supporting transformational change and enabling all parties and stakeholders to build the capacities needed to mitigate and adapt to climate change. Indeed, the premise is the participation of all, and capacity building is a fundamental precondition for this goal (Dagnet and Northrop 2015).

Climate services play a major role in building capacities at different levels and for different stakeholders. It may contribute to the reduction of risks and maximize opportunities associated with a variable and changing climate, and provide substantial social and economic benefits (Rosas et al. 2016). The GFCS has been established by the United Nations and spearheaded by the World Meteorological Organization (WMO) to support the development and application of science-based climate information and services for effective decision-making (Giuliani et al. 2017). GFCS represents a major, concerted and coordinated global effort to improve the wellbeing of all parts of society vulnerable to climate variability and climate change (Hewitt et al. 2012). The ultimate objective of GFCS is to ensure that the best available climate science is effectively used and communicated to various sectors that may benefit from climate knowledge (Lucio and Grasso 2016; Giuliani et al. 2017). GFCS recommends the establishment of Climate Services on a regional and national scale (Rosas et al. 2016). It is a user need driven, as a process and includes five major components: (i) observations; (ii) climate research, modeling and prediction; (iii) a climate services information system (CSIS); (iv) a climate user interface programme (CUIP); and (v) capacity building/development. Importantly, the fifth pillar, i.e. Capacity building supports the systematic development of the institutions, infrastructure and human resources needed for effective climate services. It refers to investment in people, practices, policies and institutions to stimulate and systematically develop capacities such as human resource capacity, infrastructural, capacity, and institutional capacity in the Pillars of the GFCS (WMO 2014). The scope of this chapter is on human resource capacity and it deals with equipping individuals with the knowledge, skills and training to enable them to generate, communicate and use decision-relevant indigenous climate information together with the scientific climate information. Though GFCS as a whole, address capacity development at the national level, this chapter inspires the goals and objectives of GFCS capacity development and adhere the recommendation of UNFCCC to apply at the local level, in particular for the low-lying coastal communities to the risk of rising sea-levels (Fig. 2.1). Figure 2.1 outlines the stepwise rationale and guiding principle based on UNFCCC and GFCS recommendations. As a result, this chapter introduces a coastal climate service awareness framework (BASIEC) for community-based adaptation to rising sea-levels at the local level.

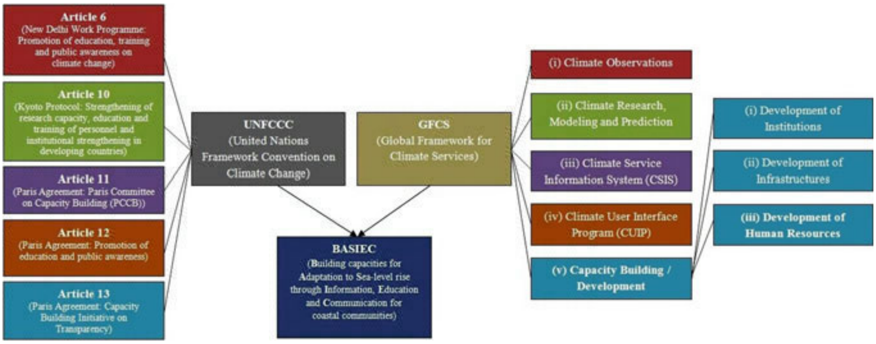

Fig. 2.1 Rationale and guiding principle of BASIEC framework

BASIEC Framework

Climate services draw on a variety of sources from scientific research, meteorological and climate models, to practical experience and local and indigenous knowledge. They also involve the process of co-producing knowledge and building the necessary skills and capacity of different user groups, both to guide the production and tailoring of climate information (to meet context-specific needs) and to be able to apply that information (Davis et al. 2016). GFCS can be used as one model among many for information sharing and knowledge co-production. However, more specific framework and tools are required to address different challenges of climate change (in this case SLR), particularly at the local level and to create awareness among the local stakeholders. Awareness raising includes establishing an overview of climate change (SLR), communicating its risk and to build capacities through education. Raising awareness is essential to facilitate identification of above mentioned opportunities and pave the way for the scaling-up and replication of identified opportunities (Trærup and Olhof 2011). Nevertheless, a framework is needed at the local level to address this and thus the "framework" is defined as "a set of ideas that provide support" or "skeletal structure designed to support", Framing theory and research seek to understand the ways in which related sets of ideas of SLR and CBA in the public sphere are organized, presented and debated, and is increasingly being used to understand a range of problems and issues (Miller 2010; Spence and Pidgeon 2010). A frame allows complex issues to be pared down and for some aspects of that issue to be given greater emphasis than others in order that particular audiences can rapidly identify why an issue may be relevant to them (Nisbet and Mooney 2007; Spence and Pidgeon 2010). In this context, this chapter introduces a framework BASIEC (Building capacities for Adaptation to Sea-level rise through Information, Education and Communication for coastal communities), a coastal climate service framework for community-based adaptation to rising sea-levels. The framework proposed as a fundamental means to describe relations between SLR and its socio-ecological interactions. The framework presented here provides the much-needed conceptual clarity and facilitates bridging the various approaches (Fussel 2007) to address SLR risk awareness through capacity building at the community level. It targets the different dimensions of SLR and CBA, and focuses on collecting SLR risk information, communicating SLR risk information and educating to build capacity to adapt to SLR risk. Thus three pillars of the BASIEC framework are (i) SLR risk information, (ii) SLR risk communication and, (iii) SLR risk education, build the architecture of the framework (Fig. 2.2). Figure 2.2 constructs the architecture of the BASIEC framework with SLR risk information, education and communication as its three pillars that has been constructed based on the guiding principles of UNFCCC and GFCS. The framework is generally applicable on the local scale as a community-based or bottom up approach and utilizes community level perceptions and experiences to identify the characteristics that influence response, recovery and adaptation, focusing on locally relevant outcomes that promote more effective planning (Chadwick et al. 2011). The framework will enhance local capacity building through improved access to both the global and local climate data and products. Suitable use of this framework provides a means of capturing the complexity of SLR and coastal system at multiple scales, and therefore a better representation of response to change (Eliot

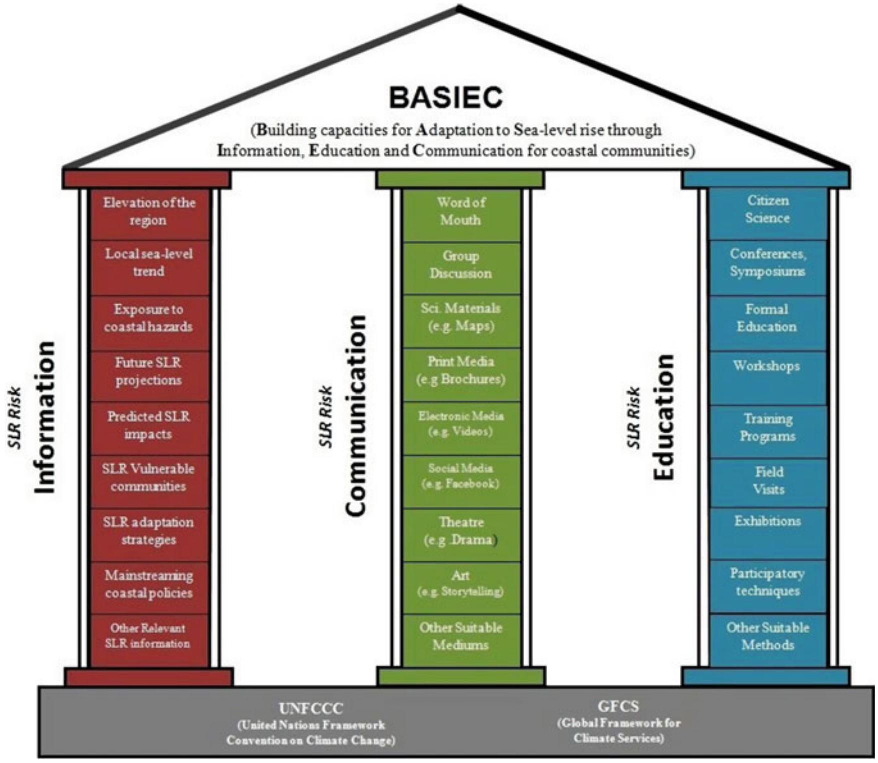

Fig. 2.2 Architecture of the BASIEC framework

2013) and in this case communicating the risk of SLR and to educate local communities. Thus, as a framework, it lays out an approach to address SLR risk awareness as coastal climate services and facilitates the process of information, communication and education in SLR risk research. This framework has been developed to explain how the emerging GFCS and recommendation of UNFCCCs might be reflected in the implementation and operation of climate services at the local level. An outline of each component of the framework is explained as follows.

SLR Risk Information

The demand for tailored climate information by the public and a variety of specific users has recently grown worldwide together with the awareness of the challenges posed to society and environment by climate variability and change (Medri et al. 2012). Climate information services and evidence from climate science can provide data to inform preparedness strategies and tools in the short and longer term. Such information would be the basis of positive coping strategies and it provides opportunities for risk reduction (ICHA 2017). Users expect climate services to provide authoritative and objective information rather than being guided by ideological motivations (Brasseur and Gallardo 2016). People require climate information over wide ranges of time and space scales for planning and operational purposes. It is imperative, therefore, to ensure that they have the highest quality and the widest possible range of products, information (including about uncertainties), and guidance on how the information can be used to provide optimal results and ensure appropriate decisions are made (Martínez et al. 2012). In many cases, the vulnerabilities identified through the "bottom up-top down" process extended beyond the generalized impacts to engage with indirect and location specific impacts—a key component in increasing the usability of scientific information (Dilling and Lemos 2011; Cash et al. 2003; Kettle et al. 2014). There are three types of climate information such as historical data (which help elucidate trends, provide climate statistics, set a context for current data, and allow, variability and the occurrence of extremes to be quantified); real-time data (i.e. current climate observations); climate forecasts (i.e. predictions of the climate, ranging from long-term weather forecasts, through seasonal forecasts, to medium- (10–30 year) and long-term climate change projections). Advances in climate science are improving the availability and quality of all three information types (Hellmuth et al. 2007). Furthermore, the climate information is often required at local scale, sometimes site-specific, and at daily or sub-daily time step. In most cases, climate data at this level of details are not readily available hence additional work is often required (NCSP 2009). Nevertheless, challenges remain for making this information readily usable and relevant to stakeholders, including downscaling results of large-scale computer models to the community level, incorporating local changes in coastline morphology, and understanding potential responses of coastal vegetation (DeLorme et al. 2018a). Moreover, stakeholders require not just access to information, but support in incorporating it into their planning procedures and communication (Tribbia and Moser 2008) as well as tools to help understand immediate risks and underlying physical, biological, and social processes (Stephens et al. 2016; DeLorme et al. 2018a). In addition to these insights, this framework details how the process of synthesizing SLR risk information as it builds context specific understanding of the SLR risk of the coastal region. Thus, this framework has jot down following major SLR risk information are required for the chosen study area to initiate address the challenges of SLR. It includes (1) elevation of the study region from the mean sea-level; (2) regional and local sea-level trend; (3) exposure and vulnerability of the region to coastal disasters; (4) future projections of local sea level; (5) predicted impacts of SLR risk; (6) identifying vulnerable ecosystems, communities/population, infrastructures etc. SLR risk; (7) list of SLR risk response strategies such as an adaptation; (8) list of existing coastal management policies and interventions and, others. The information such as changing surge and wave heights etc., in additional to SLR is required and a more pragmatic way to examine the need for climate information to support adaptation (NCSP 2009). Thus, one of the three purposes of this component of the framework is to propose ways to make climate services more effective in providing relevant and usable information of SLR to the coastal communities and stakeholders.

SLR Risk Communication

Making scientific research on SLR accessible and useful to diverse audiences is a crucial, yet complex endeavor (Moser 2010; DeLorme et al. 2018b). The transition from useful to readily-usable information can be complex and requires careful communication efforts that are customized to specific audiences (Lemos et al. 2012; Sheppard et al. 2011; DeLorme et al. 2018a). Therefore, the information to be provided to stakeholders must be credible (of high technical quality), legitimate (fair and impartial, with the interests of users in mind), and salient (relevant to users and capturing their attention) (NRC 2009). Also, timely communication of climate change risk has been found globally to be very beneficial and known to promote local ownership of adaptation planning in some cases (Dovie 2017). The term 'risk communication' as used here, refers to intentional efforts on the part of one or more sources (e.g. international agencies, local government, communities) to provide information about hazards and hazard adjustments through a variety of channels among themselves or to different audiences (e.g. the general public, specific at-risk communities), for the purpose of influencing the recipients to apply the information and take appropriate action. It also includes efforts of local communities to characterize and communicate their risk-based experiences (Martínez et al. 2012). The dissemination of such information requires, therefore, that the climate services establish a communication strategy that addresses these requirements (Brasseur and Gallardo 2016). However, communicating and disseminating risk information can be very challenging. One of the first steps for effective communication is to ensure two-way communication channels, where information providers and users can interact equally and explain misunderstandings (Martínez et al. 2012). SLR communication focuses on the interaction between scientists, policymakers, and other stakeholders for the purposes of planning, and the wider inclusion of the public in outreach and environmental decision making (Akerlof et al. 2017). SLR communication shares many of the same challenges as climate change communication, including difficulties with translating the science because of the abstract nature of the phenomena, the invisible causes, temporally distant impacts, and uncertainty surrounding the timing and probability of impacts. In addition, SLR communicators have the challenge of creating texts and images for people with a variety of worldviews and political outlooks that could result in unexpected interpretations of the information (Weber and Stern 2011; Covi 2014). Thus, transformation of climate-related data—together with other relevant information—into customized products such as projections, forecasts, information, trends, economic analysis, assessments (including technology assessments), counseling on best practices, development and evaluation of solution, and other services in relation to climate that may be of use for society at large (European Commission 2015; Brasseur and Gallardo 2016). Therefore, for effective SLR risk communication, SLR risk information must be appropriately framed, visually compelling and take into account prevailing risk perceptions and diverse viewpoints. There are various methods and medium to communicate SLR risk, some of them are (1) Word of mouth (e.g. one to one communication, public speaking, etc.); (2) Group discussion; (3) Scientific materials (e.g. maps, graphs, charts, tables, posters etc.); (4) Print media (e.g. brochures, posters, magazines, newspapers, etc.); (5) Electronic media (e.g. power point presentations, videos, television, community radios, etc.); (6) Social media (Website, blogs, facebook, twitter, etc.); (7) Theatre (e.g. drama, street play, movies, puppet show, etc.); (8) Art (e.g. paintings, storytelling, cartoons, etc.) and others. Thus, one of the three purposes of this component of the framework is to propose ways to make climate services more effective in communicating SLR risk information through various mediums and create awareness about SLR risk to the coastal communities and stakeholders.

SLR Risk Education

Education is an essential element of the global response to climate change. It helps people understand and address the impact of changing climate, increases "climate literacy" among people, encourage changes in their attitudes and behavior and helps them adapt to climate change-related trends (UNESCO 2018). Conceptualizing risk as a communication process involving public participation led us to consider the stages the public moves from awareness of a risk to the knowledge of specific solutions (Clark et al. 1999). Climate change education demands a focus on the kind of learning, critical and creative thinking and capacity buildings that will enable to engage with the information, inquire, understand, ask critical questions and take what they determine are appropriate actions to respond to climate change (Stevenson et al. 2017). However, the need is to engage all stakeholders, to facilitate awareness and education, and to support dialog so that users can help shape the services they receive (Hellmuth et al. 2007). Informal learning institutions along with formal education systems must work together to engage audiences, share new information and promote behavior change to better manage climate change risk (Caribbean Community 2018). Coastal communities do not have many communication and engagement tools/frameworks available to help their residents understand the threat of SLR and often find that public audiences are uncertain and apathetic when they lack personal experience of SLR associated impacts (Akerlof et al. 2017). Observation of how people understand and perceive SLR risk, comprehend information about their risk, and enter into processes to manage risk can provide us with a better understanding of how risk can be socially amplified or attenuated, and strategies to overcome barriers to adaptation planning (Covi 2014). Thus, educational responses to SLR best take the form of active social learning that develops the capacity for personal and societal transformative practice (Stevenson et al. 2017). If climate information and services are to support the stakeholders and local communities, their involvement is crucial. Yet much of the climate discourse so far has been at the national and international levels. This mismatch needs to be addressed if successful practices—and policies—are to be developed that make the best possible use of climate information (Hellmuth et al. 2007). There is an emerging consensus on processes useful for integrating local and scientific knowledge. These approaches often share the use of participatory methods, employment of iterative strategies to support learning and feedback, attention to temporal and spatial scales, and incorporation of values into decision processes (Raymond et al. 2010; Dietz 2013; Kloprogge and Van Der Sulijs 2006; Kettle et al. 2014). They also share an increasing focus on active engagement, deliberation, and process (rather than product alone) to enhance individual and social learning experiences (Moser and Dilling 2007; NRC 1996, 2009, 2010; Jones et al. 2009; Berkhout et al. 2002; Kettle et al. 2014). Participatory action research offers one valuable route through which academics and professional researchers can work with stakeholders to build local capacity to adapt. Academics and researchers can advance local climate change adaptation efforts through collaborative, action-oriented research that enhances the capacity of local communities. Such "participatory action research," also can help researchers produce knowledge that is more salient, legitimate, and credible to local stakeholders and directly useful for decision-making (Rumore 2014). This framework recommends various learning techniques such as (1) Citizen science; (2) Conferences and symposiums; (3) Formal education; (4) Workshops; (5) Training programs; (6) Field visits; (7) Exhibitions; (8) Participatory techniques and others. Thus, this component of the framework is to foster an atmosphere of dialogue that helps all stakeholders in general and communities, in particular, to understand the risk of rising SLR and build capacity at the local level.

SWOT Analysis of the BASIEC Framework

The effectiveness of the emerging frameworks like this can be assessed initially through a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis. It is used to provide a descriptive assessment and provide a comparison of the factors affecting the effectiveness of the tool/framework. It is an assessment of internal strengths, weaknesses, external opportunities, and threats used in the preliminary stage of strategic decision-making (Johnson et al. 1989; Berte and Panagopoulos 2014). There are several interesting observations that can be useful for anyone considers the application of a tool/framework or the development of new approaches, particularly when it comes to weaknesses, opportunities and threats (MRC 2010; Khan 2017). In this study, SWOT analysis was carried out theoretically based on the secondary literature with specific reference to BASIEC framework. SWOT exercise aimed at maximizing the potential of the strengths and opportunities while minimizing the impact of the weaknesses and threats in order to achieve the best results on the application of the BASIEC framework. Some of the key findings of the SWOT analysis of BASIEC framework are: (i) *Strength*: (1) Many of the climate change frameworks and tools are generic in nature, whereas BASIEC framework exclusively address SLR and coastal climate; (2) It integrates different dimensions of SLR risk information from observed and past local SLR data to future predicted impact and adaptation planning; (3) The three pillars of the framework are distinctive from each other yet plays a collective role in building the framework; (4) This framework is exclusively designed for SLR risk awareness and CBA at the local level; (5) The framework with a worksheet is simple and user friendly and it is applicable to any part of the global coastal region that are at risk to SLR; (ii) *Weakness*: (1) Difficulties in delineating SLR and coastal issues from the rest of the other issues such as developmental issues; (2) Lack of availability of expertise in SLR risk to handle SLR risk information to communicate and educate stakeholders and communities locally; (3) Lack of unavailability of SLR in formation at the local level, which includes future SLR projection, predicted impacts, etc.; (4) Obscurity on availability and accessibility of communication and educational aids to communicate SLR risk information and to educate; (5) Challenges in working with local communities such as gathering local communities, communicating the risk in local language etc., (iii) *Opportunities*: (1) To upscale the application of BASIEC to wider and various stakeholders and geographical locations; (2) To develop formal SLR risk communication and education curriculum for schools and colleges; (3) To develop web-based online platform to get digitized; (4) To develop a smart phone based apps for BASIEC to reach wider audiences; (5) To make BASIEC interventions in SLR policy planning; (iv) *Threats*: (1) Need of scientific information on SLR risk may lead to manipulation of SLR risk information and data; (2) Many technical information on SLR may increase complexity and leads to confusion; (3) Chances of wrong or miscommunication of SLR information and its translation into local languages; (4) The evaluation of the application o BASIEC i.e. SLR risk communication and education is majorly qualitative and is based on the expertise of an individual and group who handle BASIEC, is