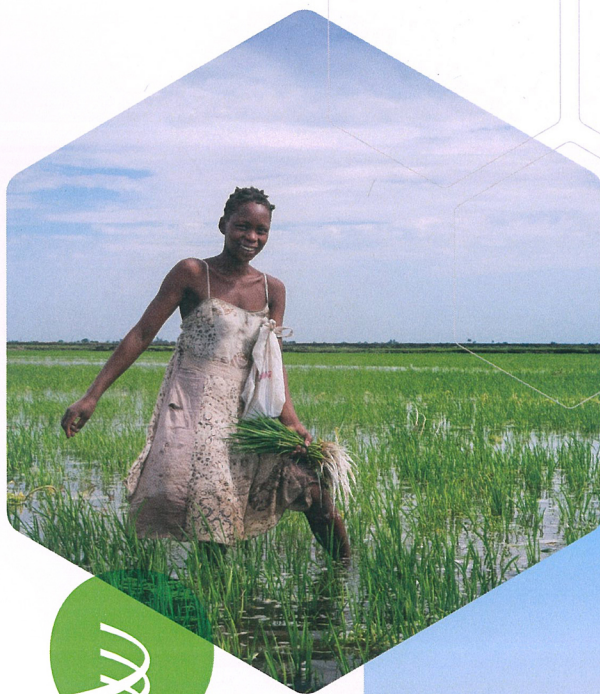


# Green Technology Book 2022

Solutions for  
climate change  
adaptation



# Contents

Foreword by WIPO	4	1 / Climate change adaptation and technology	18
Acknowledgments	6	Climate change adaptation Technology and innovation as part of the solution	18
Foreword by partners	8	Adaptation funding	20
Acronyms	10		23
Executive summary	11	2 / Innovation and transfer of solutions	26
Introduction	15	The innovation ecosystem	26
How we wrote the book	15	Intellectual property in green technology transfer	28
How we found the technologies	15	Technological knowledge within the patent system	29
Disclaimer	17		
Bibliography	171	3 / Agriculture and forestry	31
		Technological developments and trends	32
		Patents and finance	33
		Climate-resilient plants	35
		Healthy soils	44
		Farming technologies	52
		Irrigation	59
		Livestock	66
		Forest and ecosystem management	74
		Early warning systems, modelling and monitoring	81
		4 / Water and coastal regions	89
		Technological developments and trends	90
		Patents and finance	91
		Coastal protection	93
		Flood prevention and control	100
		Water treatment	108
		Water efficiency and conservation	115
		Marine ecosystems	124
		5 / Cities	133
		Technological developments and trends	134
		Patents and finance	135
		Urban planning	136
		Buildings	143
		Infrastructure and services	152
		Early warning systems, modelling and monitoring	160
		6 / Conclusion and recommendations	168

# Foreword by WIPO



Daren Tang, Director General,  
World Intellectual Property  
Organization (WIPO)

**Welcome to the inaugural edition of the *Green Technology Book*, a new flagship publication from WIPO.**

As the UN agency for innovation, creativity and intellectual property (IP), WIPO is committed to supporting the development of green technologies and new innovative solutions in the fight against climate change. The global IP system plays a critical role in ensuring that such solutions create impact. It helps translate basic research into tangible climate change solutions, incentivizes public and private R&D investment into environmentally-friendly technologies and generates a vast treasure trove of information that is open and accessible to all.

This is important. Innovation and technology are critical to tackling the many different facets of the climate crisis. This includes climate change adaptation - the theme of this year's publication.

Adaptation will increasingly become a necessity for fast-growing parts of the world's population, as well as for natural ecosystems in every region of the globe. As there is no "one-size-fits-all" approach to adaptation, the solutions take a variety of forms according to local contexts and needs. But investment in climate adaptation has long lagged behind climate mitigation.

This is despite the fact that for many countries – developing countries in particular – it is adaptation responses that have the immediate impact.

With this in mind, the inaugural edition focuses on three areas that can benefit from new technological advances: Agriculture and forestry – Water and coastal regions – and Cities. Our aim is to provide a practical guide for those at the frontline of climate change – coastal communities, farmers, vulnerable urban populations and others – as well as innovators, industry, researchers and agencies, which raises awareness of solutions. By offering this guide we hope to encourage their adoption for the benefit of all.

The book builds upon the work of our tech-matching platform WIPO GREEN, whose growing database of nearly 130,000 entries from around the world connects green technology providers with those seeking environmentally-friendly solutions.

One of the key findings of this inaugural edition of the *Green Technology Book* is that, while there remains scope for speeding up new technology deployment, we should take encouragement – and inspiration – from the sheer range of transformational tools at every stage of development.

We know that the window of opportunity for climate action is narrowing. As the most recent IPCC report states with high confidence, rising temperatures are a serious and mounting threat to human life, biodiversity and infrastructure.

Access to a balanced and neutral guide on the global state of green innovation and technology is therefore critical. By focusing attention on current and emerging technology trends we hope the *Green Technology Book* can be that resource and add momentum to those areas that are driving much-needed change.

I would like to thank our partners the UN Climate Technology Centre & Network (CTCN) and Egypt's Academy of Scientific Research and Technology (ASRT) for their support in this new initiative, as well as everyone at WIPO who has helped make the *Green Technology Book* a reality.

I hope you will find it a store of useful information and valuable insights into how innovation can help us address climate change and its impacts.

# Acknowledgments

The *Green Technology Book 2022* is the product of many dedicated contributors – from technology providers to experts in the field. The book was prepared under the general auspices of Director General Daren Tang and WIPO's Global Challenges and Partnerships Sector led by Assistant Director General Edward Kwakwa, as well as the Global Challenges Division led by Director Amy Dietterich.

Special thanks go to our partners at the Climate Technology Centre and Network (CTCN), represented by Dr Rose Mwebaza (Director) and the Egyptian Academy of Scientific Research and Technology (ASRT) represented by Professor Mahmoud M. Sakr (President) for their partnership, vision and contribution.

The *Green Technology Book* is an initiative under WIPO GREEN. It was conceived and led by Peter Oksen, Green Technology and Research Manager, who also acted as editor and writer. However, acknowledgement for the majority of the writing goes to Shanar Tabrizi, Climate Technology Expert and Lead-writer. Jeremy Rutman (CEO) RutmanIP.com helped in the search for technologies. Other WIPO GREEN staff contributed important elements, namely: Anja von der Ropp, Senior Program Coordinator, as well as Dmitry Kalinin, Nivedita Saksena Raj, Didier Georges, Minna Guigon-Sell and Cherise Trotman.

We thank Charlotte Beauchamp (Head) and Edwin Hassink (Graphic Designer) from WIPO Publications and Design Section for the layout and design work. Vanessa Harwood from the same section and Book Now Ltd provided professional language revision. We also thank the team that made the digital version of the book come to life, namely: Dan Savu (Head) and Javier Agilar Lopez, both WIPO Solutions Design and Delivery Section, Andy Donald (Vanishing Point), and Virginie Roux and Spencer Cabildo, Web Communications Section. Bénédicte Delrieu and Mathilde Hemar from the Customer Experience Section facilitated the climate change impact survey. Edward Harris (Senior Media Officer) News and Media Division provided communication support. The Language Division led by Mr Lijun Fan provided translation.

A group of colleagues from across WIPO and beyond volunteered their experience and valuable advice for which we are deeply grateful. The group includes Amy Dietterich (Director, Global Challenges Division), Andrew Czajkowski (Director, Technology and Innovation Support Division); Carsten Fink (Chief Economist, Department for Economics and Data Analytics), Kevin Fitzgerald (Director, Information and Digital Outreach Division); Walid Abdelnasser (Director, Division for Arab Countries); Aurea Plana (Assoc. Legal Officer, Madrid Legal Division); Edward Harris (Senior Media Officer, News and Media Division), Charlotte Beauchamp (Head, Publications and Design Section), Victor Owade (External Relations and Partnerships Officer, External Relations Division), Rajiv Garg (Regional Manager, CTCN) and Heather Jacobs (Knowledge and Research Specialist, CTCN).

A distinguished group of experts kindly agreed to review various sections of the publication and in doing so significantly improved quality. They include:

UN Climate Technology Centre and Network (CTCN):

- Heather Jacobs, Knowledge and Research Specialist
- Rajiv Garg, Regional Manager

International Fund for Agricultural Development (IFAD): Fanny Minjauw, Environment and Climate Monitoring and Results Specialist

International Livestock Research Institute (ILRI): Jason Sircely, Senior Scientist

Heinrich Böll Stiftung: Liane Schalatek, Associate Director

UNIDO: Patrick Nussbaumer, SDG Innovation and Economic Transformation, Innovative Finance and International Financial Institutions, United Nations Industrial Development organization (UNIDO)

UNEP–DHI Centre: Maija Bertule, Senior Technical Advisor

UNEP Copenhagen Climate Centre:

- Fatemeh Bakhtiari, Senior Researcher
- Jay Sterling Gregg, Senior Researcher
- Lindy C. Charlery, Advisor
- Susanne Konrad, Project Officer
- Talat Munshi, Senior Advisor
- Zhuolun Chen, Senior Advisor

WIPO:

- András Jókúti, Director, Patents and Technology Law Division
- Carsten Fink, Chief Economist, Department for Economics and Data Analytics
- Edward Harris, Senior Media Officer, News and Media Division
- Shakeel Thomas Bhatti, Counsellor, Traditional Knowledge Division
- Andrew Czajkowski, Director, Technology and Innovation Support Division

We sincerely thank all the organizations and technology providers making their solutions available to the world. Without them there would be no book.

# Foreword by partners



This year at COP27 in Egypt all eyes will be on the continent of Africa where climate change adaptation is a top priority. Technology is a recognized enabler of climate action for adaptation. But we have yet to fully maximize its potential. Technology and innovation are needed to address the myriad considerations that go into planning for more sustainable cities, improving agricultural production and transforming food systems, building resilience in coastal communities, and protecting and conserving our dwindling water resources. Though adaptation remains underfunded, great advances for example in digital technologies should give us hope.

The Climate Technology Centre and Network (CTCN) supports all facets of technology innovation through technical assistance, capacity building and knowledge sharing. Over the past few years, we at the CTCN have observed a rising demand for technical assistance on adaptation and cross-sectoral technologies. Among other initiatives, the CTCN has collaborated with the Adaptation Fund to foster innovation in developing countries through the Adaptation Fund Climate Innovation Accelerator. And the CTCN remains well positioned to support adaptation technology deployment and transfer in developing countries as we embark upon our third programme of work for 2023–2027.

Technology can help us tackle some of the worst impacts of climate change. And innovation is the key to unlocking technology's power to advance adaptation action. Innovation is critical to developed and developing countries alike. It is fundamental to sectors demanding creativity, ingenuity and "thinking outside the box" to address the increasingly complex issues caused and exacerbated by climate change. Each year that passes shows us that no country will escape the impacts of climate change – with each needing to develop, implement and scale up innovative technologies as effectively and efficiently as possible.

The CTCN has partnered with WIPO on this inaugural edition of the *Green Technology Book* in an effort to raise awareness about the breadth of technologies – some of which are truly remarkable – available to us all. They include some that are "proven" and those at an earlier stage of development ("frontier" and "horizon") – which is exciting for the future. Importantly, the *Green Technology Book* affirms what the IPCC has already made clear – many of the technologies and tools we need are already available to us today. It also affirms the imperative to continue our engagement in critical components of technology transfer such as research and development.

We at the CTCN look forward to this collaboration with WIPO in continuing to highlight novel technologies supporting climate solutions across the world. We hope you will be as inspired as we are in presenting them to you.

**Dr Rose Mwebaza**  
Director of the CTCN



All current national policy documents in Egypt consider science and technology to be vital for the prosperous future of the country, particularly in view of its high level of vulnerability to climate change impacts. Egypt's Science, Technology and Innovation Strategy (Egypt STI 2030) revolves around nurturing an enabling environment for STI and improving its ability to produce knowledge efficiently and effectively. This is intended to increase the growth rate of the national economy, develop society sustainably and elevate the quality of life for people.

Egypt's Ministry of Higher Education and Scientific Research has set out strategic objectives and policies aimed at directing research, development and innovation (RDI) projects toward supporting the country's efforts to achieve sustainable development under the climate change crisis. The plan dates back to early 2017 and focuses much attention on allocating the public funds needed to boost green innovation, as well as RDI in renewable energy, water desalination, recycling research, saline and dryland agriculture, biodiversity, more crops per drop of water, the blue economy and the environment.

The Academy of Scientific Research and Technology (ASRT) – Egypt's think tank – has always been capable of providing the vision, roadmaps and policies to pave the way for policymakers to implement Egypt STI 2030. ASRT has always been committed to bringing forward national plans and navigating through the United Nations Sustainable Development Goals to achieve real solutions, not only for national challenges, but global ones too.

As a result of these efforts, the Egypt STI community now runs the biggest RDI and the ASRT pilots renewable energy facilities. These include the MATS concentrated solar power station, a water desalination plant in Borg El Arab city and the China-Egypt Joint PV (photovoltaic) Lab in Sohag. Furthermore, ASRT has supported the implementation of national projects for the conservation of plant genetic resources, the reintegration of mangrove forest and coral reef rehabilitation in the Red Sea.

The *Green Technology Book* is a perfect guide for individuals, organizations and policymakers. It highlights the technological solutions available to meet today's climate challenges, as well as analyzing important current and future innovation trends. This will have a direct impact, in particular on the implementation of adaptation solutions to climate change.

ASRT is proud of its partnership with WIPO and the United Nations in launching this annual Flagship publication promoting green technologies. Our hope is that this can be a vehicle for boosting Egypt's innovation system, at the same time as creating a global awareness of Egypt's role in innovation.

**Professor Mahmoud M. Sakr**  
ASRT President



# Executive summary

Climate change impacts are here. And they are here in force. In 2022 alone, several tragic records were broken and the trend toward more frequent, extreme weather events becomes increasingly apparent with every year that passes. Adaptation is a necessity. Despite decades-long warnings and increasingly desperate calls for action, the world has not yet been able to mitigate climate change. At the current pace of action, it is unrealistic to keep global warming below the 1.5°C that the 2015 Paris Agreement is aiming at under best circumstances.

## The role of technology in climate change adaptation

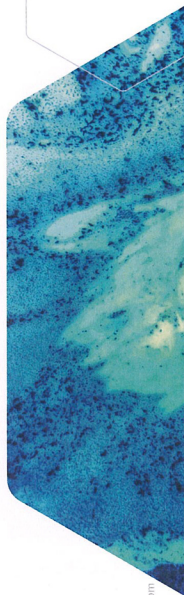
Climate change adaptation aims to increase resilience to climate impacts and reduce vulnerability. Climate change impacts can be difficult to predict and their effects take many forms. It is not only a question of protecting ourselves against extreme events. It is also a matter of adapting to the gradual incremental changes likely to change life from how it is for the majority of us. Climate impacts affect how we grow crops, rear livestock, use water, live with the sea, plan our cities and much more. Also, because many natural ecosystems are under threat, they will need our active support if they are to avoid collapse and widespread species extinction averted. While every country is facing climate change impacts, many developing countries are particularly vulnerable. This could be because like the least developed countries they have only limited means with which to respond. Or it could be because of their geographical setting, which is the case for some small island states. Moreover, as many developing countries were never and are not major CO<sub>2</sub> emitters, actions to mitigate climate impacts may be far less relevant in their case than adaptation measures.

Green innovation and technology have solutions to offer. However, it is not a matter of relying on quick fixes and scaling up of a few major breakthrough solutions. It is instead a matter of developing and deploying thousands of solutions at all levels of sophistication. But it would also be wrong to believe that innovation and technology can solve everything. They cannot. Technology is no substitute for a broad range of fundamental and necessary changes to the way we produce and consume.

In this first edition of the *Green Technology Book* – a new WIPO Flagship publication – we aim to demonstrate that a wealth of innovation and technologies aimed at adaptation is not only being developed but currently available. We look specifically at the major sectors of agriculture and forestry, water and coastal areas, and cities. By showing tangible examples of technologies, we hope that this may inspire others to discover and develop solutions to their own challenges. We have chosen to showcase more than 200 technologies but many more exist which to our knowledge are not inferior to the ones included here. Many more solutions can be found in the WIPO GREEN Database of needs and technologies. Solution providers can freely upload to the database, making it a continually expanding source of innovation, technology and solutions.

## Adaptation technologies are available but not always accessible

Although there are many technology-based solutions available, they are not being deployed fast enough to meet the multiple climate change challenges. Adaptation technologies are generally behind mitigation technologies in terms of policy support and funding. However, adaptation is gaining traction. Several funding and support institutions specifically target adaptation. The private sector is also coming onboard, as more ways of assessing the returns to and impact from adaptation investment are developed. One sector seeing a remarkable investment growth is AgTech. Many countries have also prepared and are now implementing specific



adaptation plans. An increasing portion of climate funds is being allocated to adaptation, although still outweighed by mitigation funding. It should also be noted that many of the technologies classified as adaptation technologies also have mitigation aspects, bridging the well-established dichotomy between adaptation and mitigation. Nature-based solutions, where natural processes are utilized or reinforced in order to, for example, protect against floodwaters are gaining ground. Many of those fit under the term “no-regret” solutions providing benefits independent of whether the climate change impacts for which they were designed actually happened as predicted.

A small number of developed countries dominate the innovation space for adaptation technologies, at least when analyzed through patents. Transfer of adaptation technologies to developing countries is happening but at a level well below that of mitigation. This is not so surprising given the often highly advanced technologies being developed for greenhouse gas emissions reduction compared to the very diverse and often less sophisticated solutions needed in adaptation. However, this is not in itself an expression of unwillingness. And what is more, innovation in adaptation technology is growing.

Solutions are created within an innovation ecosystem dependent on many underlying factors. These factors span education, market size and sophistication, and the rule of law. The innovation ecosystem provides the conditions under which an inventor can develop, finance, publicize, market, protect and benefit from an innovation. Intellectual property right is a cornerstone of the innovation ecosystem. And it is through the patenting system that a huge amount of innovation information is made accessible. Technology knowledge can be searched for in several public patent databases. This enables the authorized use of an invention in countries where a patent has been granted, free use in countries where a patent has not been granted, and further development into new patentable inventions.

### Thematic areas of the *Green Technology Book*

In this publication, we have focused on three main areas where climate change impacts will be highly significant, namely agriculture and forestry, water and coastal areas, and cities. We have searched for examples of innovation that can provide solutions. They are presented here in order to show what is possible and what can be done.

Technologies are divided into three groups

- Proven technologies which have been around for some time and are well tested;
- Frontier technologies which are new, less well-tested but available; and
- Horizon technologies which are near-future solutions expected on the market within the foreseeable future.

### Climate-smart agriculture and forestry

Agriculture and forestry are already heavily influenced by climate change. This manifests itself in changes to cropping season length, higher temperatures and less water, as well as floods, soil salinity and the creation of conditions conducive to pest spread.

In response to these risks, significant developments are taking place in relation to optimized and sophisticated practices. They include using remote and in-field sensing data to provide a detailed understanding of the condition and needs of plants and animals. This information

# The *Green Technology Book* is meant to inspire everyone who needs a solution to a climate change challenge

can then direct various machinery to for example dispense an exact dosage of herbicide or water. This reduces the potentially harmful use of such products, saves resources and helps optimize production in a changing environment. Many of these technologies are best suited to larger operations able to access capital for investment in equipment. However, other advanced technologies may not need such large investments. For example, using almost omnipresent mobile devices, advanced data and control technologies can be made relevant in far smaller and poorer contexts. Moreover, simple improvements in techniques can have a significant effect. For example, by saving on water farmers can reduce their vulnerability to climate change impacts. Many of the practices and technologies that come under the broad term *climate-smart agriculture* benefit both mitigation and adaptation alike. Modifying plants and animals to better cope with a changing climate is another active innovation area. But one which, depending on the methods applied, may carry with it the controversy associated with genetic modification.

## Water preservation and coastal protection

Water is fundamental to life. Climate change causes too much or too little. For coastal communities, rising sea levels, violent storms and floods, as well as salt water intrusion, are an increasingly common risk. But so is more acidic and warmer oceans, and this calls for strengthened and innovative approaches to marine ecosystem conservation.

Many important innovations can help save water, as well as monitor quality and the state of water reserves. Remote and in-field sensors play an important role in directing other technologies, for example to regulate water use. Improved rainwater harvesting systems and water storage tanks can maintain supply during dry spells. In some countries, an increasing demand for massive water desalination plants is driving innovation toward higher efficiency and lower costs. Water treatment and advanced control of distribution networks combines several innovative technologies to realize impressive water savings. The need for protection against too much water arriving all at once has prompted significant innovation in flood barriers, nature-based stormwater storage and early warning systems. Coastal zones are particularly vulnerable to climate change. As they are often densely populated and important economic zones, the impacts can be far reaching. Advanced modelling of water and sediment movements helps determine what is the most appropriate protection measure, be it beach nourishment, dikes or other hard and soft protection structures. Here also nature-based solutions such as restoring mangrove forests and coral and other reef types can be no-regret solutions with widespread benefits for people and marine ecosystems.

## Climate-adapted cities and urban planning

Extreme weather events in recent years have made it abundantly clear that cities and their populations are highly vulnerable to climate change. New thinking – not least new innovation – is required. Heatwaves, heavy rainfall, floods, storms and rising sea levels have already exacted a toll on populations and impacted city budgets.

Advances in urban planning may provide some solutions. For example, incorporating green infrastructure like stormwater drainage and temporarily transforming underground parking and road networks into reservoirs can reduce a city's vulnerability toward heavy rainfall. New materials and green building design can help mitigate heatwave impacts and reduce the heat island effect found in most cities. Many options exist for greening the cityscape. These can help increase surface water infiltration, reduce heat, provide shade and even produce food.

## The global progress of adaptation technologies

Searching for solutions from a variety of sources has taught us some important lessons and it is these that inform the following recommendations.

It is clear that the need for adaptation is not confined to developing countries. Climate change adaptation is needed the world over. But the urgency and the diverse solutions required in developing countries is pronounced. A lot of adaptation is directed there already. But often solutions originating in developing countries are less visible when searching through public and globally available channels. This does not mean that innovation is not taking place. Rather, greater visibility is necessary for adaptation solutions originating in developing countries, not least with the aim of transferring solutions between developing countries and the rest of the world.

Supporting the innovation ecosystem is important. It is important not only for innovation creation, but also for receiving, adopting, adapting and developing it further. Supporting the innovation ecosystem pretty much comes down to nurturing all the many factors that enable people's imagination and creativity to flourish and supporting them in developing their ideas into workable and possibly marketable solutions.

Planning for adaptation is complex. Adaptation has highly diverse needs with many unknowns or uncertainties. Therefore a thorough analysis of the risks, costs and benefits before an initiative is undertaken is crucial in order to avoid maladaptation. Using and improving already mainstreamed safeguarding tools such as Environmental and Social Impact Assessments may be a way forward.

Solutions whether simple or sophisticated are required. In many settings, cheap and simple techniques may at first appear the most suitable and feasible. But highly advanced technologies such as satellite imagery and advanced sensor data can through mobile devices make the difference between being prepared or losing everything. They can also help track the development and impacts of climate events in close to real-time.

The *Green Technology Book* is meant to inspire everyone who needs a solution to a climate change challenge. It may also be a valuable source of inspiration for other related needs. We hope it will. We plan this to be an expanding publication with a new edition added every year. We also want to make the WIPO GREEN Database of needs and green technologies an innovation anchor point. One which will grow alongside the publication every time a user uploads a new solution. This will help make even more innovative solutions known to the general public, experts and lay people alike.

# Introduction

The *Green Technology Book 2022* is for anyone who has ever wondered about climate adaptation technologies. It is for those seeking concrete solutions with which to adapt their crops, protect their homes and prepare for the adverse impacts of climate change. It is for those curious to know what adaptation technologies are available today and what in the near future – and importantly how to access them. It is for those seeking to invest. It is also for those who design our cities and buildings, and for those who lead our communities, cities and countries along a more resilient path.

By drawing out examples of solutions, we aim to inspire action. The *Green Technology Book* is not a comprehensive collection of all adaptation technologies. Nor does it cover all the areas where adaptation technologies could be relevant. We have chosen instead to focus on three broad areas where we believe climate change adaptation is and will be particularly critical. They are Agriculture and forestry, Water and coastal regions, and Cities.

We welcome greater visibility for local innovation, especially from those countries most affected by climate change. Often the best technology may not be the one on the market but the one available locally but not widely known about, maybe reviving ancient skills and insights. The *Green Technology Book* is more than a catalogue meant for inspiration but a living project where everyone can contribute. The publication links to the free public [WIPO GREEN Database](#) of needs and green technologies, where users can create a profile and share their climate solutions and needs.

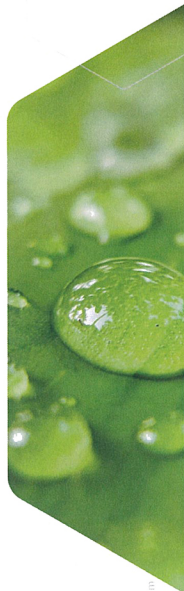
## How we wrote the book

For the purposes of the publication, we considered a broad set of scientific articles, gray literature as well as technology databases developed by private, public and civil society entities and organizations. Search strings included broad terms related to climate adaptation paired with key terms for the three thematic areas, and key terms related to specific technologies (“desalination,” “seawall,” “fertilizer” and so on). Delimiting technology areas was greatly helped by adaptation taxonomies developed by the United Nations Climate Technology Centre and Network (CTCN, 2017), UNEP Copenhagen Climate Centre, and the Korean Green Technology Center (UNEP-DTU, 2021). Translation engines enabled us to search articles in several languages to ensure a broad geographical spread.

Owners of the technologies identified were contacted, and all were uploaded to the [WIPO GREEN Database](#) of needs and green technologies, either by the technology owner or by us at WIPO.

## How we found the technologies

Throughout the publication, we operate with three concepts: innovation, solution, and technology. While sometimes used almost interchangeably, they do have different meanings. We here utilize the term innovation to cover all intellectual creativity that can result in a solution. Solution broadly means to deploy the output of this innovation to solve a specific challenge. Technology is a broad term, but we apply it more narrowly to any physical entity or technique, with or without additional equipment, that is deployed to resolve a specific challenge. We are primarily interested in a technology’s potential for responding to impacts from climate change. We therefore cover technologies broadly, ranging from the very simple to the highly complex. Often the scope of climate technologies is expanded to include enabling mechanisms such



as ownership and institutional arrangements that pertain to the technology (e.g., water user associations or pricing schemes). While recognizing the importance of such mechanisms, we focus mainly on tangible technologies or actual techniques.

It is important to emphasize that the technologies presented here have not been tested or in any way vetted by WIPO, and that we rely on publicly available material. Inclusion in the *Green Technology Book* is therefore not a recommendation of a particular technology. Technologies presented here should be seen as examples of a technology area, of which there may be many similar offerings which to our knowledge are in no way inferior. Photos illustrating the technologies are used with permission from the technology owners. When a permission could not be obtained, we use relevant stock-photos. Photos of technologies may therefore not represent the actual technology.

The appropriateness of a technology is often highly context-specific and relates to factors other than geographical location. Therefore no recommendations on where, when or how the technologies are suitable have been provided. Such an assessment should always be made with the involvement of local experts and stakeholders. Technology owners can freely upload their technology to the WIPO GREEN Database and thereby become part of the project.

The following criteria were used when selecting technologies for the *Green Technology Book 2022*:

- relevance for climate change adaptation;
- relevance for the three thematic areas: 1) agriculture and forestry, 2) water and coastal regions, and 3) cities;
- pertain to:
  - a product or service available for purchase or licensing;
  - a product or service available for free/open source;
  - a guidebook on application of a method or technique;
  - a research project or similar (for horizon technologies).

In addition, the following factors were taken into consideration:

- anticipated impact from implementation;
- availability of sufficient quality information or third-party endorsements;
- market availability (for proven and frontier technologies);
- cost in relation to impact;
- geographical balance;
- business balance (large- and small-scale businesses, start-ups, research teams, non-governmental organizations and so on);
- no harm principle.

We have divided technologies into three broad groups in order to indicate their maturity and availability. *Proven technologies* have been on the market for some time and therefore rely on a tried and tested concept. *Frontier technologies* are available, but still relatively new, and as such possibly less validated in a real-world setting. *Horizon technologies* are those new concepts being developed and expected to become available within a few years' time; that is to say, technologies that are realistic and likely to become available soon.

When presenting technologies, we have included a few classifiers as an easy guidance to relevance for a reader. We have aimed for a broad representation of technologies at various stages of complexity and readiness. We classify technologies as either a low, medium or high level of complexity. This serves as an indication only and does not follow a strict definition

of complexity. It reflects the level of human, material and monetary resources required to implement the solution. Meanwhile, technology maturity was broadly assessed according to the standard Technology Readiness Level (TRL) definition. According to this measure, horizon technologies have the lowest readiness level but are still close to full development (TRL 3–6), whereas proven and frontier technologies are validated and ready for to be scaled-up if not already done (TRL 7–9).

We hope that you will be inspired by the creativity, ingenuity and diversity of the technologies that we have chosen to present. We welcome feedback and suggestions, which can be sent to us through the WIPO GREEN website.

## Disclaimer

This publication, WIPO, and WIPO GREEN are in no way affiliated with any of the featured companies. Nor does this publication imply that other non-featured companies or technology solutions do not exist. All content in this publication is provided in good faith and based on information provided directly from the providers and/or using publicly available materials. Photos of technologies may not necessarily depict the actual technology. Therefore WIPO and WIPO GREEN disclaim any warranties, express or implied, as to the accuracy, adequacy, validity, reliability, availability, or completeness of any information provided. WIPO and WIPO GREEN are not responsible for any negative outcomes as a result of actions taken based on information in this publication.

### URL Links

This publication contains links to external websites that are not provided nor maintained by WIPO or WIPO GREEN. Responsibility for the content of the listed external sites lies with their respective publishers. These links are provided for contact and informational purposes only; WIPO and WIPO GREEN do not sponsor or endorse any of the content therein. While every effort has been made to establish the legitimacy of each linked site, WIPO and WIPO GREEN disclaim any warranties, express or implied, as to the accuracy of the information in the linked content, and also disclaim any responsibility regarding the potential for data breaches as a result of accessing the links.