PLACARD

Economics and finance of disaster risk reduction and climate change adaptation

Main gaps identified in arising alignment opportunities for the EU Green Deal

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List of acronyms

AI	Artificial Intelligence
AM	Adaptive management
CAP	Common Agricultural Policy
CBA	Cost-benefit analysis
CCA	Climate Change Adaptation
CEA	Cost-effectiveness analysis
CIF	Climate Insurance Fund
CRA	Climate Risk Assessment
CRI	Climate-resilient investments
CRM	Climate Risk Management
CSR	Corporate Social Responsibility
DG	Directorate General
DG CLIMA	Climate Action
DG ECHO	European Civil Protection and Humanitarian Aid Operation
DG JRC	Joint Research Centre
DG R&I	Research and Innovation
DLT	Distributed Ledger Technology
DRMKC	Disaster Risk Management Knowledge Centre
DRR / DRM	Disaster Risk Reduction / Disaster Risk Management
EC	European Commission
EEA	European Environment Agency
EESG	Economic, Environmental, Social, Governance
EFSF	European Financial Stability Facility
EIB	European Investment Bank
ERTM	European Risk Transfer Mechanism
ESG	Environmental, Social, Governance
EU	European Union
FbF	Forecast-based Financing
GD	The EU Green Deal
HDII	Hydrological Drought Index Insurance
IAMs	Impact Assessment Models
IBI	Index-based insurance
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
MCA	Multi-criteria analysis
MPI	Multi-peril insurance
PA	Paris Agreement
RDM	Robust decision making
SDGs	Sustainable Development Goals
SFDRR	Sendai Framework for Disaster Risk Reduction
SPV	Special Purpose Vehicle
UN	United Nations
UNFCCC	United Nation's Convention on Climate Change

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1. Introduction

a. Objectives

The following report identifies political, economic and financial shortages in the EU Green Deal, brings the light on knowledge gaps between Climate Change Adaptation (CCA) and Disaster Risk Reduction (DRR) communities – explores the opportunities for improvements of the main EU strategic document by bridging identified gaps. This knowledge has been used in the PLACARD coordination agenda on interchange and collaboration between the above-mentioned communities in order to create synergies among both fields and to improve the overall resilience building process. In addition, it seeks to identify concrete actions to eliminate and prevent overlaps[1] and/or conflicting actions taken within both communities as well as to effectively counteract fragmentation of knowledge.[2]

In brief, the report investigates the most important finance and economic gaps[3] that currently hinder production, integration and practical implementation of knowledge by DRR and CCA stakeholder groups. Those gaps provide also specific opportunities for a better alignment between both fields if addressed properly by appropriate stakeholders capable of introducing required changes. The alignment opportunity results from the fact that finance, insurance as well as risk transfer remain main driving forces for climate adaptation and disaster risk management leading to long-term sustainability. Consequently, the identified opportunities can be also used to improve the EU Green Deal and assure higher efficiency of the implemented measures. PLACARD as a platform for DRR and CCA community actively supports and contributes to that alignment process and a better integration of CCA and DRR into European Green Deal.

1 Overlap arises when a particular issue that is addressed independently by both CCA and DRR community and thus duplicative work is performed which increases the overall effort to reach the goal.

2 Fragmentation of knowledge occurs when a specific information/ know how on a particular topic or issue is concentrated in a particular community or organisation which is not broadly known and thus little or totally not accessible to others stakeholders.

3 Gap is a barrier that hinders understanding and collaboration between DRR and CCA communities. In effect, it has a negative effect on the production, integration and practical implementation of the knowledge to increase resilience.

b. Methodology, Scope and Structure of the Report

The issues addressed in this report have been identified as particularly important based on the expertise and knowledge gathered as a part of the PLACARD interchange with relevant DRR and CCA stakeholders, (e.g. through the participation and/or organisation of several workshops, meetings, conferences etc.). This means that the report does not cover all existing gaps between DRR and CCA, but focuses only on those that repeatedly were mentioned by CCA and DRR stakeholders during the PLACARD events as the biggest challenge to achieve resilience – could be important for improvements of the EU Green Deal (see Table 1). For this reason, the scope of this report has been evolving from the beginning of the PLACARD project in 2016 in form of a "living document" to reach the current final version.

Table 1: Events within the PLACARD project on CCA, DRR finance and economics.

Event	Date	Place	Type of participation	Organisation
European Urban Resilience Forum	25 May, 2019	Bonn	Participation in the discussions (specifically coherence with sustainable finance)	UFZ
10th Global Forum on Urban Resilience	26–28 May, 2019	Bonn	Participation in the discussions	UFZ
18th Joint Seminar of the European Association of Law and Economics and the Geneva Association	13–14 June, 2019	Milan	Participation in the discussion	UFZ
OECD and PLACARD joint workshop: Investing in infrastructure: costs, benefits and effectiveness of disaster risk reduction measures	18–19 September, 2019	Paris	Presentation and participation in the discussions	UFZ
Partnership of European Environmental Research (PEER): Multi-Hazard/Multi-Risk-Workshop	14–16 October, 2019	Copenhagen	Participation in the discussions (specifically coherence with sustainable finance)	UFZ
Finance for disaster risk reduction – Boosting public-private sector cooperation: Roundtable organised by DG ECHO and UNDRR	24 October, 2019	Brussels	Participation in the discussions	UFZ
Innovations by Nature	15–16 November, 2019	Kyiv	Participation in the discussions (specifically coherence with sustainable finance)	UFZ

Source: built by the authors.

The practical knowledge of those challenges gathered from the practitioners has been completed by a comprehensive desktop research including stocktaking of DRR and CCA science and policy reports, scientific papers, case studies, policy briefs, notes and other background materials.

In particular, the report identifies six main areas that currently hinder DRR and CCA collaboration to a great extent, but could become possible **connectors**. This include: (i) *Policy coherence*, (ii) *Methods and tools in CCA and DRR management*, (iii) *Impact/damage data*, (iv) *CCA and DRR Finance*.[4] The current version of the report places a particular emphasis on financial tools and related political agendas to bridge CCA and DRR communities.

To each gap/opportunity, specific target group(s) have been assigned that currently experience(s) the impact of a gap, but could benefit most if it was overcome. Finally, the report provides specific recommendations how to tackle each specific gap and take the chance of the resulting opportunity including a brief description of PLACARD's contribution to close the specific gap.

c. Main gaps and resulting opportunities

In search for feasible "Gap-Solutions", we have been relying on different approaches and methods depending on the issue at stake. In particular, we used (i) *outcomes of PLACARD work* including background materials, analyses (Flyers of Paris Agreement and Sendai Framework for Disaster Risk Reduction) and dialogues to decrease fragmentation with regard to political agendas in place. This part of the Gaps-Opportunities Report is focused on the common goals, targets and measures for CCA and DRR communities. Further, we extensively used (ii) *desktop research* and expert/practitioners knowledge, (e.g. intensive exchange with experts from European Association of Law and Economics, Geneva Association, Partnership of European Environmental Research (PEER), OECD).

For instance, a roundtable on **Finance for disaster risk reduction – Boosting public-private sector cooperation** was organised by DG ECHO and UNDRR on 24th October 2019 in Brussels as a platform to share and discuss recommendations of the PLACARD project on European Risk Transfer Mechanism with colleagues from other H2020 projects and their partner organisations.

The following table presents a brief overview of selected gaps analysed in this report and elaborated related solutions for improving the EU green Deal trough bridging the gap between CCA and DRR communities – improving effectiveness of climate risk management and providing innovative financial instruments for achieving climate neutrality and resilience of the continent (see Table 2).

Identified gaps and elaborated related opportunities could improve significantly the EU green Deal not only in political sense, but also offer a wide range of different innovative financial tools to mobilise private climate finance and facilitate transfer of climate-related risks.

4 The identified knowledge gaps were used to prepare a PLACARD contribution to the H2020 online consultation in January 2017.

Table 2: Gaps and opportunities for the EU Green Deal in CCA and DRR coherence.		
Topic	**Gaps**	**Opportunities**
Topic 1. Policy Coherence	Largely unrelated political processes which have an overlapping goal with different and often incompatible indicators to measure their progress	Elaboration of common the CCA and DRR indicators, goals for the EU Green Deal
Topic 2. Methods and tools in CCA and DRR management	Uncoordinated methods and tools in CCA and DRR management	Climate Risk Management (short, CRM) to facilitate climate-resilience decision-making at the intersection of DRR and CCA
Topic 3. Impact/ damage data	Lack of reliable and frequently updated data on climate-related risks, damages and losses for the economy	Application of Distributed Ledger Technologies and Internet of Things to collect, process and safely store necessary information
Topic 4. CCA and DRR Finance	Lack of private and public financial resources	Lowering transaction costs through common taxonomy for green projects, principles for green bonds, innovative IT-solutions and financial instruments

Source: built by the authors.

2. Climate Risk Management (CRM) to facilitate climate-resilient investment (CRI) in DRR and CCA

a. Policy coherence in CCA and DRR

How do CCA and DRR fit into the European Green Deal?[5]

On the 11th of December 2019 European Commission presented its Green Deal (GD) – a new political strategy that should lead the old continent towards sustainability and prosperity. Echoing postulates of ecological economics, the European Green Deal recognises that natural resources have become "the new limiting factors" (see Daly, H. 2005) and proposes 50 specific countermeasures.

The suggested actions are organised around the following pillars:

- Increasing the EU's Climate ambitions for 2030 and 2050 (with an ultimate goal of climate neutrality by 2050).
- Supplying clean, affordable and secure energy.
- Mobilising industry for clean and circular economy.
- Building and renovating in an energy and resource efficient way.
- Zero pollution ambition for a toxic-free environment.
- Preserving and restoring ecosystems and biodiversity.
- Fair, healthy and environmentally friendly food system.
- Accelerating the shift to sustainable and smart mobility (GDI, p.3).

5 This part has been published on PLACARD Blog: www.placard-network.eu/why-cca-and-drr-are-crucial-for-achieving-european-green-deal-goals/

Although the general idea is praiseworthy, there is, however, one significant shortcoming of the GD that cannot be attributed to the notoriously vague nature of the political concept at an early stage: GDl makes way too little mention of Climate Change Adaptation and Resilience. Such status quo can be traced back to the enormous political pressure on the European Commission (EC) to take action in the face of the protests of young and old people on the streets of Europe, which took place every Friday in the last years.

In particular, in the description of the Europe's climate ambitions, a careful reader can find a brief mentioning of "a new, more ambitious EU strategy on adaptation to climate change" (due 2020/2021 (GD, p.5). With regard to risk management, GD in the section on mobilising research and innovation, paragraph on accessible and interoperable data, promises to "boost the EU's ability to predict and manage environmental disasters" through combined industry-science expertise (GD, p.18). This implies availability of high-quality climate impact and loss data which is indeed one of the most urgent and steadily repeated requests of the DRR community (DRMKC 2019). But basically, there is not much more on the topic of climate adaptation and resilience, unfortunately.

This understatement is problematic for at least **three reasons**. First, it ignores the harsh reality that many of the most serious consequences of climate change – more frequent and harsh *floods, droughts, heatwaves – are already unavoidable* because the 1.5-degree mark has already been exceeded on all territory worldwide. In this situation, an effective climate policy requires more than just emission control and renewable energies. Policy must also reduce the risks that are already plaguing the world in many different places and will continue to do so in the future on an unprecedented scale. The failure to mainstream CCA and DRR on a broad scale NOW will threaten sustainability that GD aims to achieve.

Second, *adaptation represents a great opportunity* for an overarching societal pro-climate political alliance. In the past, climate policy has not been of great importance to many voters, and conservative voters in particular not. While there is a growing social consensus that climate change is a real and current problem that deserves government attention, it is often difficult to activate all groups of society around global mitigation strategies such as carbon budgets and low carbon development plans. Put simply, many individuals struggle to imagine how these programs can actually improve their daily lives. Adaptation turns this perception completely round by funding easily observable projects that address the immediate concerns of the community. From building new dams in flood-prone communities to creating cooling zones in urban heat islands, adaptation projects improve resilience, highlight the immediate effects of climate change, and enable incumbent politicians to return goods and services to their neighbourhoods but also to the world at large.

Third, *adaptation* is probably *the most feasible international policy response to climate change under current circumstances*. The world's most vulnerable islands and low-lying countries in Africa and Asia have already indicated that they will make climate resilience alongside with clean energy investments a key component of the policy proposals during the coming sessions of COP under the Paris Agreement (PA). GD would benefit from a growing momentum towards building resilient infrastructure and support provisions for financing adaptation projects at an international level. A well-balanced approach of mitigation and adaptation within a climate resilient infrastructure debate would benefit the sustainability of GD beyond Europe.

As a result, GD handles the topic of CCA and DRR very scarcely, but both fields are as much important as emissions mitigation efforts to reach the overarching goal of sustainability. Thus, we plead for an active involvement of the CCA and DRR in delivering GD postulates triggered top-down (consultancies requested by EC) and bottom-up coming directly from CCA & DRR stakeholders.[6]

PA and SFDRR – the ways of cohesion

CCA and DRR policies belong to two distinct, but very close and correlated areas. Currently, actions and measures for both communities are being regulated and coordinated by different international agreements – Paris Agreement (PA) and Sendai Framework for Disaster Risk Reduction (SFDRR). Obviously, there is a need to look more precisely into those two documents in order to identify commonalities and differences in dealing with CCA and DRR issues, which in turn can lead to a more effective resilience building policy.

For this reason, in the following sections we explore what the Paris Agreement targets mean for disaster risk reduction and what the Sendai Framework Disaster Risk Reduction (SFDRR) means for climate change adaptation. In particular, we analyse targets and priorities of both agreements from the perspective of the counterpart community. Moreover, we compare the general frameworks incl. agreements' main components, time horizons, approaches, and reporting particularities. The overall goal is to identify ways of pulling together PA and SFDRR to set up the basis for improvements within the EU greed Deal. The presented analysis is based on the two posters **Paris Agreement through a disaster risk reduction lens** and **Sendai Framework for Disaster Risk Reduction through a climate change adaptation lens** prepared within WP3 by the UFZ team.[7]

The overall goals of PA and SFDRR are important components of building up resilience to climate change. While PA focuses on mitigation and adaptation to climate change, SFDRR aims at reducing exposure to climate-related risks. In fact, PA could contribute only to improvements in the so-called static resilience[8] by limiting temperature increase and building up adapting capacities of the economic and social activities. Dynamic resilience could be achieved only by developing further static capabilities through investments in reduction of disaster risks measures and improved climate risk management (economic and social losses). Combination of CCA and DRR measures will allow quick recovery of the system in the most effective way through investments in related measures. For this reason, it is very important to identify commonalities and differences in the above-mentioned agreements and elaborate the ways of their synchronisation that can allow achievement of the synergetic effect.

6 EC launched a platform 'Have Your Say – Lighten the Load' where all stakeholders are invited to get involved in the process of initiating sustainability transformation: https://ec.europa.eu/info/law/better-regulation/lighten-load. The EC interchange with stakeholders should be further strengthened by the European Climate Pact to be launched in March 2020. City networks like Covenant of Mayors should receive particular attention which gives hope for a rapid application of innovative adaptation and risk management solutions in urban areas.

7 Both posters can be found online on PLACARD website: www.placard-network.eu/wp-content/PDFs/PLACARD-Paris-DRR-leaflet.pdf and www.placard-network.eu/wp-content/PDFs/PLACARD-SFDRR-CCA-leaflet.pdf

8 Ability to use remaining resources to move to a higher level of performance during recovery (Rose, 2017).

According to the official data, cities are responsible for almost 70% of global energy-related greenhouse gases emissions (IEA, 2016). Moreover, around 66% of the world's population will be living in the cities by 2050 (UN, 2018). Hence, the urban areas could be hit by the consequences of climate change consequences most harshly and should respond to this challenge by mobilising climate finance both, for mitigation, adaptation and DRR projects at the local level. For this reason, there is an urgent need to synchronise approaches within PA and SFDRR – in particular use the "bottom-up" approach in order to achieve goals in the most effective way (see Table 3). Hence, cities and municipalities networks could be excellent forerunners.

Although SFDRR is being assessed globally, but at the same time countries report nationally. Thus, the overall global indicators could be completed by national indicators to make monitoring and reporting scale between SFDRR and PA consistent (at the national level). Moreover, common indicators could facilitate increased coherence between CCA and DRR policies, align activities of CCA and DRR communities and thus make them more efficient.

Table 3: Comparison of the main characteristics of the PA and SFDRR

	Paris Agreement	SFDRR
Agreement type	Pledge and review (bottom up).	Voluntary
Stakeholders	Ministries and government agencies, different sectoral experts, private sector actors, NGOs, local stakeholders and international partners.	Multi-stakeholder approach incl. local government and businesses.
Time horizons	2015–2030 (for NDCs), 2025 (for the mobilisation of 100 Bill. USD/ year financial flows from private and public sources).	2015–2030 (15 years) 2020–2030: real assessment period in comparison to 2015 baseline
Monitoring, Assessment and Reporting	2015 – Intended Nationally Determined Contributions (INDCs) submitted. 2018 – Facilitative Dialogue (Talanoa Dialogue). 2020 – Communication (for 2025 targets) and update (for 2030 targets) of the NDCs (pledges).	2015–2020: set-up phase for establishment of national and regional DRR strategies.
Monitoring instruments	Nationally Determined Contributions (NDCs, Art. 4.2). National Adaptation Plans (NAPAs, Art. 7.9) /Adaptation Communication (Art. 7.10 incl. NDCs).	The progress of SFDRR will be measured every two year by the UNISDR and presented in the Sendai Framework Progress Report. Seven global targets (A-G) of the Sendai Framework will be assessed by means of 38 numerical indicators. *

Source: built by the authors
www.preventionweb.net/drr-framework/sendai-framework-monitor/indicators

Table 4: CCA-related aspects contained in SFDRR targets	
SFDRR target	**CCA relevance**
Targets A-D: aim at protection of life and assets incl. critical infrastructure.	Consistent with climate change adaptation goals in the context of climate risk assessment
Target E: aims at institutional strengthening, further development of DRR policies across different levels	Multiple hazard approach: climate change is here one of hazard drivers (attention: it can exacerbate but also diminish some disaster risks, Kelman 2015). Thus, adaptation to climate change belongs naturally to DRR prevention and preparedness work. The aim of expanding national disaster risk reduction strategies is also consistent with the efforts of CCA community to put the topic of climate risk on the national agenda.
Target F: aims at improved coordination with other fields and political frameworks with a particular emphasis on developing world.	Climate community that is going to work with the International Mechanism for Loss and Damage (L&D) could benefit from DRR community experience in that area. Especially, DRR could provide a good orientation for target values, effective monitoring and measurement. It is, however crucial, that both communities agree on a standardised und unambiguous L&D definition. DRR knowledge in the development aid can be used to evaluate if climate finance is sustainable and truly effective by assessing its capability to improve general living conditions. DRR experience in the population evacuation can be used by the CCA to deal with the climate migration movements.
Target G: aims at enhancement of prevention and preparedness	Risk modelling and simulation, predominantly on the local level, are an important part of the risk assessment and enhancement of prevention and preparedness. With regard to climate-related risk, CCA community with a strong scientific background can help to complete that task. The importance of the "climate" factor was emphasised in Paragraph 34c of SFDRR that mentions connections to the Global Framework for Climate Services. A harmonisation of early-warning systems and risk assessment indicators can lead to more effective work (by elimination of duplication) and creating synergies (by merging different knowledge pools). Furthermore, it can decrease the effort to report on different international agendas like Paris Agreement, SFDRR, SDGs.

Source: built by the authors

Table 5: Priority actions within PA and SFDRR	
SFDRR	**Paris Agreement**
Priority 1. Understanding disaster risk	Comprehensive risk assessment and management (in particular in the areas of food production poverty and inequality, deforestation and forest degradation, scarcity of the natural resources).
Priority 2. Strengthening disaster risk governance to manage disaster risk	
Priority 3. Investing in disaster risk reduction for resilience	Financing resilience of communities, livelihoods and ecosystems.
Priority 4. Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction	Early warning systems, emergency preparedness to avoid non-economic losses, slow onset events and events that may involve irreversible and permanent loss and damage.

Source: built by the authors

First specific target within the PA is aimed at enhancing adaptive capacities, strengthening resilience and reducing vulnerability to climate change (Article 7) with direct reference to the Article 2 where the temperature goal is mentioned. The second one forces the parties of PA to minimise losses and damages from climate-related extreme events. For this reason, such instruments as comprehensive risk assessment, risk insurance facilities, climate risk pooling should be implemented to improve resilience of the economic and social activities to climate change.

The synchronisation of targets and indicators could lead to more effective efforts and actions in CCA and DRR areas – create a synergy effect in combating climate change. Major improvements could be achieved in the area of risk assessment, implementation of the CCA and DRR aspects into the national policies. Moreover, the International Mechanism for Loss and Damage could be further developed and improved through application of the experience and data from DRR field. Additionally, knowledge and experience in development aid and population evacuation could be used for better assessment of financial needs for CCA measures (see Table 4). It is clear, that first set of priorities within the PA refers to the necessity of increased ambitions, active pre-2020 actions and Talanoa Dialogue. At the same time, within the text of the PA agreement other more detailed priority actions are described and they are very close (the same or complementary) to those stated in the SFDRR (see Table 5).

There are **three common themes** within the PA and SFDRR: *climate finance, climate risk management and ecosystem-based approach* in dealing with climate-related risks. Synchronisation of CCA and DRR aspects while improving climate risk management and elaborating innovative financial instruments could save financial resources and improve overall effectiveness of the measures. Moreover, emphasis on the ecosystem-based approach (e.g. community risk assessment) could be considered as a clear practical example of effective integration of CCA and DRR issues for achieving the goals of both PA and SFDRR.

Communities should be engaged more intensively in the process of climate risks reduction – incorporate climate risks into their strategies and reduce their vulnerability to climate change (Van Aalst M.K., Cannon T., Burtin I., 2008). Additionally, coordination of CCA and DRR actions should be reflected in the strategic documents on the EU level (such as EU Green Deal). This requires a set of joint adaptation strategies and innovative insurance mechanisms to protect economic agents and society against climate-related damages (Schwarze, R., 2017).

As a result, we can argue that If harmonisation is achieved, the Paris Agreement and the Sendai Framework reinforce each other in terms of their implementation. It will hardly lead to effective actions if the amounts of money pledged are not increased! With this regard, pragmatic approach is necessary to support and foster cooperation and collaboration between DRR and CCA.

GAP:	The EU Green Deal does not fully encompass CCA and DRR aspects, as well as does not highlight any mechanism for mobilisation of related financial resource.
Recommendation 1.1	Incorporation of the CCA and DRR aspects from PA and SFDRR into the strategic documents within the EU Green Deal.
How:	Take into account CCA and DDR targets, metrics and priority actions from PA and SFDRR while elaborating new updated version of the EU adaptation strategy, roadmap for the EU Green Deal.
Who:	EU Commission, High-Level Expert Group on Sustainable Finance.

b. Economics of DRR and CCA of climate-related investments

Blended Value Creation – bottom-up approach

Nowadays, we are witnessing a deep rooted, ongoing conversation concerning evolution of the **Corporate Social Responsibility** (CSR) to the **triple bottom line** and further to the **full sustainability** concept.[9] Hence, a question arises whether non-financial factors (e.g. environmental, social and governance) could affect different financial indicators (share prices, profits, cost of capital, etc.) or not and if the answer is positive – to which extent? Numerous researches show both "pros" and "cons", but now it's already clear that this influence could be identified even in the short-term period (for instance, corruption as a governance aspect of the non-financial disclosures and ratings). At the same time, companies and financial institutions are "experiencing" even today the impact of non-financial factors on their investment decision-making process on the long-term run (e.g. internal carbon pricing).

Since introduction of the CSR concept by Michael Porter (1947), companies were trying to improve their image and receive more favorable conditions for making more profits or increasing their sales. Today it's clear that only corporate responsibility itself as a philanthropic approach is not sufficient to give a strong impulse and stimulate sustainable development – achieve the SDG Goals (short, Sustainable Development Goals). Moreover, those non-financial risks have already an impact on the business activities and can lead to additional expenses (e.g., allowances for the GHG emissions within the EU Emissions Trading Scheme). As a response to this challenge a completely new concept was introduced by John Elkington (1949) at the end of XXth century – a triple bottom line concept.

9 Ability to create additional value on the long-term basis.

This concept brought a revolutionary business-based approach in dealing with non-financial risks – companies should pay attention not only on their financial, but also on their non-financial results and benefits. This means that dealing with existing non-financial risks is not a charity, but a business opportunity and could be transformed into the assets (e.g., reduced and certified GHG emissions could be classified as intangible assets).

This concept was only a step towards our modern perception of the value as a blended set of economic, environmental, social and governance components. With this regard, Jed Emerson at the beginning of the XXIh elaborated more comprehensive approach which states that reduction of environmental, social and governance risks as well as improvement of the ability to achieve sustainable growth and long-term return on investments (economic component) could contribute to the so-called **blended value creation** process. In practice, economic agents and their activities could be evaluated not only according to the **ESG methodology**, but already according to the **EESG approach** (Economic, Environmental, Social, Governance), which means that non-financial improvements could be turned into the financial benefits and contribute to the overall "blended value creation" process within the economy.

In order to explore the meaning of "blended value" we should go back to the concept of social category ("soziale Kategorie") introduced in 1896 by Rudolf Stolzmann (1852-1930) with the main emphasis on necessity of shifting from economy of individual households to social relations and legislation – pull all these separated elements together (Stolzmann 1896). Another important contribution towards modern definition of social value was elaborated in 1889 by Friedrich von Wieser (1851–1926). He underlined the role of natural value ("natürlicher Werth"), which consists of personal and material components, "produced by separate acquisitive organisations that are socially related" (F. von Wieser, 1912). This split of the natural/social value into two major components underlines importance of the current dispute concerning the ability of GDP to capture results created within the economy, especially if we are talking about the blended nature of the value created.

But shifting from traditional "one-bottom line" business model to the modern "triple-bottom line" approach is associated not only with additional benefits, but also could bring high transaction costs. Such costs could be related to the following challenges:

- new accounting and reporting approaches (reporting on nonfinancial results);
- more complex risk monitoring and evaluation systems;
- deeper information asymmetry between managers and owners of the company.

In order to facilitate accounting of additional "positive" benefits (in societal or environmental terms), financial department within the company needs more time to account and report on related business activities. Moreover, to apply the principle of "materiality", new accounting standards need to be elaborated and enacted. For example, every reduced unit of the greenhouse gas emissions could be incorporated into financial statements according to the IAS 38, 20 and 37. At the same time, all the users of financial resources on the financial market are already preparing reports according to the existing reporting standards (e.g., Global Reporting Initiative Standards), which are approved and accepted by the main stock exchanges and institutional investors.

Application of the ESG Principles while evaluating necessary information should be accompanied with the so-called Key Performance Indicators (short, KPI) elaborated for different sectors of the economy and with regard to specific features of each business activity. More complex and detailed integrated reports require more sophisticated approach in understanding the situation and making right investment decisions.

But on the other hand, the above-mentioned challenges could be paid off by new opportunities:

- influence of all activities and results on the overall company`s evaluation;
- link between the needs of companies and the interests of the financial market;
- relatively "cheap" financial resources for the companies;
- additional stimulus for the company to improve environmental conditions.

Being more sustainable to non-financial risks and able to transform environmental, social and governance threats into the opportunities and financial benefits makes it easier to get an access to relatively "cheap" financial resources. In fact, financial markets are ready to finance social, environmental projects, as well as improve governance structures or management methods of the company. For this purpose, new financial instruments have been already elaborated to cover huge financial needs in sustainable and climate finance for related projects. As a example, the market for green bonds is the most rapidly growing segment of the financial market where companies, municipalities and countries can mobilise financial resources to improve their ESG performance. Moreover, rating agencies (e.g. Moody`s and S&P) are already using ESG principles to perform evaluation of different economic agents. The better are the results, the higher is the ESG rating and the lower are interest rates on the market for the economic agent.

As a consequence, transition from CSR to "triple bottom line", full sustainability and "blended value creation" brought us not only the new way of doing business with regard to the nonfinancial results, but also changed investment decision-making process. In this case, investors are be able to evaluate financial and nonfinancial risks associated with selected project or company.

Costs, benefits and effectiveness of DRR measures in infrastructure

This section focuses on the most challenging aspects of the analysis of costs and benefits from investments in resilient infrastructure. Gaps and opportunities described in this section are based on the expert meeting jointly organised by PLACARD-project and Organization of Economic Cooperation and Development (short, OECD) on the 18-19th of September 2019. It served as a platform to identify the most important challenges while estimating costs and benefits of investments in resilient infrastructure and helped to identify the main challenges in the above-mentioned area.

From the methodological point of view, it is important to estimate costs while implementing a DRR project – from major initial outlays to maintenance expenses, and how to compare costs and benefits with economic efficiency decision criteria. A fruitful discussion brought some insights from the case studies examples on how resilient infrastructure measures

have been evaluated in different countries in terms of losses avoided. Moreover, additional criteria have been identified that have proven challenges to be quantified due to the high uncertainty (e.g. climate-related projecting future losses).

Modelling the net present value of resilience measures very often relates to the question whether investments in resilience measures entail weighing present costs against future benefits or not. In this case, calculation of net present value in the context of investments in DRR should take into account variables of discount values. Existing examples of different discount rates for related projects show that the range is wide. This implies the need to unify or at least adjust discount rates – reduce them in order to make CCA and DRR projects more attractive.

Assessing the value of intangibles is difficult due to the fact that it is hard to value non-market goods, such as human lives, quality of the environmental or cultural treasures. Protecting against disaster damages to such intangibles, however, provides economic and social welfare benefits. Methodologies that allow to put a value on a statistical human life are subject to ongoing complex ethical debates. In many cases, however, it is only by including the value of such intangibles that protective measures lead to a positive cost-benefit ratio. Application of the social welfare approach in Netherlands showed higher benefits for poor and vulnerable populations.

Monetising the benefits of multi-purpose resilient infrastructures is a challenging thing for the projects within DRR investments where multiple dividends could be generated. In addition to reduction of disaster risks, other measurable benefits could include better livelihoods, unlocking development potential, and creating "co-benefits" which are not contingent upon a disaster occurring. Decision support tools such as CBA can be used to integrate all such benefits or "dividends" into one single calculus.

Evaluation of **the impact of community-based DRR projects** shows that DRR projects can be small-scale, driven by community-level actors. Taken in sum, community-based measures can have a significant impact on reducing the total cost of disasters, despite being "small-scale". However, applying economic analyses such as CBA to assess individual community-based projects can be too costly and time-consuming.

With this regard, useful are the methodologies to calculate losses avoided developed by FEMA in the USA. Application of such methodologies could facilitate calculation of the Return on Investment (ROI) for related projects. Additionally, this approach allows to get a positive ROI after one or two events and promote mitigation measures by elected officials.

It is also important to take a look at how governments prepare themselves for and respond to disaster risks at different levels of government, including the national and subnational (i.e. municipal) levels of government and among communities. Tools such as comprehensive climate risk management (CRM) at the local and national level in Austria involve a layering of measures at local and national levels to enhance coverage of communities and populations. CRM may include fiscal risk assessments with longer-term budget analyses and fiscal stress testing for economic effectiveness at national level, blended with local level training and soft investments.

Austrian experience shows that there is an urgent need in more integrated approaches and solutions in adapting to climate change and reducing risks of natural disasters. For this purpose, access to more reliable and updated data is crucial, as well as related metrics and indicators should be realistic. Moreover, more inclusive measures as a response to climate change could contribute the most to effectiveness of the planned measures.

Assessment of the economic value of eco-system-based measures demonstrates that traditional DRR measures involve "hard" infrastructures that physically protect a population or built environment. Risk managers increasingly employ non-structural measures that reduce hazard exposure of communities or decrease their vulnerability. Assessing the cost-effectiveness of non-structural measures, however, presents specific challenges. In some countries a regulatory impact analysis (RIA) is legally required to bring more objectivity and transparency to the costs and benefits of such non-structural measures as prescriptions on land-use.

Experience of the Great Manchester (UK) showed that market-based approach is needed to secure multiple environmental outcomes. For instance, farmers and land managers bid for funding in order to conduct climate resilience actions/projects. Moreover, integration of non-market benefits is important to valuate hazard costs and to justify funding decisions.

As a result, two days of discussions brought an opportunity to summarise the most important challenges in the area of cost benefit analysis for investments in resilient infrastructure:

- changes in governance are needed to meet the above-mentioned challenges;
- different CBA approaches (history, social welfare economics) are being used to identify the best projects in the area of DRR and CCA;
- monetisation and inclusion of intangible factors differs in countries around of world;
- a wide range of discount rates is applied and there is a need to improve the existing approaches.

GAP:	No unified methodology or standard on how to account and monetise non-financial benefits (intangible assets) while conducting CBA analysis for CCA and DRR projects.

Recommendation 1.2	EU-wide or international standard or guidance on how to monetise and account intangible values from CCA and DRR measures.
How:	EU-wide or international standard or guidance on evaluation and accounting of the social, economic and governance assets from CCA and DDR projects.
Who:	European Commission, International Accounting Standards Board.

Best Practice example	
Who:	International Accounting Standards Board.
How:	In 2004 International Financial Reporting Committee issued IFRIC 3 on how to account the schemes that are based on "cap-and-trade" model.
Source:	www.iasplus.com/en/projects/completed/assets/project112

c. Methods and tools for risk management and policy planning in CCA and DRR[10]

Disaster risk management (short, DRM) aims to reduce the damage caused by natural hazards like earthquakes, floods, droughts and cyclones, through an ethic of prevention. It necessitates a range along the cycle: risk assessment – risk prevention – preparedness – response and recovery (see Fig. 1). This section deals with the methods and tools for risk assessment and policy planning in CCA and DRR (left hand side) and is based on the international risk management standard ISO 31000.

Risk assessment accordingly consists of three steps:

- Risk identification – finding, recognising and describing risk
- Risk analysis – estimation of the probability of its occurrence and the severity of the potential impacts
- Risk evaluation – comparing the level of risk with risk criteria to determine whether the risk and/or its magnitude is tolerable.

In the context of climate risk assessment these steps need to consider all relevant climate and non-climate factors that generate a particular climate risk (Fenton/Neil 2012).

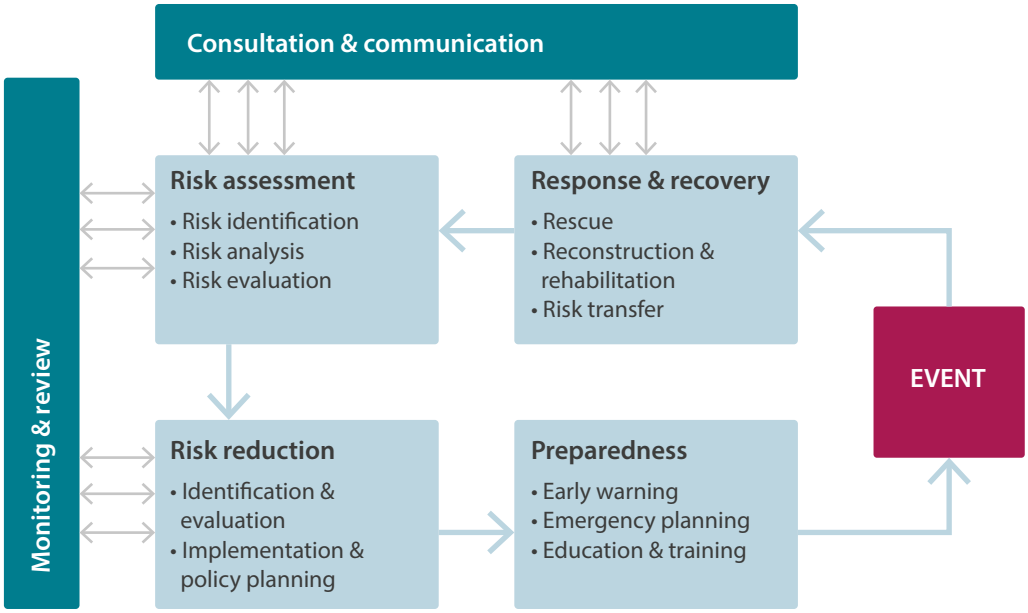
It inherently relates to the choice of different risk reduction options in terms of climate risk mitigation and adaptation (termed "risk treatment" in ISO 31000). Similar to the assessment of risk, the treatment options need to undergo an assessment procedure, consisting of identification, analysis and evaluation (of bundles) of risk treatments to be able to effectively support policy planning and implementation of disaster risk reduction.

Risk assessment and risk reduction are both systematically embedded into communication with, and consultation of, stakeholders; and they are iterative in nature, i.e. based on the monitoring and review of each and any component of DRM.

10 This part builds on an initial version of the Chap. 2.2 of the EEA Report No 15/2017 (Climate change adaptation and disaster risk reduction in Europe Enhancing coherence of the knowledge base, policies and practices) originally written by one the authors of this report.

Figure 1: Components of Disaster Risk Management.

Source: built by the authors (based on ISO 31000).



Vulnerability vs. risk-based assessment

Following ISO 31000, climate risk is to be determined as the product of the likelihood of a climate-related event and its negative consequences. IPCC-SREX (2012) puts it as the product of hazard ("potential occurrence of a climate-related physical event")

x

vulnerability/susceptibility – propensity or predisposition to be adversely affected

x

exposure – presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected

In the CCA community, vulnerability is more broadly defined as the relationship of all these components, i.e. hazard, vulnerability (in the narrow sense of susceptibility) and exposure, in relationship to the capacity of human and natural systems to cope with this risk ("coping capacity"). It is rooted in the IPCC-AR3 definition of vulnerability as "the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which the system is exposed, its sensitivity, and its adaptive capacity" (IPCC 2001, 165). Vulnerability assessment (VA) has in fact become the leading tool in adaptation planning in practice.[11]

11 For an overview of national vulnerability and impact assessments (VIA) to climate change in Europe see climate-adapt.eea.europa.eu/countries-regions/countries, for example, SYKE (2011) and UBA (2015). Global developing countries' national VIA activities are summarised in UNFCCC (2014, 2015).

DRR, in contrast, is more focused on the 'classical' concept of risk assessment, which ultimately implies a societal evaluation of the negative consequences of a risk against some social, economic, political, cultural, technical or environmental criteria of acceptability (in a commensurable metrics). Moreover, DRR links the assessment of risk logically to the assessment of the different risk treatment options, from the elimination of the source of risk to a reduction of risk, with the latter also including preparedness and response options such as risk information (early warning) and risk sharing (insurance), again in a commensurable metrics.

"Wait and see" is also a possible risk treatment strategy within the DRM framework: if a risk is very uncertain, and if we can expect improved information in the future, it is "tolerable" to first monitor the risk until we gain a better understanding. VA avoids these explicit criteria-weightings of risks and risk treatments by turning to stakeholder discourses on systems' vulnerability (in a broader sense) and coping capacity.

Quantitative vs. qualitative impact models

In practice, climate risk assessment (CRA) is often conducted by means of science-based models[12] which aim to represent the causal relationships between the various climate and non-climate factors that generate risk. In the face of the complexity of these causal chains, and given the poor availability and/or accessibility of data, it is often impossible, however, to apply quantitative numerical models of climate impacts. Qualitative models, which are grounded in expert judgment and local peoples' knowledge thus play a crucial role in climate risk assessment. This is not to be seen as a 'deficit' but as a necessary methodological ingredient when uncertainty and conflicting values and beliefs ('normative ambiguity') are involved (Klinke and Renn 2002; Renn, Klinke and van Asselt 2011). Climate change is such a problem in relation to both, future developments of the climate and changing socio-economic systems (Groves and Lempert 2007, Hallegatte et al, 2012). This calls for a systematic involvement of stakeholders, effective bi-directional discourse and iterative learning.

Despite mounting criticism (summarised in Rosen and Guenther 2015), quantitative numerical impact assessment models (IAMs) remain the most prominent tool to support decision making on climate risks. Their main advantage lies in the fact that they can be based on large ensembles of different climate models and risk scenarios and, thus, can identify model inputs that cause significant uncertainty in the output (perform 'sensitivity analyses') and help quantify uncertainty.[13] In principle they can also be applied to choose robust risk treatment options (e.g. Lempert and Groves 2010). For to be 'useful and used', however, they have to leave their academic silos (Lemos and Rood 2010). A decade of climate services experiences shows that applied IAMs have to be salient (*perceived to be relevant*), credible (*perceived to be of high technical quality*) and legitimate (*perceived to be based on non-discriminatory process*) (Bowyer et al 2014, 87).

12 For overview see MEDIATION/PROVIA toolbox, available at: www.mediation-project.eu/platform/toolbox/toolbox.html

13 For more information see https://ec.europa.eu/jrc/en/samo

Therefore, effective quantitative models need to be rooted in structural and sustained stakeholder dialogues. After all, "if the local community is not involved in the development process it will not trust (or use) the end product" (OECD 2012, 9). Moreover, they must be 'learning tools' which are constantly updated based on the monitoring and (forensic) analysis of extreme events with a subsequent review of the modelling parameters as suggested by Kreibich et al (2014).

Risk treatment between optimisation and experimentation

The assessment of climate risks is not only sequentially but logically followed by a choice on risk treatment options. Whether conducted in economic terms or by any other societal evaluation criteria, the tolerability of risk is intricately linked to the desirability of treatment options. Therefore, they need to undergo a similar process of identification, analysis and evaluation, sometimes summarised as "optimisation". The methods and tools available to assess risk treatments, strategies and measures, are similar to the ones applied in climate impact modelling but to some extent also specific to this task. They include cost-benefit analysis, cost-effectiveness analysis (CEA), multi-criteria analysis (short, MCA), robust decision making (RDM), real options analysis (short, ROA) and adaptive management (AM).[14] From left (CBA) to right (AM) they allow for a deeper consideration of normative ambiguity (conflicting values and beliefs) and uncertainty. RDM, for example, aims to support decisions in the absence of any probabilistic information on scenarios and outcomes, i.e. 'deep uncertainty', while AM allows for the updating of actions on the basis of incoming new information and therefore closely relates to risk management principles of monitoring and evaluation, and learning. The motives of moving from traditional frameworks of an economic-engineering methods of assessment (such as CBA and CEA) are, firstly to be able to consider pluralistic views on risk, and secondly to identify robust[15] (rather than economically optimal) strategies and measures of risk treatment. The recently concluded Know-4-DRR-project of the European Union's 7th Framework Programme of Research goes even further in its summary call for open-outcome social experiments or 'living labs of DRR' (see Fabrice et al, 2015: D.3.3., p. 23).

Moreover, there is *no suitable system to share information and knowledge* among the countries in Europe (drought monitoring and early warning systems do not work in concert). Moreover, droughts in the agricultural sector are subject to the highest level of uncertainty (IDMP, 2017).

Management of multi-hazard risks within the supply chains

Climate-related risks and events have multiplied negative effects on our daily life. Moreover, extreme weather events or natural disasters have cascading effects on our economic and social activities. Over the next decades the risks of cumulative multi-hazard events in the EU are expected to increase.

14 For an overview see the MEDIATION/PROVIA tool box. Available at: www.mediation-project.eu/platform/toolbox/toolbox.html

15 Robustness is defined as decision making attribute that gives a positive value to flexibility (in the sense of keeping options open) and allows a tradeoff of optimal performance for less sensitivity over a wide range of equally plausible scenarios.

At the same time, the impacts of heat waves, droughts, wild fires and coastal flooding could have the strongest cascading influence on our economy and social spheres (e.g. climate-related health problems, deaths, etc.).

Existing researches suggest, that methodological challenges of a multi-hazard risk assessment (short, MHRA) are numerous. They are even more complex when we are talking about accounting of cascading effects (Kappes et al 2012; Gallina et al 2016). Quantifying the interactions of risks is also particularly difficult in case of climate change – probabilities of events are changing on different time paths (Liu et al 2015). MHRA is very case-sensitive (i.e. depending on the set of hazards selected) even in less challenging settings (such as independent hazards) and demanding in terms of understanding inter-hazard physical relationships as well as input data (high resolution data in space and time are needed) when it comes to cascading effects.

It is obvious, that cities and municipalities will be affected the most by climate-related risks, extreme weather events and natural disasters. At the same time, opportunities of these local jurisdictions in mobilising public or private climate finance are limited. This is due to the fact that tax revenues on the local level are limited and creditworthiness is very low – high cost of capital. This fact makes it difficult not only to mobilise climate finance, but also could reduce effectiveness of the climate risk management if the necessary infrastructure will be lacking.

In case of critical infrastructure (like pipelines or power lines), large companies are the owners of such assets and should carry about its resilience to climate change. This is due to the fact, that any kind of extreme weather event or natural disasters could affect the ability of objects of critical infrastructure to perform at the planned level (e.g. transport important goods and services).

At the same time, large multinational companies carry out their business activities all around the globe and are affected directly or indirectly (e.g. suppliers of raw materials, electricity) by climate change. Even if the company is based in the EU and the main sustainability indicators are pretty good, environmental, social or governance problems by the suppliers will be reflected in the sustainability report and will influence the overall non-financial ranking. Moreover, if extreme weather events or natural disasters take place along the supply chain it could affect production and supply of raw material, services or end products.

To reduce exposure to the risks of natural disasters or extreme weather events large multinational companies and financial institutions develop supply chain financing mechanisms. Such instruments could provide relatively cheap climate finance from developed country to the supplier in developing countries – improve climate risk management within the supply chain. At the same time, better resilience in supply chain will improve non-financial ratings both for supplier and end-user of delivered goods, services.

Existing initiatives for disclosure on non-financial risks already cover environmental/climate risk management aspects and allow to assess the risks while making investment decisions or providing climate financing. Unfortunately, these aspects are still lacking in existing legal requirements in the EU on non-financial reporting and should be incorporated into the updated version of the EU Green Deal.

GAP:	Current version of the EU Green Deal doesn't contain any requirements for disclosure on CCA and DRR aspects, as well as on the climate risk management within the supply chains of large companies.

Recommendation 1.3	Disclosure on Climate Risk Management (short, CRM) at the intersection of DRR and CCA (e.g. multi-hazard risk with cascading effects).
How:	Improvement of the EU Green Deal (update of the Directive 2014/95/EU) through requirement for large companies to disclose on information about the climate risk management the within their supply chains.
Who:	European Commission, national legislative authorities.

Best Practice example.	
Who:	Carbon Disclosure Project, Global Reporting Initiative.
How:	CDP Guidance on how to disclose information on climate change, forest and water security and supplier engagement.
	GRI Standard 102-30 requires disclosure on assessment of the effectiveness measures within the risk management of environmental, social and governance aspects.
	GRI Standard 308 provides guidance for the reporting companies on how to disclose information on significant actual and potential environmental impact identified in the supply chain.
Source:	www.globalreporting.org/standards/gri-standards-download-center/

d. The role of loss and damage data

Climate change is associated with already noticeable **negative consequences**: (i) increase of the temperature (both of the air and oceans), (iii) melting of ice and (ii) rising sea levels.

Against this background, the international community (e.g. United Nations) is paying due attention to this problem and taking steps towards the establishment of a common legal framework and incentives to combat climate change and adapt to its consequences. The signing of the Paris Agreement in 2015 was an important step towards *reducing greenhouse gas (GHG) emissions* and towards concrete national and civil society commitments to limit global warming to less than 2 degrees Celsius (UNFCCC, 2015).

Losses for the world economy caused by the natural disasters and extreme weather events reached the USD 225 billion threshold in 2018. This level is ten times higher than in 2000, and the year 2018 itself was the third year in a row with actual losses in excess of USD 200 billion. It is important to note that only 40% of these losses were covered and compensated by insurers (Aon, 2019).

At the same time, we are currently on a pathway to global warming of 3.2 degrees Celsius. Hence, not only adaptation to climate change, but also reduction of the risks of disasters and extreme weather events is of particular importance and requires appropriate measures as well as sufficient financial resources (UNEP, 2018). According to UN estimations, the annual financial needs for adaptation to climate change worldwide are between USD 140 to 300 billion. By 2050, the cost of adaptation to climate change could reach a level of USD 280-500 billion. In fact, annually only USD 26 billion are being collected for the purpose of adaptation to climate change (Micale V. et al., 2018).

Climate-related disasters are causing over USD 100 billions in annual losses each year, and such events could have serious social and economic consequences. For example, the number of climate-induced migrants is steadily increasing, and with regard to the actual path of global warming, we may face millions of people in the coming decades who will be forced to change their place of residence due to the adverse environmental conditions (IOM, 2009). In order to reduce the risks of climate-related disasters, another important agreement was signed in 2015 under the auspices of the UN: The – Sendai Framework on Disaster Risk Reduction (SFDRR) covers the time horizon of 2015-2030 and is aimed at *protecting people's lives* as well as *critical infrastructure* (energy sector, transport, agriculture, etc.) (UNISDR, 2015).

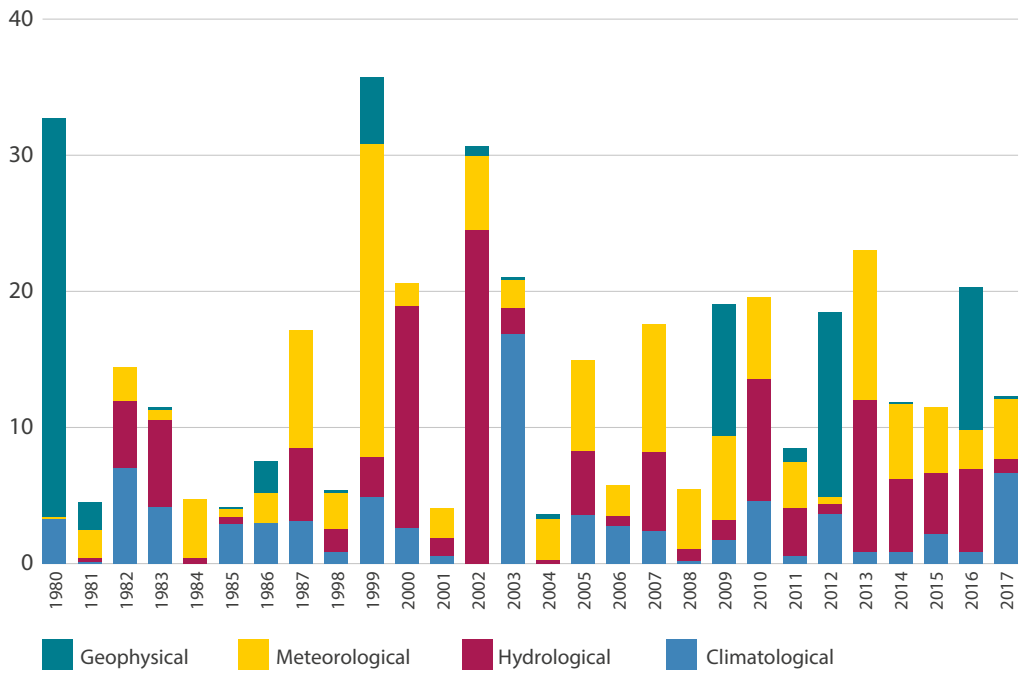
The Global Risk Report 2020 of the World Economic Forum sees climate change and associated consequences as the risks with greatest probability of occurrence and the impact on economic relations (WEF, 2020; IPCC, 2018). Resilience is the common goal of both Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) community. Hence, closer coordination between the above-mentioned communities could increase effectiveness of the overall efforts aimed at combating climate change and adapting to its consequences.

According to the methodology used by the European Environmental Agency (short, EEA), there are four major **groups of weather and climate-related extreme events**, which are leading to economic damages: (i) *geothermal* (earthquakes, tsunamis, volcanic eruptions); (ii) *meteorological* (storms); (iii) *hydrological* (floods, mass movements); (iv) *climatological* (heatwaves, cold waves, droughts, forest fires (see Fig. 2).

Of importance is the fact that climate change *indirectly* affects other extreme weather events that are classified as meteorological or hydrological. Hence, climate change is responsible for the vast majority of damages experienced by the economic sector, society and financial markets. In other words, climate change requires more effective measures in order to prevent losses and damages and to make the infrastructure more resilient. In addition, there is an urgent need for innovative financial products and instruments to support the above-mentioned measures with the overarching aim to facilitate access to the market of climate finance.

Figure 2: EU-28, economic damages caused by weather and climate-related extreme events in Europe (1980-2017), EUR, billions.

Source: built by the authors, data from Munich Re.



In fact, according to the data from NatCatSERVICE, Eurostat and MunichRe, the extent to which climate-related losses are covered by insurance services is insufficient and the best results in 2017 was achieved by United Kingdom (short, UK), where insured losses accounted for over 70% of total losses. The most critical situation in covering climate-related risks and losses was identified in countries such as Greece, Portugal, Poland and Italy – where damages from climate-related events remained almost uncovered (only 1% of damages were insured). Very good rates were also achieved by Belgium, Denmark, Lichtenstein and Luxembourg – where over 58% of the losses were insured. At the same time, countries such as Germany, France, Ireland, Iceland and Switzerland were able to cover almost 50% of the damages caused by climate-related extreme events and natural disasters (EEA, 2018).

One of the main reasons of such low penetration rate on the market relates to relatively high transaction costs in case of small economic agents (e.g. small farmers). Hence, elaboration and implementation of innovative financial instruments in combination with IT-solutions is needed. Moreover, such innovations should be elaborated in collaboration between private and public sectors, where national or EU institutions will be contributing to reduction of transaction costs and providing administrative/financial assistance.

In order to foster development green and climate segments of the financial market, some concrete **recommendations/measures** have been elaborated during the COP24 in Katowice (Poland) conference with the purpose not only to boost green financial flows, but also to improve sustainability of the financial system to non-financial risks (reduce systemic risk):

- creation of the green financial centres to speed up and facilitate climate-related financial flows (e.g. Luxembourg, Singapore, etc.);
- provision of financial aid at the project-level to support mitigation and adaptation to climate change;
- support to the long-term project financing and innovative financial instruments.

The most successful example of supporting elaboration of innovative financial instruments and mechanisms is the Climate Finance Accelerator in Luxembourg. A pioneer of the green bonds transformed from the "tax haven" to the leading green finance center – in 2007 the first ever green bond of the European Investment Bank (short, EIB) was listed on the Luxembourg Stock Exchange (short, LSE). Currently, LSE is the largest marketplace for the listed green bonds – more than a half of the all issued green bonds are circulating there.

GAP:	Limited number of innovative financial instruments and insurance services with regard to the outstanding climate-related financial needs.

Recommendation 1.4	Innovative financial instruments and IT-solutions to reduce transaction costs for climate-finance and insurance products.
How:	Climate Finance Accelerators in the EU-countries should be established in collaboration between private sector, financial institutions, national and EU authorities.
Who:	Ministries of Finance, Ministries of Environmental Protection, European Investment Bank, European Bank for Reconstruction and Development.

Best Practice example.	
Who:	Climate Finance Accelerator in Luxembourg.
How:	Government of Luxembourg, EIB, Luxembourg Stock Exchange together with private investor created a special agency with the aim to support asset managers from all over the world in mobilising climate and sustainable finance, provide certification of the green financial instruments ("green labelling") – reduce transaction costs, associated with mobilisation of green finance and make them more attractive for the issuers with unfavourable credit ratings (especially, from developing countries).
Source:	www.icfa.lu

3. CCA, DDR finance and insurance recommendations for the Sustainable Europe Investment Plan

a. Financial innovations for CCA and DRR

Climate change as a driver for innovations on financial instruments

Provision of financial resources is a common need in terms of provisions both within the Paris Agreement and Sendai Framework on Disaster Risk Reduction. In fact, finance could contribute to the improvements in risk management – another common topic for CCA and DRR communities. Additionally, both communities are aiming at promotion of economic, social and cultural investments in order to improve resilience to climate change (UNISDR, 2015a).

Moreover, climate-related investments in critical infrastructure (transport and energy sectors) should encompass co-benefits in economic and social dimensions. This requires improvements in existing methodologies of cost-benefit analysis in order to monetise achieved intangible assets as a result of the improved resilience. Also, integration of DRR (e.g. structural improvements) and CCA (e.g. social, economic and environmental quality) could bring more favourable return on investments – improve efficiency of the funding mechanisms.

Disaster financing comprises a variety of instruments designed and appropriate to achieve different outcomes. A strategy based on a diverse set of complementary financial instruments and institutions is more capable of managing and responding to a variety of environmental and man-made risks. Insurance offers individual protection against the risk of damage caused by various natural hazards. But it has to be embedded in government action to regulate and complement them. For example, comprehensive agricultural multi-risk management systems have to be supported by common market programmes.

Existing **financial mechanisms** in the area of CCA and DRR could be divided into four broad groups: savings or self-financing; contingent and *crisis financing*; *debt financing*; *climate insurance*; *risk transfer* (reinsurance).

Self-financing instruments without IT-solutions were a prerogative for economic agents in developed countries. With introduction of Distributed Ledger Technologies such instruments become applicable even for developing countries. In this case, even small farmers from poor countries could analyse their cash flows and adjust them to the existing weather and financial circumstances.

Alongside with self-financing there are other mechanisms of debt financing, climate insurance and risk transfer. Such mechanisms could provide additional source of financial support and contribute to the process of bridging the gap in DRR and CCA finance on different levels, improve management of climate-related risks and resilience of the finical system to non-financial threats.

Financial market is actively working on elaborating innovative debt mechanisms and instruments in order to accumulate the necessary financial resources and direct for building up resilience (e.g. infrastructure projects) – make economic and social assets more resilient to the climate risks.

Currently, there is a set of different debt Instruments to finance resilient infrastructure elaborated on the financial market:

- green bonds;
- catastrophe bonds (short, cat bonds) and catastrophe swaps (short, cat swap);
- resilience bonds (catastrophe bonds for the municipalities).
- environmental Impact Bonds;
- blue bonds;
- sustainability bonds.

According to the findings, provided by the OECD, investments in flood defences for the coastal cities could generate a very high rate of social return on investment (OECD, 2018). As indicated in a report from ASAID, one dollar of the financial aid for disaster risk reduction in 1998 resulted in savings of at least 45.58 USD for the 1999 rainy season. On a per-family basis, supported disaster risk reduction measures resulted in a "savings" of 426 USD, or the equivalent of nearly 54 percent of average annual income, thereby enabling families to purchase the food, clothing, medicine, and other essential items that they may have had to forego in case if the event of a flood will occur once again (USAID, 2008).

European Commission Action Plan on Sustainable Finance

On the financial market, there is no unified understanding of the green assets – this led to increase in information asymmetry and high transaction costs. The lack of standards in this area limits green investment flows. At the same time, on the financial market there are different debt instruments which can help to mobilise climate and environmental finance. Among those instruments green and sustainable development bonds are playing the most important role.

The main advantage is the fact that international financial institutions have elaborated their own standards to identify green and sustainable assets and the use of proceeds. At the same time, there is now unified standard for classification of the green assets – only debt market can deliver limited portion of the financial resources for sustainable development projects. In other words, international financial community is still trying to deliver common rules on how to identify green/sustainable investments and avoid the so-called "green washing" – create clear rules to unlock green/sustainable financial flows.

Currently, on the international level there are several versions of standards and principles for green/sustainable debt financial instruments. Different initiatives on the national level and from financial market (e.g. Climate Bonds Initiative) have already elaborated their versions of such regulations. Implementation of the new legal framework on the basis of the above-mentioned standards/principles will contribute to the overall reduction of transaction costs.

As a response to the outstanding threats, European Commission published in 2018 an **Action Plan on establishing Sustainable Financial System in the EU**. The overall goal of this document was to facilitate mobilisation of climate finance and improve resilience of the financial system to non-financial risks. In order to achieve this goal, European Commission elaborated a set of **aims**: reorientation of the capital flows towards *sustainable investments*; *enhance management* of environmental and social risks; higher *transparency* of the economic and financial activities.

In 2019 three reports related reports have been prepared by the specially appointed High-level Expert Group on Sustainable Finance: disclosure of non-financial information; green benchmarking and taxonomy. Reorientation of financial flows into the green sector could be achieved through implementation of a clear guidance on classification of green projects. Moreover, labelling of the financial instruments should contribute to reduction of the so-called "green washing" on the financial market. At the same time, investors should be aware about the level of climate-related risks while making their investment decisions. For this purpose, additional more comprehensive requirements will be implemented for big companies in the EU to disclose on their non-financial risks.

Presentation of the EU Green Deal during the COP25 in Madrid (Spain) was an important signal to other signatory parties of the Paris Agreement to take more ambitious climate pledges. According to this strategic document, European continent should be climate neutral by 2050 which requires revision of the existing climate-related strategic documents (e.g. EU climate change adaptation strategy), reorientation of public climate finance and mobilisation of private climate finance. At the same time, CCA and DRR aspects are presented in this strategic document only partly. Moreover, existing European Green Deal's Investment Plan is oriented only on mitigation (e.g. renewable energy production) issues. Hence, additional financial instruments and mechanisms in CCA and DRR area are needed in order to make transition to climate neutral continent possible.

CCA and DRR funding for the EU Green Deal

An action plan adopted by the Coalition of Finance Ministers from more than 50 countries was important achievement of the COP25 meeting in Madrid (Spain). Started in October 2018 at the Annual meeting of The World Bank Group and International Monetary Fund, this initiative was supported and is being co-leaded by the ministers of finance from Chile and Finland. The core of this document is a set of principles (the so-called Helsinki Principles) adopted by the members of this coalition in February 2019. According the Helsinki Principles, ministers of finance are ready to share best practices and experiences on macro, fiscal, and public financial management policies for low-carbon, climate-resilient growth.

In fact, actions and initiatives of the international financial institutions are important in mobilising and channelling climate finance to limit global warming and adopting to climate change. At the same time, there is a need in sound policies on the national level in order to overcome the limits of climate finance mobilisation – reduce information asymmetry and related transaction costs.

Even despite the fact, that Santiago Action Plan was important achievement of the COP25, concrete steps were unclear and needed practical examples. So, presented by the President of the European Commission Ursula von der Leyen to the public the EU Green Deal (short, GD) should serve as a good explain and help to implement on the EU-level new model of economic growth. This strategic document is in line with the **Helsinki Principle 1**, which favours implementation of the strategies for low carbon and resilient economies.

In fact, GD is a strategy for a low carbon and resilient economic growth. Implementation of the measures on the way to climate-neutrality requires financial resources and innovative mechanisms in order to mobilise and provide necessary financial means for climate-related projects. Currently, there is a need in over EUR 260 billion in order to fulfil the purpose and establish a climate-neutral continent by 2050.

For implementation of the **Helsinki Principle 4** (Climate Change in Macroeconomic Management and Public Finance), European Commission has already elaborated the EU Green Deal Investment Plan (aka, Sustainable Europe Investment Plan), which contains Just Transition Mechanism (short, JTM) to combine facilities of the existing EU Funds (as well as support from the member states) and provide a leverage to help in private climate finance mobilisation. The facilities of the JTM will be based on **three pillars**: *Just Transition Fund* (30–50 billion EUR for 2021–2027); *Invest EU* (45 billion EUR for 2021–2027) and *Public Sector Loan Facility* (650 billion for 2021–2027) dedicated to support the regions which will be affected the most by the transition to climate neutrality. The capacities of the JTM should help to mobilise EUR 100 billion on the annual basis in the next 10 years. Financial resources of the JTM should serve as a leverage to facilitate mobilisation of private climate finance to replace production of the energy from fossil fuels to generation of sustainable and clean renewable energy.

Even despite the fact, that EU Green Deal and Just Transition Mechanism make emphasis on resilient economic growth, there is no concrete and direct plan on how much and in which way CCA and DDR finance will be mobilised.

In order to find the traces of such funding we have to look more precisely at the EU Green Deal Investment Plan (short, EUDGIP; aka, Sustainable Europe Investment Plan).

The overall amount of financial resources for the next decade within the EUDGIP is about EUR 1 trillion and the main **sources** are the following: *EU Budget, European Investment Bank, European Regional Development Fund, European Social Fund Plus, InvestEU Fund, Just Transition Fund, national climate finance funds*. Only EU budget and EIB are eligible and have capacities for providing financial and technical support for CCA and DRR projects. But still, there is no clear signal that some specific amount of money will be dedicated to the above-mentioned projects within the EUDGIP.

Very important is to create appropriate conditions and framework for the financial market in order to make mobilisation of private climate finance for mitigation, adaptation and disaster risk reduction measures possible. These steps are in accordance with the **Helsinki Principle 5**, which is aimed at supporting financial sector development that underpins mitigation and adaptation. To achieve this goal European Commission created a High-level Expert Group on Sustainable Finance to elaborate strategic documents and measures to make financial system and financial market sustainable to non-financial risks, facilitate mobilisation of the private climate finance. As a result, a set of reports has been prepared (European Commission Action Plan on Sustainable Finance) and integrated into the EU Green Deal.

GAP:	CCA and DRR measures, targets and metrics are not fully encompassed by the EU Green Deal

Recommendation 2.1	EU Green Bond Standard and EU Taxonomy on green projects with CCA and DRR components
How:	Incorporation of CCA and DRR indicators and metrics into the EU Green Taxonomy and EU Green Bond Standard for labelling of the green debt financial instruments.
Who:	European Commission and High-Level Expert Group on Sustainable Finance.

Best Practice example	
Who:	Climate Bonds Initiative.
How:	In 2019 CBI released Climate Resilience Principles to enhance its Climate Bonds and Certification Scheme for green bonds by integrating criteria for climate adaptation and resilience.
Source:	www.climatebonds.net/climate-resilience-principles

b. Forecast-based financing

Bridging the gap between DRR and CCA with FbF

Different international agreements are aimed at limiting global warming by implementing policies and measures to achieve the one common goal – combat climate change and limit global warming. Nowadays, as a part of the Sendai Framework on Disaster Risk Reduction (short, SFDRR) there is an ongoing process of strengthening the Early Warning Systems to prevent us from more severe consequences of the possible natural disasters. At the same time, the Paris Agreement is aimed at reducing the risks of extreme weather events by implementing Nationally Determined Contributions (short, NDCs) where adaptation strategies should set clear targets not only for reduction of the GHGs, but also for the purpose of setting up concrete steps to adapt to climate change. Actually, disaster risk reduction could be considered as a common theme for all of the above-mentioned areas and serve at the same time as an important prerequisite to achieve the SDGs.

The **first and most important step** on the way to harmonisation of the CCA and DRR is an improved *EU climate change adaptation strategy*, where the goals and measures in both above-mentioned areas should be incorporated and synchronised. Synchronisation of the goals and measures in both directions would be necessary not only to achieve the goals of CCA and DRR, but also could contribute to the overall effectiveness of the actions/measures.

Second important crosscutting point for both communities (stressed out in related international agreements) is a *set of common goals*, which could be achieved through the implementation of FbF. In case of the SFDRR, **implementation of FbF** could contribute to the following goals: a, b, c, f and g (see section 2a). Moreover, it goes in line with the four Priorities of Action due to the necessary *analysis of risks*, *coordination of responsible actors*, introduction of the *new innovative financial instruments* (German Red Cross, 2017).

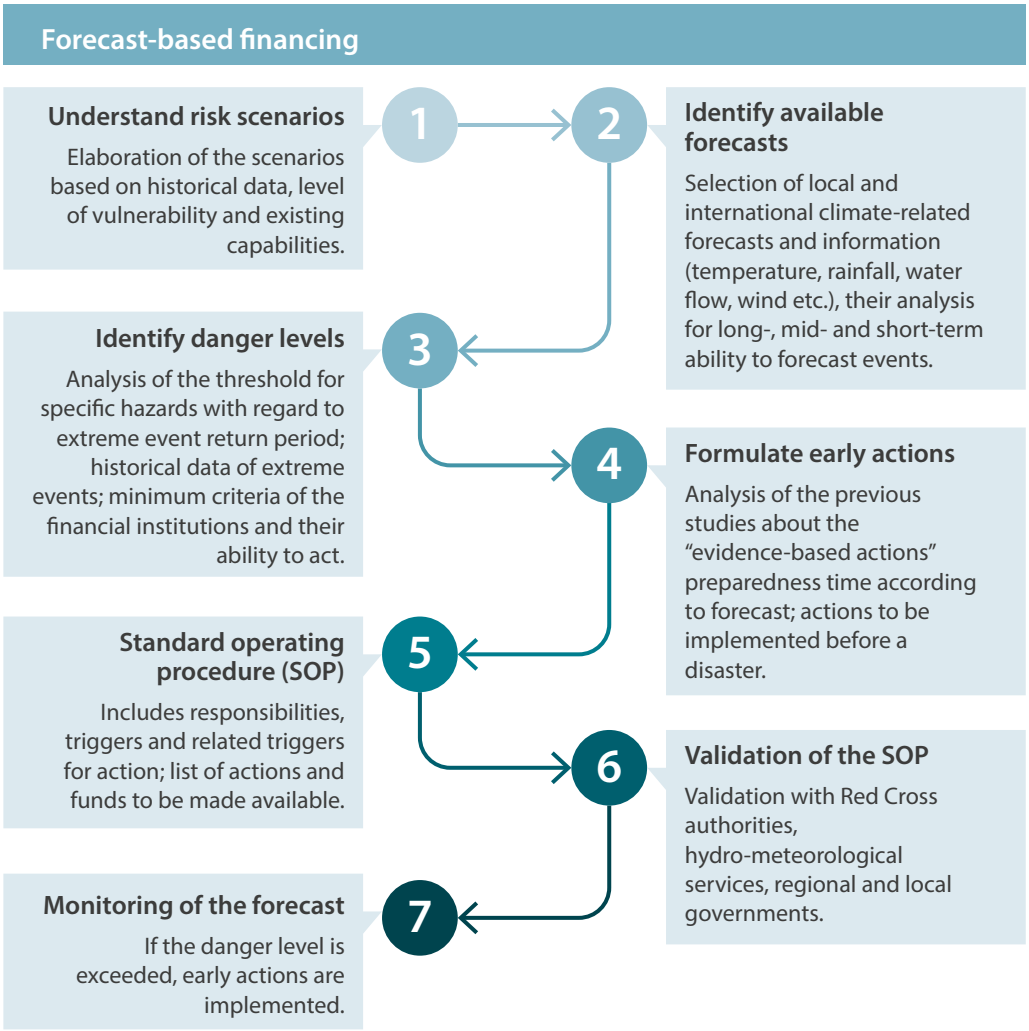
It's obvious that all measures in the CCA and DRR areas require financial resources and appropriate IT-solutions in order to facilitate the process of adaptation to climate-related change. With this regard, forecast-based financing is a very useful tool to connect CCA actions with DRR measures. Hence, this tool should encompass existing specific features and the interconnections of both areas.

The **FbF process** consists of the following **five stages**: *collection of the data*; *elaboration of the model to predict disasters and extreme weather events*; *planning of the preventive actions*; *elaboration and improvement of the Standard Operating Protocol* (SOP); *delivering financial aid; reporting and evaluating results* (see Figure 3).

A time between early warning message and the actual event is too small. Hence, it's important to mobilise financial resources very quickly to save money, health and human lives. In fact, experience of Uganda in 2007 showed that the time for activation of the SOP is about 15 days and could be reduced through automatisation and more profound digitalisation of the processes. Another 30–60 days are needed to evaluate results and report on it (Zommers Z., et al., 2018).

Figure 3: Major elements of the Forecast-based financing.

Source: built by the authors on the basis of German Red Cross National Headquarters.



In case of data collection, it's important to ensure reliability and precision of the information what could be crucial for the whole FbF process since the quality of those data will influence accuracy of the models. This, in turn, could trigger false preventive actions and lead to misusage of the financial resources as a result.

Moreover, prompt reaction to possible extreme weather event or natural disaster requires coordinated actions by separate authorities and actors. A set of different authorities, governmental bodies and public actors should be involved in the process of preventing from extreme weather events, natural disasters and financial support of related measures. Such coordination could be also facilitated via modern IT-solutions which are being used also in international trade, where one operation should be processed and controlled by various authorities (e.g. tax administration, customs service etc.).

An important advantage of the FbF relates to the fact that the costs of preventive measures are significantly lower in comparison to the damages caused by natural disasters or extreme weather events. Experience from Uganda shows that in some cases the difference between costs of preventive actions and climate-related losses could range from 1:100 to 1:200. Related reports of UNDRR (i.e. the Global Assessment Report 2013) show that rate of return for DRR investments is about 7:1. But in order to benefit from this opportunity a well-designed FbF mechanism should be elaborated and enacted.

DLT-solutions for forecast-based financing.

In fact, FbF has many advantages in bridging the gaps between CCA and DRR, it also gives an opportunity to prevent huge losses/damages associated with natural disaster or extreme weather events. But there are certain challenges and potentially negative features. **Obstacles in the functioning of the FbF** range from technical to purely economic: *limited number of local observations* for the modelling; modelling *focuses only on the local level* (no regional or national perspective); distribution only on non-food items, relatively *long period of time to enact the SOP*.

In case of floods eligible institutions and authorities start to care about the so-called "soft" emergency actions (e.g. evacuation, temporary flood protection measures, etc.). Alongside with such measures, special purifying tablets are also being distributed within the community to prevent possible diseases. There are some evidences that these measures are not always effective due to the fact that health problems after the floods can be very different (e.g. skin and soft-tissue infections, gastroenteritis). For this reason, facilitation of *money transfers* to the end-recipients is a more preferable way of preparing the communities to the risks of natural disasters and extreme weather events. Hence, there is a need in new innovative financial instruments, which could make the transfer of money fast and easy not only from the financial market to the special purpose vehicles (short, SPV), but also could facilitate distribution of the necessary financial resources to the recipients in the time of need.

The rest of negative feature of the FbF directly or indirectly relates to the problem of the *data collection and processing* – could decrease effectiveness of such mechanism. With this regard, positive features of the newest IT-solutions should be considered to improve existing financial mechanisms in the CCA and DRR areas. Nowadays, opportunities of **Distributed Ledger Technology** (DLT)[16] could contribute to improvements in FbF tools by: *reducing time and costs* for transactions; *limiting corruption*; *improving accountability* of the actions (Zwitter A., et al., 2018).

Coordination of different actors and accountability of the benefits is crucial for the purpose of well-functioning mechanism of the FbF. The DLT-solutions could solve the-above mentioned problems through the algorithms encrypted in smart contracts, where simultaneous verification of the actions is needed in order to save time, money and provide necessary aid to selected communities.

16 Distributed ledger technology (DLT) is a digital system for recording the transaction of assets in which the transactions and their details are recorded in multiple places at the same time. Unlike traditional databases, distributed ledgers have no central data store or administration functionality. Available at: searchcio.techtarget.com/definition/distributed-ledger.

GAP:	High transaction costs of climate finance for small economic agents. Difficulties in estimating actual losses and damages from extreme weather events or natural disasters – significant time gap between actual event and the moment of repayment/reimbursement

Recommendation 2.2	Self-financing and crisis financing mechanisms with application of Distributed Ledger Technologies (short, DLT).
How:	National DLT-based platforms for accumulation of the savings and facilitation of climate-related crisis financing.
Who:	Ministries of Finance, Ministries of Environmental Protection, International Organisations.

Best Practice Example	
Who:	International Federation of Red Cross and Crescent Societies (short, IFRC).
How:	In 2018, the IFRC and Kenya Red Cross Society implemented the pilot DLT-based project in Kenya to assist more than two-thousand households affected by drought.
Source:	IFRC, 2018.

c. Climate Insurance in the EU

Yield-based insurance – prospects for the EU

Three-quarters of the EU countries, including France, Italy, Spain, Austria and the Netherlands, already subsidise the so-called multi-risk policies of insurers, which cover all weather risks – including droughts. In addition to insurance, a big part of the funding comes from the EU financial sources. (Peters L. 2018).

Agriculture is one of the sectors, which is affected the most by climate change. There are two major **types of agricultural insurance** in Germany: (i) *crop hail insurance* and (ii) *livestock insurance*, where the first type was introduced in 1733 and the letter one in 1830. Meanwhile, multi-peril insurance (short, MPI) is not as widespread (see Table 6) and is only offered by some insurance companies due to the strict underwriting conditions.

Table 6. Insurance and compensation systems in the EU.					
	Hail	Storm	Heavy rainfall	Frost	Drought
Belgium[1, 3]	X	X	X		
Denmark	X	X	X		
Germany	X	X	X	X	X[2]
Italy[1, 3]	X	X	X	X	X
Croatia[1, 3]	X	X	X	X	
Luxembourg[1, 3]	X	X	X	X	X
Latvia[1, 3]	X	X	X	X	
Lithuania[1, 3]	X	X	X	X	X
Netherlands[1]	X	X	X	X	X
Austria[1, 3]	X	X	X	X	
Poland[1, 3]	X	X	X	X	
Spain [1, 3]	X	X	X	X	X

Note: 1) multi-peril insurance 2) IBI 3) state subsidies [45-60%]
Source: built by the authors.

Crop insurance in Germany is covered by different mutual insurers, private and public companies. There are **two types of cover for animal insurance**: *animal losses* due to the epidemic diseases; and *forecasts interruptions* due to the accidents, fire, epidemic diseases, movement restrictions.

For example, in the Netherlands and Luxembourg, yield losses in the field are determined by evaluating dried parts of the plant, the size of the cobs or the weight of the grains. In the Netherlands, more than a quarter, in Luxembourg almost every second hectare of the insured area, is already insured against drought damage. The demand is correspondingly high, as a risk premium subsidy of 50-70% is granted to the insurance premium from national and/or EU funds. In addition, an insurance tax of 19 % on the insurance premium for drought makes risk protection in Germany completely uninteresting. In almost all the EU countries, this is zero percent – in addition to state support for risk provisioning" (Rittershaus D. 2018).

Also, Italy protects its farmers against weather risks with around EUR 1.6 billion, France with EUR 600 million. Only Germany, Ireland, Great Britain and some others leave this risk to the agricultural enterprises (Krohn P. 2018).

Yield-based vs. index-based insurance (IBI)

As a rule, climate catastrophes occur unexpectedly and the damage caused by such events is not precisely predictable. "Classical" insurance techniques and instruments are often not effective enough to solve the problem as the contractual compensation mechanism works on the basis of the yield losses that have been observed in the past. In practice, the problem in claims management is that it often takes months to determine and settle the refunds – months during which the losses could increase (such as prolonged moisture penetration can reduce the condition of buildings and their drying capacity or make them vulnerable to possible subsequent frost damage).

Existing yield-based approaches to the insurance of climate-related risks in agriculture have in fact **a number of drawbacks**: *fraud detection* and *risk modelling*. Agricultural firms and farmers tend to overestimate their real losses and claim higher compensation from the insurance companies. Hence, claims management becomes very difficult and requires additional expenditure (both in terms of money and time) to determine and verify appropriate amount of compensation for the clients. The second negative feature of yield-based insurance relates to the modelling of risks, especially when the average surface temperature on Earth will rise faster than expected – making forecasts extremely difficult.

Nowadays, ex-post and ad hoc compensations are becoming more and more expensive – in 2014–2020 more than 65% of insurance premiums are being covered by the EU within the framework of the Common Agricultural Policy (Hochrainer-Stinger, Hanger-Kopp, 2017). In addition, yield-based insurance may not even be applicable in certain areas – for example, grasslands have different number of harvests per year and a very small difference in damages depending on the seasonal occurrence of extreme weather events. Therefore, in such cases IBI could be considered as the most appropriate solution (IIASA, 2017).

IBI relies on the application of physical indicators (like temperature or level of soil moisture, etc.) which are being used as a "trigger" for compensation of losses. Compared to the yield-based insurance, IBI has some **positive features**. Firstly, this approach is *more objective* due to the fact that indicators depend only on physical features of the environment. Additionally, compensation is limited to the specific amount of money calculated on the basis of losses from previous periods. This approach can significantly *reduce time for calculation* of the losses and the time between actual event and *compensation payment*. Another important advantage of the IBI is *improved trust* between insurance companies and their clients. At the same time, IBI could simplify *field loss assessmen*t, *reduce bureaucracy*, *increase transparency*, thereby make it *less costly for small customers like farmers* (Gommes, Kayitakire, 2013).

Introduction of the IBI is associated with certain **obstacles**: *lack of reliable data*, *existing basis risk* and some *technical requirements*. Additionally, *premiums per farmer are small* and insurance companies usually have to aggregate risks in order to transfer them to the reinsurer (Hess, Rosy, 2005).

There are 3 different **types of IBI**: *crop*, *grassland* and *livestock insurance*. For the crop insurance we can distinguish the following **types of indices**: *meteorological* trigger, *area yield* trigger, *vegetation index*, *several factors* in crop growth model.

At the same time, for grassland insurance we can find the following **types of indexes**: *meteorological* trigger, and *vegetation index* (remote sensing). For livestock IBI products are based on measured *livestock mortality* and *vegetation* indexes (The World Bank Group. 2011).

In order to implement the most effective indicator for a crop IBI product several studies have been carried out examining different conditions and options. One of the studies suggests, that Normalized Drought Vegetation Index (NDVI) could be used In Europe, where summer temperatures are above 16 Degree Celsius, vegetation responses in summer only to drought-stress fluctuations and not to temperature (Peled, Dutra, Viterbo, Angert, 2010).

Another option is to use the so-called Combined Drought Indicator, which is composed of the Standardized Precipitation Index (short, SPI) and fraction anomalies for the absorbed photosynthetically active radiation (short, APAR). The SPI was computed with the data at the European level from different weather stations in Member States (Sepulcre-Canto, Horion, Singleton, Carro, Vogt, 2012).

In addition, a Hydrological Drought Index Insurance (short, HDII) for irrigation districts was proposed in case of Spain, where indemnity is based on the Drought Index (short, DI), which, in turn, is multiplied by a uniform water value for the region. Important is the fact that a transfer of water rights should be prohibited under such scheme – farmers could request a double compensation (in case of yield-based approach). However, if indemnity is based on external objective indicator, voluntary exchange of water rights is possible (as well as water banking) (Leiva, Skees, 2008).

International financial institutions actively offer a wide range of mechanisms to cover climate-related risks, especially for developing countries with limited access to financial resources and mechanisms. For example, the International Financial Corporation (short, IFC) offers the Global Index Insurance Facilities (short, GIIF) as opportunity to facilitate the access to financial resources for SMEs, catastrophe risk transfer solutions and IBI in developing countries.

From the EU prospective, IBI could bring more benefits than negative consequences by solving **several problems** arising from the particular situation in agriculture. However, there is *no market for related derivatives* across Europe and risk *management is not unified* across the EU (Ramsey, Santaremo, 2017). In other words, on the way to the EU IBI, several problems should be kept in mind: *costs of implementation* could be enormous and *basis risk* could lead to *problems of market acceptance* (IFAD, 2017). Moreover, pool insurance of agricultural risks is more suitable than individual insurance (Villarroya, Agronoma, 2016).

InsurTech for insurance industry

Nowadays, huge amount of data should be processed in order to cover the needs of insurers (as well as of insured) at least in the above-mentioned areas. Moreover, in the modern world protection of the information becomes increasingly important for all economic agents. For this reason, companies and governments from different countries and branches are looking deeper into the opportunities of the Distributed Ledger Technology (short, DLT). The starting point and the most popular type of solutions has been prepared on the basis

of blockchain[17] (type of DLT). Despite the fact that this technology has some limitations (like amount of operations within the given time horizon), the level of data protection is high enough to reduce significantly the risks of intervention from the outside ("hacking") on the data or important business information. Additionally, integration of DLT technologies with artificial intelligence, internet of thing, big data and other innovations could give unprecedented breakthroughs for the entire insurance sector. That is why, "InsureTech" is the innovative use of technology in insurance and is not just a modern trend, but will become a part of our daily business activities in a wide range of economic sectors (see Annex 1).

Several important benefits are associated with the application of the DLT in conjunction with IBI (especially for agriculture): (i) improved *real-time exposure assessment*; (ii) enhanced *accident and risk prediction*. Those benefits contribute to improvements in **data processing** and facilitate understanding of the scenario-based assessments of a large set of changing parameters (in a real-time mode).

DLT could significantly reduce the time needed for negotiations and quotations. According to some estimations, application of the DLT in insurance sector could reduce time for negotiations and quotations by up to 90% (Mesropyan, 2018.). As a result, reinsurers could make the process of reserve calculations easier, establish the so-called "streamlined reinsurance" operations. But the most important benefit for all insurers would be associated with improved liquidity control.

First, InsurTech facilitates deeper risk assessment, offers more sophisticated preventive models, enhances interactions, improves operational capabilities, efficiently leverages ecosystem and market resources. According to the findings provided by PwC, the most important opportunity for the insurers stems from self-directed services (customer acquisition and customer services) and usage-based insurance (pay-as-you-go) (PwC, 2016).

Second, a variety of **operational benefits** for agricultural insurance relates to improved claims management: (i) *coordinated and synchronised view and verification* of the transactions and other information; (ii) *enhanced third-party transactions* ("claim leakage"); (iii) *enforced fraud detection* (iv) facilitate alignment with *new legal requirements for the financial institutions*. Such improvements could create additional benefits via behavior-based underwriting (pay-as-you-go).

In addition, existing enhanced requirements for the financial market (e.g. Basel III, Directives 2016/2341, 2017/828) impose certain limitations on the activities of the financial institutions. In this case not only insurance companies should comply with existing requirements while providing their services, but also other institutional investors should pay attention to the existing limitations. Prominently, new requirements are forcing institutional investors to analyse non-financial risks while making their investment decision.

17 Blockchain technology is most simply defined as a decentralised, distributed ledger that records the provenance of a digital asset: builtin.com/blockchain

Third, a set of **market benefits**, associated with application of the DLT, relates to the **new business opportunities**: (i) *access to small clients*; (ii) *common platform* for all the key participants of the insurance process; (iii) *common space* for understanding the quotations workflow.

The most important positive feature of the modern symbiosis between IBI and DLT is an opportunity to reach out to the small customers – farmers. Exactly in this case, the insurers could drastically reduce administrative costs and make their services more accessible for those, who were excluded from the classical schemes due the negative cost-benefit ratio of the insurance services.

International financial institutions are actively trying to develop technical solutions for dealing with agricultural risks. For example, the UN created so-called "New Climate Chain Coalition" which purpose to facilitate achievement of the SDGs, implementation of the DLT for better climate change solutions – avoid frauds and address challenges associated with the DLT applications (UNFCCC, 2018).

There are certain **barriers** on the way to implementation of the DLT in combination with IBI. Firstly, *privacy challenges* emerge during analysis of the data, where data protection law is very restrictive. Second important obstacle on the way to the application of DLT for insurance in agriculture is associated with existing *different regulations* in separate jurisdictions – this could impose some difficulties while implying different legal acts to the operations. Another challenge is associated with *decentralised way of storing the data* – no certain person or entity is responsible for the stored information.

GAP:	Small economic agents (like small farmers) don't have an access to climate insurance products

Recommendation 2.3	Sovereign Climate Insurance Funds (CIF) with application of IBI and DLT
How:	Sovereign Climate Insurance Funds (polls) could provide protection against climate-related risks through the state guarantees and public financial resources, contributions from the local level. Additionally, such SIFs allow an access to resources of the market financial by implementing innovative financial instruments (e.g., derivatives).
	The CIF should be able to issue sustainability, environmental impact, catastrophe, water and/or pandemic bonds (as additional source to public funds). Application of the catastrophe swaps could give an opportunity to transfer climate-related risks to the financial market via facilities of the European Financial Stability Facility or European Investment Bank (see Recommendation 2.2).

Who:	Ministries of Finance, Ministries for Environmental Protection, UNFCCC, national authorities responsible for auctioning of the emission allowances, local/regional authorities.

Best Practice example

Who:	ACRE Africa, Etherics, The Blockchain Climate Risk Crop Insurance.
How:	A DLT-based platform has been developed in 2019 to provide index insurance for small farmers in Kenya to facilitate payments of insurance premiums as low as 50 cents.
Source	www.climatefinancelab.org/project/climate-risk-crop-insurance/
	climatepolicyinitiative.org/wp-content/uploads/2019/10/Blockchain_instrument-analysis.pdf

d. Risk transfer and data collection by DLT

First reason for introduction of the risk transfer schemes at the EU-level is that climate change could contribute to systemic risk in the financial system. According to the report of the European Systemic Risk Board (short, ESRB), climate change could affect **systemic risk** through the following channels: (i) macroeconomic impact of sudden changes in *energy use*; (ii) reassessment of carbon-intensive assets (stranded asset risk); and (iii) increase in the frequency and severity of natural catastrophes, extreme weather events.

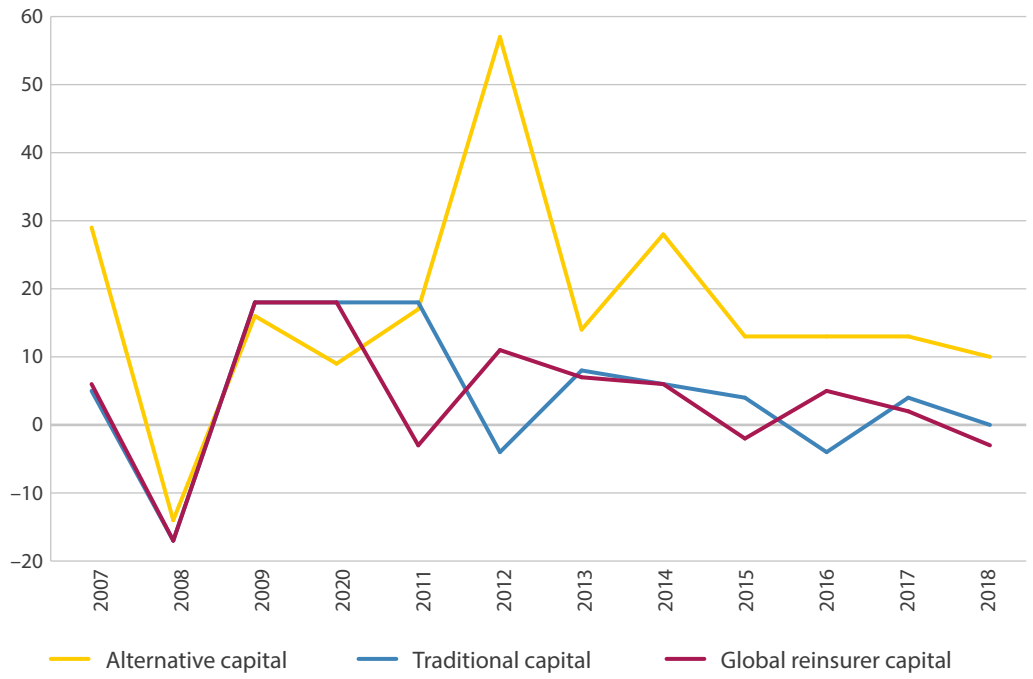
The fact that climate change could contribute to systemic risk requires adequate response at the EU-level to protect entire financial and economic system. In this context, a Special Purpose Vehicle (short, SPV) is needed to issue debt instruments or offer swaps and coordinate new risk transfer mechanism in the EU (see Annex 1).

Moreover, existing pattern of the reinsurance mechanisms shows that the market for alternative capital is driven mostly by collateralised reinsurance schemes. Even despite the fact that alternative part of the overall global reinsurance market is still below 20%, it shows higher growth rates in comparison to traditional reinsurance market (see Figure 4).

The biggest chunk part of the alternative reinsurance market belongs to collateralised reinsurance schemes – the share is over 50% of the total amount of the global reinsurance capital and has the most rapid growth rates in 2008-2018. The fact that *synthetic instruments* are playing again an important role on the financial market could be considered as a potential additional source of *systemic risks* like before the last financial crisis in 2008 on the U.S. mortgage market.

Figure: 4: The growth rates of the global, traditional and alternative reinsurance capital (2007–2018), %.

Source: built by the authors, data from Aon SecuritiesInc.



In addition, recently enacted Solvency II regulation recognises derivatives or securitisation schemes as an effective risk mitigation technique and gives a green light for further development of alternative approaches to risk transfer (Aon, 2017).

Existing Common Agricultural Policy (short, CAP) could contribute to the functioning of the new risk transfer system at the European level by *covering the basis risks*. This could be achieved through the facilities of the EU agricultural funds, where the primary purpose is to provide direct payments to the farmers. As we already know, there are **two major gaps** in protecting agriculture from climate-related risks: *time* and *administrative costs*. These two components could be considered as an evidence that the level of transaction costs is high and requires adequate solutions on the EU-level. Moreover, existing two pillars of the CAP cannot provide full protection for agriculture in case of extreme weather events or natural disasters. Only one pillar – European Agricultural Fund, has been created to provide subsidies to agricultural producers and has up to EUR 14 billion to improve resilience of the sector. Another important pillar (European agricultural fund for rural development) is **devoted exclusively to income stabilisation** and is not able to execute preventive function.

For this reason, it is important to establish a **European Risk Transfer Mechanism** (ERTM) to transfer risks from sovereign insurance funds (see Recommendation 2.3) to the financial market – if losses are too high to be covered by SIFs. In this case, an instrument such as catastrophe swap combined with a catastrophe bond could help to cover capital needs for any outstanding risks and obligations (see Annex 2).

A **European Financial Stability Facility** (EFSF) already exists in the European Union and was established in 2010 with the aim to provide financial assistance to some EU-member states with severe debt conditions. This body can issue debt instruments and swaps, which could serve as an effective instrument for transferring risks to the financial market. Such an approach could in case of issuing catastrophe bonds as creditworthiness of the EU is much higher than for some member states (number 1 in in the Annex 2).

Another important reason for establishing the ERTM is the fact, that there are different types of actors on the financial market who try to trade debt instruments and related swaps in order to increase their revenues. Example of the last financial crisis in 2008 demonstrated that the EFSF could not only play an important role in providing relatively cheap financial resources to all the member-states, but also serve as a *contractor for speculative swaps*. In fact, the EFSF could protect against possible speculations with catastrophe swaps.

After mobilisation of the necessary financial resources, sovereign funds or special insurance agencies could use cat bonds and cat swaps in order to transfer the money and exchange related risks with EFSF (number 2 in the Annex 2). Moreover, implementation of the DLT could allow the transfer of information and financial resources between the EFSF and sovereign insurance funds (amendments to the existing legal framework and rights of the EFSF is needed).

Application of DLT could not only ensure *collection and processing of climate-related information*, but also guarantee very *high level of security* and *access to insurance products for small clients* (e.g. small farmers). In addition, issuance and management of the financial instruments (like bonds, swaps) could be made more *efficient in terms of time and costs* (number 3 in the Annex 2).

At the same time, European Parliament has already adopted directives forcing big companies to *disclose information about the level of non-financial risks* on the annual basis. But still, European companies can still choose the way in which they report on their non-financial risks and results. At the same time, the Sustainable Finance Action Plan provides concrete metrics to be enacted by the end of 2020 (DIRECTIVES (EU) 2013/34, 2014/95, Action Plan on Sustainable Finance). This will require more efforts to collect relevant data for both non-financial reporting and effective risk management.

Today, pension funds and insurance companies in the EU need to *analyse level of the non-financial risks* before acquiring assets on the financial market. This means that major institutional investors are already paying attention to climate-related risks and trying to avoid investments with high level of the above-mentioned threats (DIRECTIVE (EU) 2016/2341). Current draft of the upcoming changes to the existing legal framework at EU-level opens new opportunities for stakeholders to interact more actively with corporate governance structures regarding the extent to which non-financial risks (e.g. environmental, social and governance) are taken into account while making investment-decisions (DIRECTIVE (EU) 2017/828).

As a result, introduction of the DLT-based risk transfer mechanism on the EU-level (**ERTM**) could bring various benefits by solving existing problems in agricultural insurance and would offer new opportunities for further improvements. In fact, benefits could be measured both in terms of saved time and money on each stage and level of the insurance process:

1. Low costs of implementation

The ERTM mechanism contains already existing IT-solutions and its implementation could cost significantly less than in case of building up a completely new system from scratch.

2. Access to the services for small customers/farmers

Application of the DLT could grant access for small users/customers on a per-to-per basis by reducing transaction costs and facilitating flow of payments between the users of such system/mechanism. Moreover, in some cases peer-to-peer insurance could generate a cashback of up to 80%. In addition, such system could be considered as an effective tool to increase the level of penetration on the market.

3. Simplified and improved execution of the contracts

Smart contracts, as a basis of the DLT, will reduce significantly time not only for signing the contract, but also optimise time for execution of transactions (comparing with classic insurance).[18]

4. Quick compensation payments

Index-based insurance, as we have already discussed above, is a simplified approach to deliver protection against possible losses not only for agriculture, but also in other sectors, where a specific parameter (e.g. temperature, moisture) is being used as a trigger. Such approach allows to save time and speed up compensation payments without additional verifications and calculations on the ground. Application of the DLT could make the process of such payments quicker by arranging prompt reimbursement of the losses on the account of the user within the DLT platform.

5. Reduced basis risk

DLT could also reduce existing basis risk is case of IBI by identifying the bottlenecks in data about real exposure to risks and the actual level of losses. In fact, existing DLT applications allow reduction of under-insured policies for up to 25%.[19]

6. Reduced systemic risk

Existing DLT-platforms are contributing significantly to the improvement of risk management not only in terms of time saved (up to 90% of time), but also allowing to reduce possible losses from failing to comply with existing legal framework and obligations. In other words, such improvements could reduce possible influence of climate-related risks on systemic risk escalation within the entire financial system.

7. Improved risk transfer

Combination of synthetic financial instruments (like, cat swaps) and IBI could improve significantly efficiency of the reinsurance process via granting a prompt access to the financial market. Application of the DLT-solutions could additionally save up to 15-20% of related expenses.[20]

18 Available at: https://financialprotectionforum.org/file/1257/download?token=7-5z7Nj5

19 Available at: www.oxbowpartners.com/pdfs/Atidot.pdf

20 Available at: www.disruptordaily.com/blockchain-use-cases-insurance/

Implementation of the smart contracts could help to the necessary information within a few seconds and facilitate processing of the uniform and synchronised data. Moreover, smart contracts should bridge the gap between insurance service providers and small consumers (like farmers) and contribute to faster aggregation of small pieces of information within the system.

Within such system of transparent and reliable data an additional option arises to develop a DLT-based system for issuing innovating CCA and DRR financial instruments. This step could accelerate the process of accumulation of the necessary climate financial resources, facilitate elaboration of innovative insurance services.

GAP:	Possible sovereign debt crisis and increase of systemic risk due to climate change.

Recommendation 2.4	Risk Transfer and data collection through European Risk Transfer Mechanism.
How:	A DLT-platform on the EU-level for national and sub-national authorities/institutions in order to transfer climate-related risks to the financial market, collect and process related data (e.g. loss data, level of risks). Such data could contribute to reduction of transaction costs and improve management of climate-related risks on the EU-level.
Who:	Ministries of Finance, Ministries of Environmental Protection, European Financial Stability Facility, European Investment Bank.

Best Practice example	
Who:	The World Bank, Philippines Government Service Insurance System
How:	The World Bank Issued catastrophe bond in 2017 to mobilise private financial resources and extend parametric insurance cover by the Philippines Government Service Insurance System up to USD 390 million. Catastrophe swap was used to provide the government with a source of parametric risk transfer.
Source:	www.phoenix-re.co.uk/2019/01/14/philippines-parametric-insurance-doubles-cat-bond-on-the-way-world-bank/
	www.artemis.bm/news/world-bank-arranges-206m-catastrophe-swap-for-the-philippines/

4. Summary and conclusions

Presentation of the EU Green Deal during the COP25 in Madrid (Spain) was important not only as a step on the way to a climate-neutral Europe, but also as an example of more ambitious climate targets for other parties within the Paris Agreement. In order to build up resilience and achieve climate neutrality of the continent, the European Commission is going to improve its adaptation strategy, as well as related strategic documents. The overall goal is to make the financial system more sustainable to non-financial risks and facilitate mobilisation of climate finance.

The first **important complex gap** identified within this report relates to the fact that *CCA and DRR aspects are not fully encompassed by the current version of the EU Green Deal*. Climate change adaptation and disaster risk reduction communities are being regulated on the international level by two different agreements – Paris Agreement and Sendai Framework on Disaster Risk Reduction. At the same time, those documents have common targets, priority and areas of action. Hence, **synchronisation** of the components from above-mentioned agreements within the EU Green deal is recommended in order to increase effectiveness of related measures – improve resilience of the economy and society to climate change.

With this regard, an updated adaptation strategy on the EU-level should be based on the main synchronised components of the Paris Agreement and Sendai Framework on Disaster Risk Reduction. Moreover, the EU Green Taxonomy and EU Green Bond Standard should be enriched by CCA and DRR metrics, targets and measures. This will allow not only to redirect financial flows to green and climate-related projects, but also could facilitate achievement of a **dynamic resilience** within the EU.

A wide range of intangible co-benefits from conducting CCA and DRR measures (e.g. saved lives, health of cultural heritage) could be created and there are different methodologies to monetise them. At the same time, there is no **unified guideline or standard on how to account intangible benefits and assets** of such projects. For this reason, we are arguing for elaboration of the unified standard, methodology on the EU-level for monetising and accounting of intangible benefits, assets co-created as a result of CCA and DRR projects.

Incorporation of the above-mentioned measures into the strategic documents within the EU Green Deal could not only improve efficiency of the measures, make investments in the CCA and DRR projects more attractive, but also could contribute to elimination of other gaps.

The **second group of gaps** relates to the fact that current approach in *management of climate-related risks doesn't contain fully CCA and DDR components.* Hence, there is a need for a comprehensive unified approach to the climate risk management on the EU level. Moreover, as part of the EU Green Deal new framework for disclosure on climate-related risks is going to be established by the end of 2020. Such legislative initiative could improve risk assessment and risk management in the area of climate change and reduce associated transaction costs while mobilising climate finance. In this case, it would be necessary to take into account already existing principles and standards for reporting on non-financial risks (e.g. Standard 103 by Global Reporting Initiative) to improve **risk management** and related legal acts within the EU – to achieve synchronisation of CCA and DRR components.

Taking onto account the role of supply chains in transferring non-financial risks along the value chain, we recommend to include requirements to report on the climate risk management within the supply chains by large companies. For this reason, there is a need to incorporate such provisions into the new version of the DIRECTIVE (EU) 2014/95/EU on non-financial reporting, which is going to be the subject of upcoming updates within the road map for the EU Green Deal.

We have also underlined in current report that sufficient amount of data and climate finance are lacking to conduct appropriate disaster risk reduction and adaptive measures (UNEP, 2018). Hence, the **third important gap** identified in this report relates to the lack of reliable, frequently updated loss data and vulnerability to climate-related risks. Lack of the data leads to increase of transaction costs and limits the access to climate finance, especially for small and medium economic agents (e.g. small farmers). This challenge is a complex one and requires implementation of the so-called **3D Nexus** (*de-risking, digitalisation and decentralisation*), which grants collection, processing and storage of reliable and frequently updated climate-related data.

As a result, we have additionally identified the **fourth gap** – lack of CCA and DRR finance. In fact, there is a need in innovative financial instruments, which could facilitate climate finance flows towards small economic agents and grant for them an access to the insurance services.

For this purpose, in this report we have classified existing **variety of innovative CCA and DRR financial mechanisms and instruments** into the following types: *savings* or self-financing; contingent and *crisis financing*; *debt financing*; *climate insurance*; *risk transfer* (reinsurance). Implementation of the above-mentioned financial instruments and mechanisms in combination with IT- solutions (e.g. DLT, IoT) is necessary not only to mobilise a sufficient amount of climate finance, but also important in facilitating the transfer of climate risks to the financial market.

Implementation of the newest IT-solutions (e.g. Distributed Ledger Technologies, Internet of Things) facilitates implementation of the **self-financing mechanisms** through optimisation of the financial flows. At the same time, this source is limited by own financial capacities and additional climate finance could be delivered by the so-called contingent or crisis financing.

Introduction of **Forecast-based Financing** (FbF) as a crisis financing instrument/mechanism could be considered as an important step towards better management of disaster risks and adaptation to climate change, especially in the least developed countries.

Taking in to account existing gap in adaptation finance, the FbF could solve partially this problem by implementing measures prior to the possible events and reducing, as a result, expenses (both in time and money). Moreover, well-designed FbF mechanism could bridge the gap between CCA and DRR communities by synchronising their goals and measures, facilitate the achievement of the SDGs.

Existing negative features of the FbF mechanism could be solved through the implementation and utilisation of modern IT-solutions (e.g. DLT, IoT). Such modern technologies could ensure reliability of data, improve quality of the models which are being used to predict natural disasters or extreme weather events. Also, transfer of the money could be facilitated via different applications based on DLT-solutions – identification of the end-consumers, verification of the data, confirmation of the results of preventive actions. Moreover, such solutions could be an important tool to connect and coordinate actions of different authorities involved in the process of dealing with natural disasters and protecting communities from possible negative consequences.

Alongside with self-financing and crisis financing, there is another set of mechanisms for debt financing, climate insurance and transfer of climate-related risks. Such mechanisms could contribute to the process of bridging the gap in DRR and CCA finance on different levels, facilitate management of climate-related risks and improve resilience of the finical system to non-financial threats.

Debt climate finance and **risk transfer mechanisms** can help bolster immediate actions after disaster, speed up recovery, support access to critical services and rebuilding critical infrastructure for people, communities and economies. Currently, existing climate risks could be covered or transferred to the financial market with innovative **debt financial instruments** (e.g. green bonds, catastrophe bonds) or derivatives (e.g. catastrophe swap). Moreover, combination of debt finical instruments and derivatives has already demonstrated high level of efficiency in mobilising climate finance from and transferring climate risks to the financial market.

Assessment of climate risks and elaboration of appropriate protective/adaptive measures requires collection, processing and storage of related data. With this regard, application of DLT-based insurance mechanisms on the national levels is important not only for providing protection against climate change, but also for improved management of risks and data. Such mechanism could encompass CCA and DDR aspects and facilitate incorporation of related information into **de-risking strategic documents** on the national level.

In this report, we have identified a relatively low rate of penetration for insurance against climate related risks (e.g. only 40% in agriculture). Implementation of the DLT could improve effectiveness of the Sovereign Insurance Funds – facilitate **digitalisation** and **decentralisation** of insurance products, collection, processing and storage of related data (e.g. loss data, risk information, weather data, expected or experienced impacts of extreme weather events).

In fact, SIF has a strong support backup with tax revenues or other state revenues which could be used as a leverage to mobilise additional private financial resources. Sovereign climate insurance could also fit into the existing set of mechanisms under of the UNFCCC.

Taking into account **high transaction costs** for small investors and issuers of debt financial instruments a DLT-based risk transfer mechanism is crucial. In fact, application of the smart contracts would be necessary to connect existing separated platforms of Sovereign Insurance Funds with the financial market (**ERTM**). This way *immediate transfer of the money from financial market* to Sovereign Insurance Funds could be organised, as well as *collection and evaluation* information about damages/losses could be also facilitated. As a result, we can achieve improvement of the *management for climate-related risks* within the EU.

A debt crisis of 2010-2013 in the EU has been driven by differences in costs of capital across the EU countries and showed that the entire European financial system could be affected by a systemic risk. This could happen if innovative financial debt instruments and synthetic derivatives will be misused by financial institutions and speculators on the market. Hence, European financial system should be protected against climate-related risks through a special mechanism. This mechanism is needed in order to issue debt instruments (like cat bonds), derivatives (like cat swaps) for transfer of climate-related risks to the financial market.

In order to grant functioning of the **ERTM**, it is necessary to appoint European Investment Bank or European Financial Stability Mechanism as the managers of such risk transfer mechanism. These institutions could issue the above-mentioned financial instruments to facilitate mobilisation of the financial resources and provide transfer of the risks from SIFs to the financial market. In addition, they have very high level of creditworthiness which could be important for equalisation of the costs of climate finance among different EU member states.

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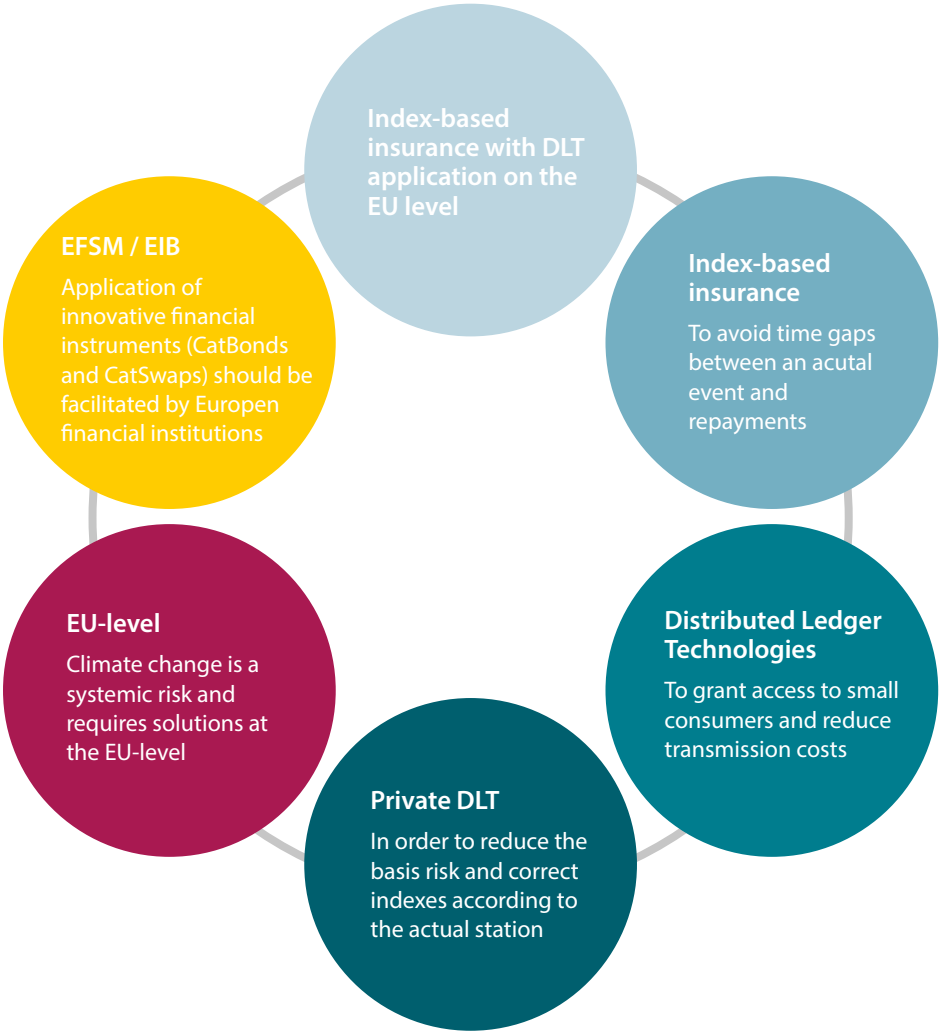
Annex 1

Components of the new risk transfer scheme in combination of the DLT-technologies on the EU-level.

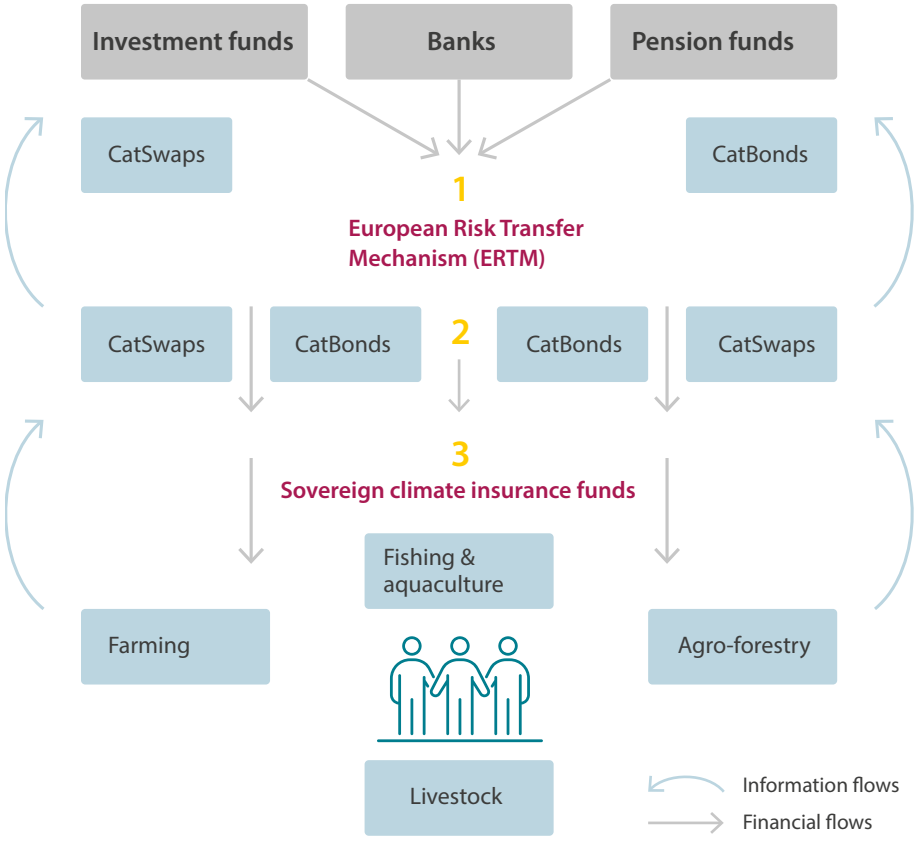
Source: built by the authors.



Annex 2

European Risk Transfer Mechanism (ERTM) with application of the DLT and index-based approach for agriculture.

Source: built by the authors.



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