NOTICE FOR PRESENTER OR READER

- Talking points and additional resources are in the "notes" section of each slide.

- **Bold text** highlights the main points and could be read aloud during a presentation, while non-bold text provides additional supporting information.

NATURE-BASED SOLUTIONS FOR DISASTER RISK MANAGEMENT

Overview of Hazards and Solutions

Photo credit: Flickr/Melissa Leake, DoD

PRESENTATION STRUCTURE

- Natural hazards that can be addressed by nature-based solutions (NBS)
- Structural infrastructure strategies in disaster risk management
- NBS options for coastal, urban, and riverine hazards
- Finance and policy considerations
- Implementation guidance
- World Bank portfolio and wrap-up

Photo credit: Flickr/Ted McGrath

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NATURAL HAZARDS CAN BE ADDRESSED THROUGH NATURE-BASED SOLUTIONS (NBS)

In this presentation:

- **Coastal flooding and erosion**
- **Urban flooding and stormwater hazards**
- **Riverine flooding**

Also relevant for:

- Landslides
- Droughts

Photo credit: Flickr/Peter Morgan

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DISPROPORTIONATE CONSEQUENCES

The **poor and disadvantaged** suffer disproportionately from natural disasters

9 of the 10 **most vulnerable cities to flooding** are in **lower- and upper-middle-income countries** (Côte d'Ivoire, Bangladesh, Ecuador, Indonesia, Vietnam, China)

Photo credit: Flickr/CAPRA Initiative

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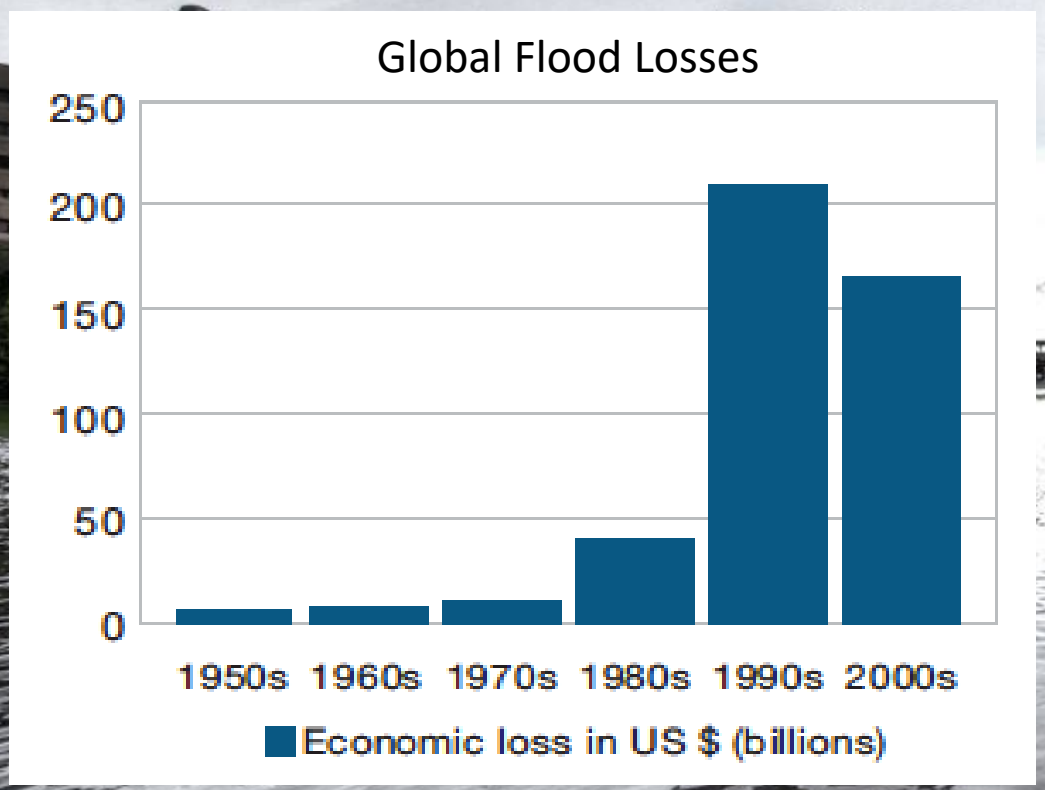
COSTLY CONSEQUENCES

Among natural hazards, the occurrence of floods is most frequent, and **flood risk is increasing**.

Flooding is most frequent among disasters. Losses totaled over **US$40 billion** in exceptional years.



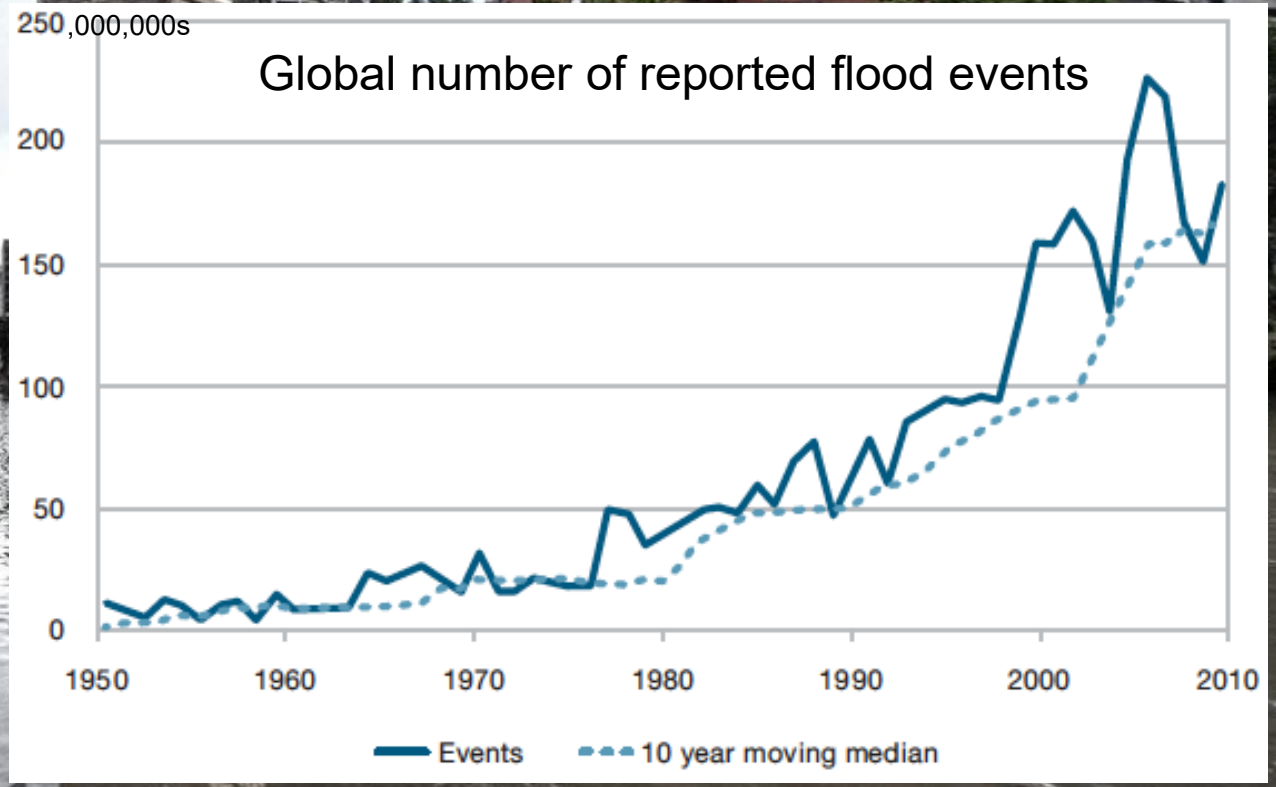


Photo credit: Wikipedia/Ryan L. C. Quan; Graphics: Jha et al. 2012

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STRUCTURAL STRATEGIES

	Nature-based Solutions (NBS)	
Built	**Hybrid**	**Natural**
Hard, gray, engineered structures built to address development objectives	Combination of ecosystem elements and hard engineering interventions to address development objectives	Creation, protection or restoration of only ecosystem elements to address development objectives

Source: World Bank 2017

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CONVENTIONAL: ‘BUILT’ INFRASTRUCTURE

- **Controlled disruption** of ecosystem by building man-made structures
- **Examples:** pipes, levees, dams, flood walls, gutters

Photo credit: Flickr/darkday

NBS: ‘NATURAL’ INFRASTRUCTURE

- Nature-based solutions include **regenerating, protecting** and **creating ecosystems**
- Newer and **not as well-tested** as built infrastructure, but can be more **cost-effective** in some cases
- **Examples**: mangroves, wetlands, floodplains, upland forests

Photo credit: Flickr/Ed Hunsinger

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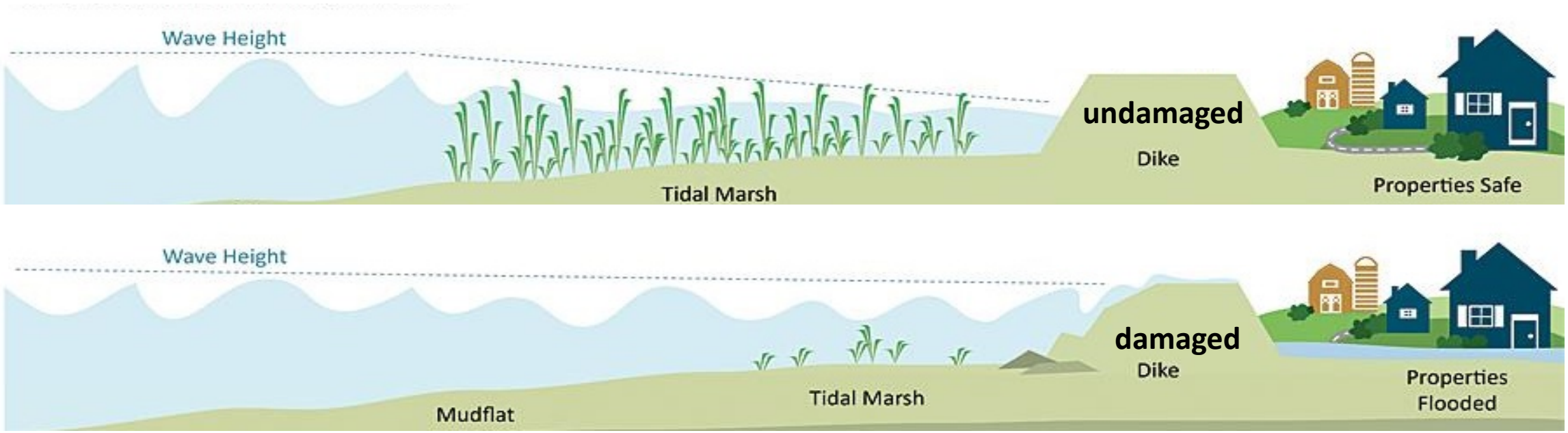
NBS: 'HYBRID' INFRASTRUCTURE

- Nature-based solutions alone are **often insufficient** to meet all needs
- **'Hybrid'** solutions **integrate and enhance** the benefits of natural and built solutions

- **Examples:** permeable pavements, constructed wetlands, removable sea walls, green roofs



Graphic: Ferdana et al. 2014

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MANY TERMS FOR “NATURE-BASED SOLUTIONS”

Source: Cohen-Shacham et al. 2016; UNEP et al. 2014; EC 2015; Lo 2016; WWF 2017; USACE n.d.; EcoShape 2018; WBCSD 2017

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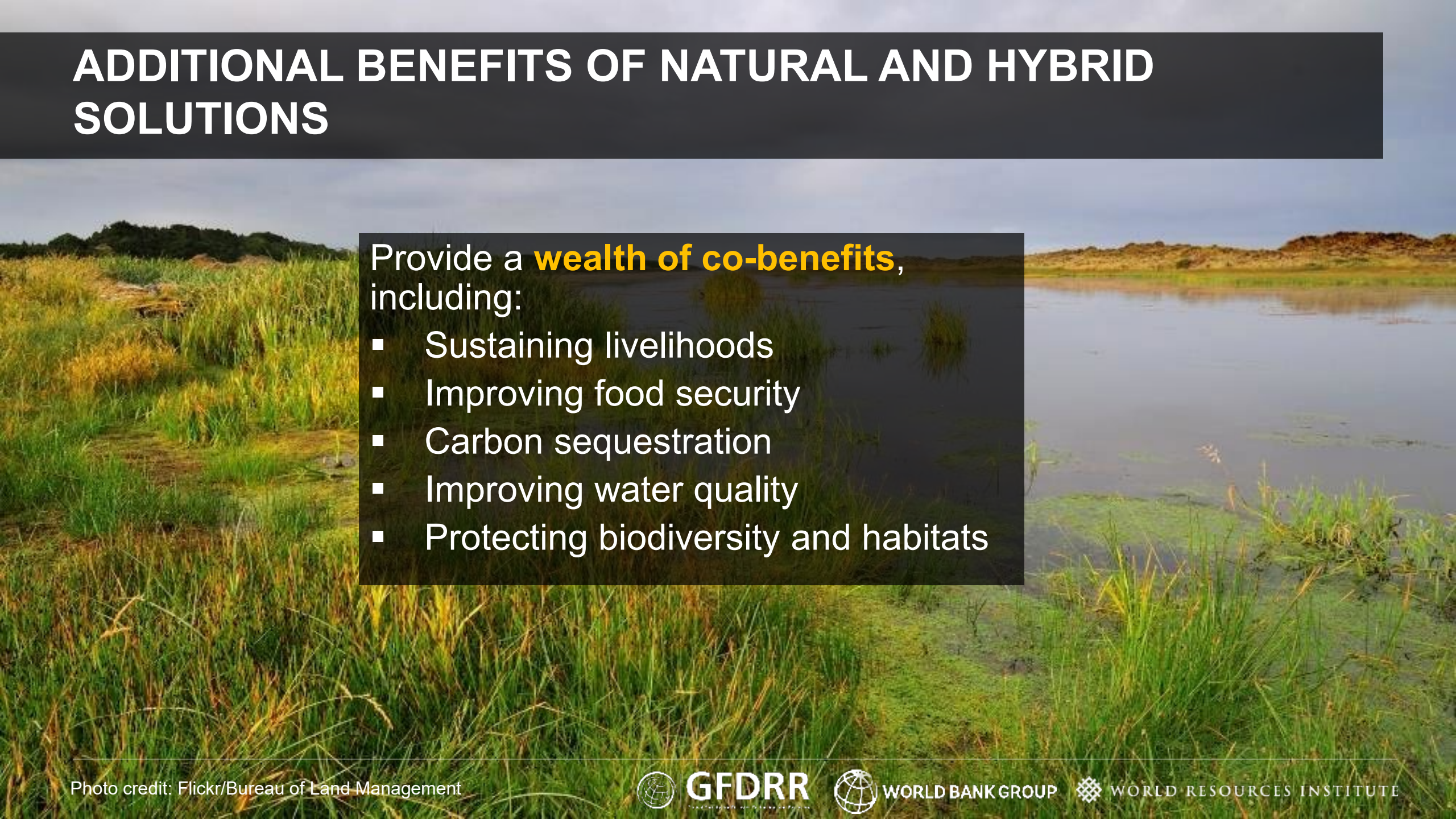
ADDITIONAL BENEFITS OF NATURAL AND HYBRID SOLUTIONS



Provide a **wealth of co-benefits**, including:

- Sustaining livelihoods
- Improving food security
- Carbon sequestration
- Improving water quality
- Protecting biodiversity and habitats

Photo credit: Flickr/Bureau of Land Management

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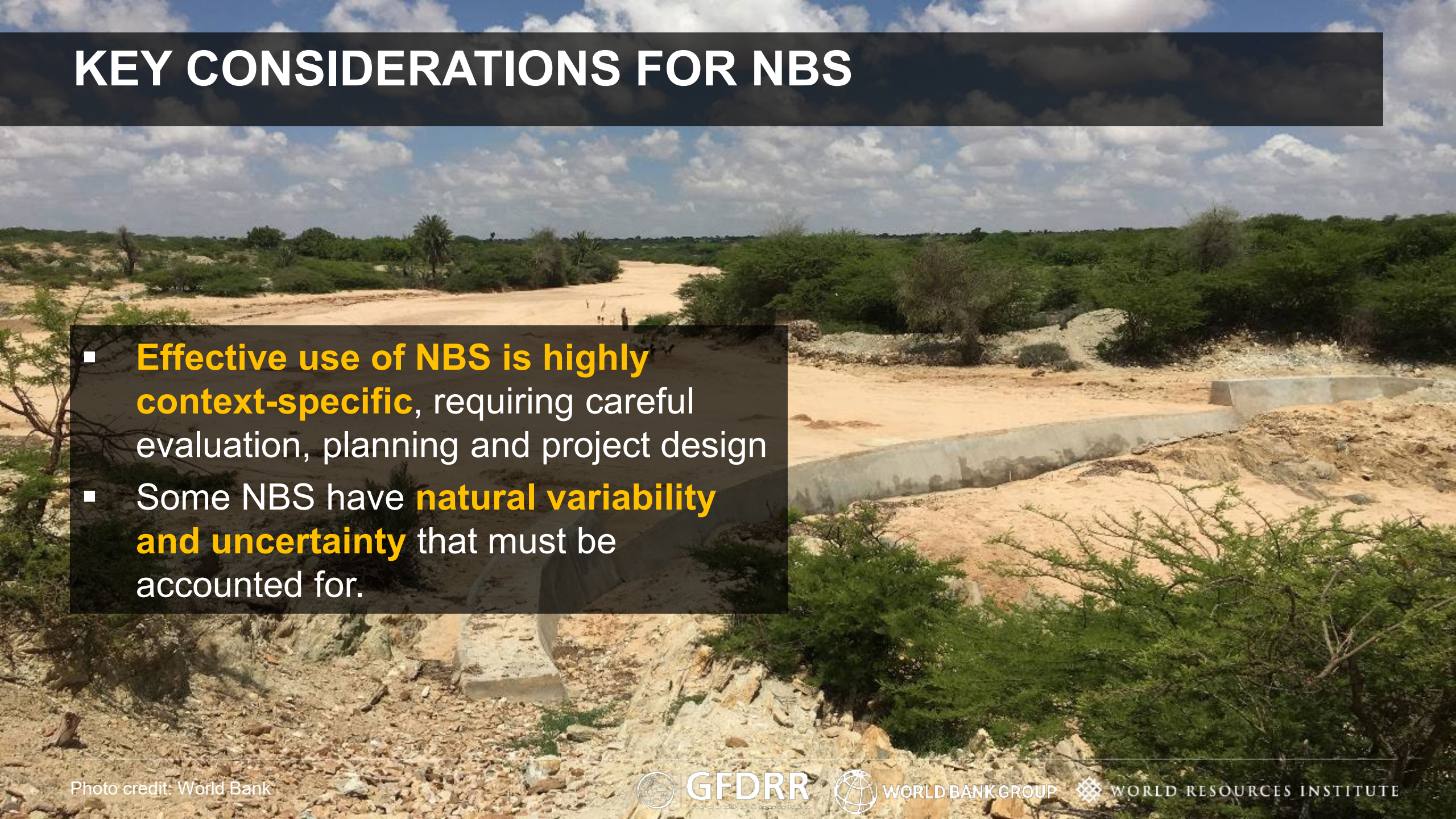
KEY CONSIDERATIONS FOR NBS



- **Effective use of NBS is highly context-specific**, requiring careful evaluation, planning and project design
- Some NBS have **natural variability and uncertainty** that must be accounted for.

Photo credit: World Bank

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HAZARDS AND NATURE-BASED SOLUTIONS

Nature-based Solutions		Challenges		
The conservation, restoration, construction, or strategic management of…		Coastal flooding and erosion	Urban flooding and stormwater	River flooding
Coastal	Coral and oyster reefs	X		
	Sandy beaches and dunes	X		
	Seagrass	X		
Wetlands	Salt marshes	X		
	Mangroves	X		
	Constructed wetlands		X	
	Inland wetlands			X
Urban	Green roofs		X	
	Permeable pavement		X	
	Open spaces (e.g., parks)		X	
	Bioretention areas (e.g., vegetated basins)		X	
Rivers	Floodplains and bypasses			X
	River beds and banks			X
Forests	Upland forests			X

Note: "X" signifies that the solution is featured in this presentation, in relation to the designated challenge.

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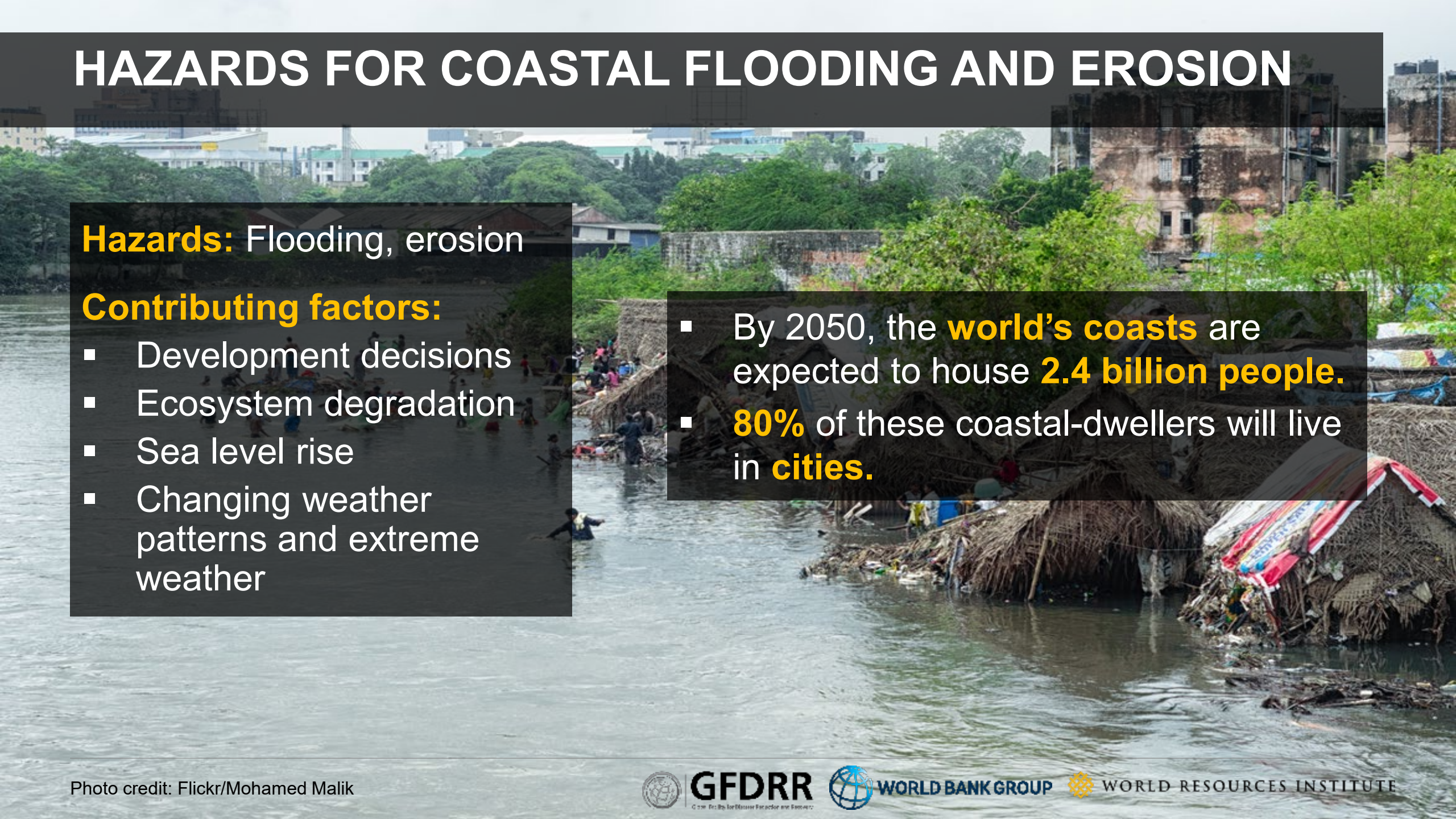
HAZARDS FOR COASTAL FLOODING AND EROSION



Hazards: Flooding, erosion

Contributing factors:

- Development decisions
- Ecosystem degradation
- Sea level rise
- Changing weather patterns and extreme weather

- By 2050, the **world's coasts** are expected to house **2.4 billion people.**
- **80%** of these coastal-dwellers will live in **cities.**

Photo credit: Flickr/Mohamed Malik

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NBS FOR COASTAL FLOODING AND EROSION

The solutions:

- Mangrove forests
- Coral reefs
- Oyster reefs
- Sandy beaches and dunes
- Salt marshes
- Seagrass

Photo credit: Flickr/Anh Dinh

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RISK REDUCTION AND ADDITIONAL BENEFITS: COASTAL FLOODING AND EROSION

Mangrove forests

- Reduce wave energy; stabilize shoreline; elevate soil

Additional benefits

- Forest products; biodiversity; long-term carbon sequestration; tourism and recreation

Oyster reefs

- Reduce wave energy; stabilize and raise shoreline; protect adjacent habitats

Additional benefits

- Habitat for fisheries; water filtration; food supply and livelihoods

Photo credit: Flickr/WRI

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RESTORING OYSTER REEFS IN THE GULF OF MEXICO

Problem:
Need for storm and ecosystem protection
(85% loss of oyster reefs globally)

Solution: **5.9 km of restored oyster reefs** in Mobile Bay, Alabama

- **Reduces wave height/energy:** by 76-99% for top 10% of waves
- **Produces marine food supply:** 3,460 kg of oyster harvest/yr
- **Purifies water:** 1,888 kg of nitrogen/yr removed nearshore

Photo credit: Galveston Bay Foundation; Cesar Harada

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URBAN FLOODING AND STORMWATER HAZARDS

Hazards: Flooding, stormwater pollution, landslides

Contributing factors:

- Urbanization
- Lack of drainage
- Insufficient water infrastructure
- Climate change

- Urban flooding occurs when water flows faster than it can be absorbed or transported away
- **By 2030, global urban population** will increase by another **1 billion**.

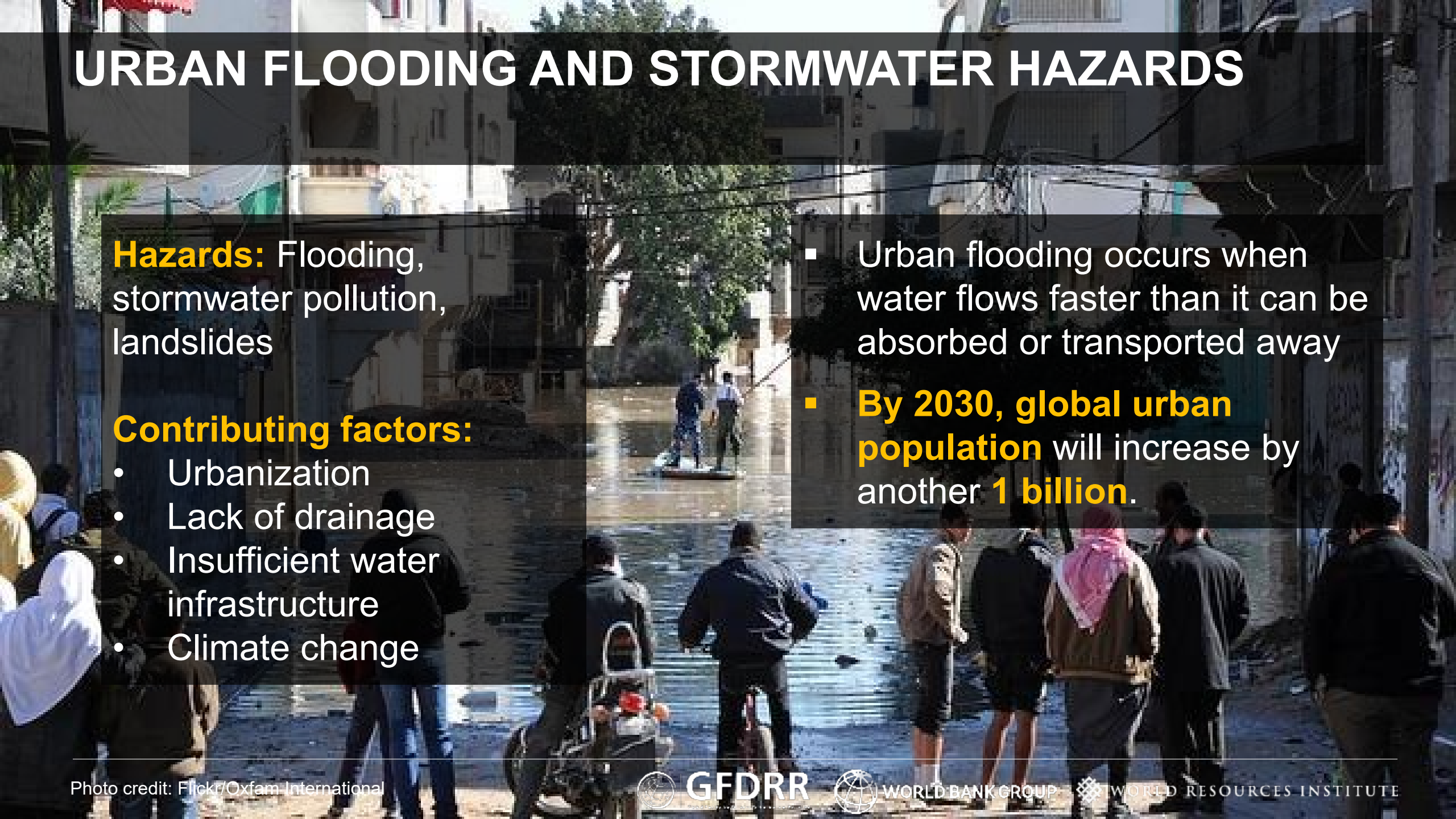

Photo credit: Flickr/Oxfam International

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NBS FOR URBAN FLOODING AND STORMWATER HAZARDS

The solutions:

- Open spaces
- Constructed wetlands
- Bioretention areas
- Green roofs
- Permeable pavement

Photo credit: Flickr/NACTO

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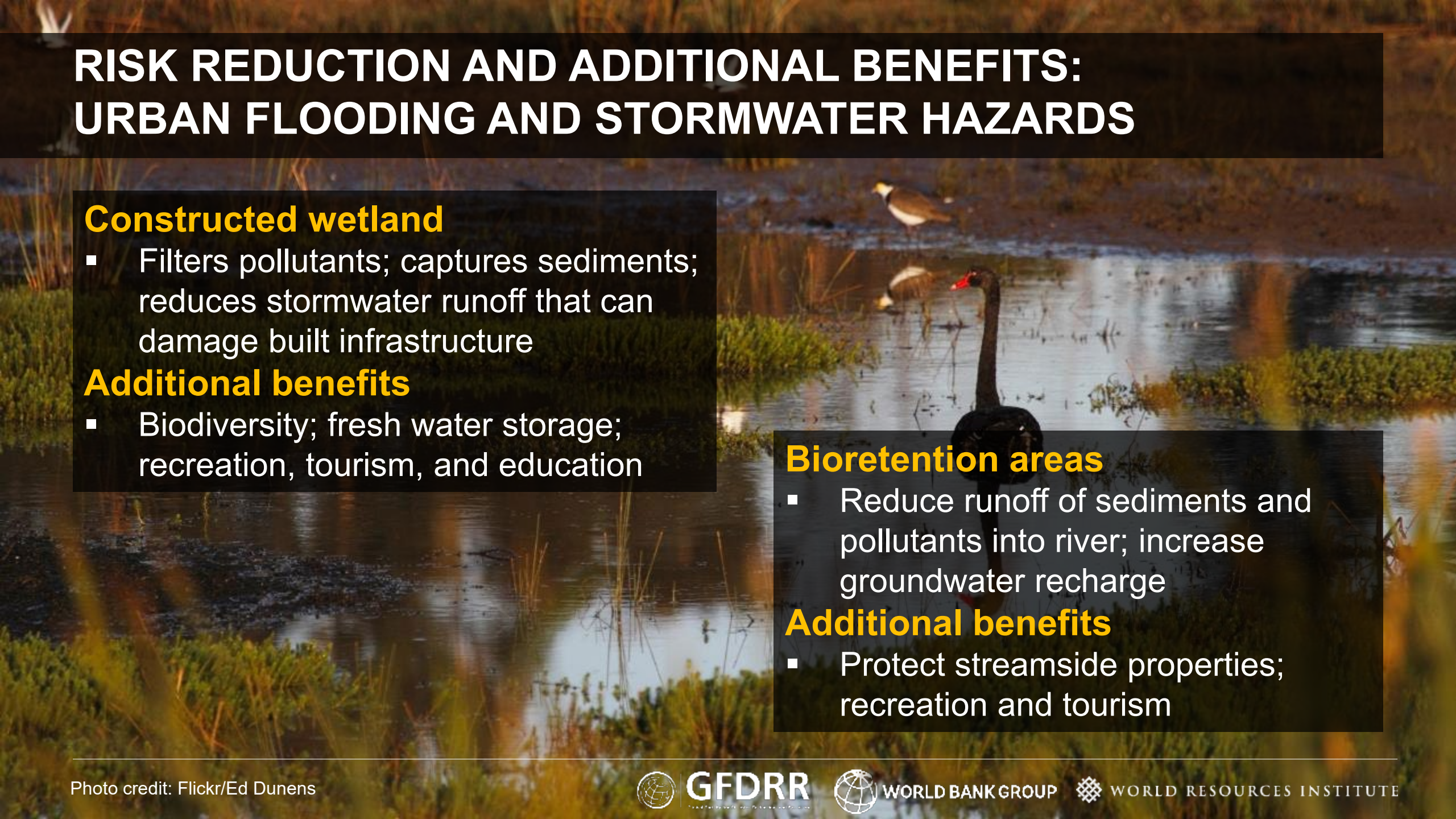
RISK REDUCTION AND ADDITIONAL BENEFITS: URBAN FLOODING AND STORMWATER HAZARDS



Constructed wetland

- Filters pollutants; captures sediments; reduces stormwater runoff that can damage built infrastructure

Additional benefits

- Biodiversity; fresh water storage; recreation, tourism, and education

Bioretention areas

- Reduce runoff of sediments and pollutants into river; increase groundwater recharge

Additional benefits

- Protect streamside properties; recreation and tourism

Photo credit: Flickr/Ed Dunens

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URBAN FLOOD MANAGEMENT WITH GREEN ROOFS IN SHANGHAI, CHINA

- Problem: **Poor wastewater management**
- Solution: Small-scale, decentralized **wetland system** for pollutant removal
- Lesson: **Community support essential** for low cost construction and maintenance
- Only **$290/year** to treat **80 households' worth of wastewater**

Photo credit: Flickr/kafka4prez

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HAZARDS OF RIVERINE FLOODING

Riverine flood hazards:
infrastructure and property damage, ecosystem disruption, water contamination

Contributing factors:
- Agricultural activity
- Residential encroachment
- Weak water infrastructure
- Climate change

- **Floodplains** are relatively flat lands adjacent to rivers or streams that are prone to flooding
- Floodplains are home to some **9.6 million households** in the US

Photo credit: Flickr/US Army Corps of Engineers

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NBS FOR RIVERINE FLOODING

The solutions:

- Floodplains and bypasses
- Inland wetlands
- River beds and banks
- Upland forests

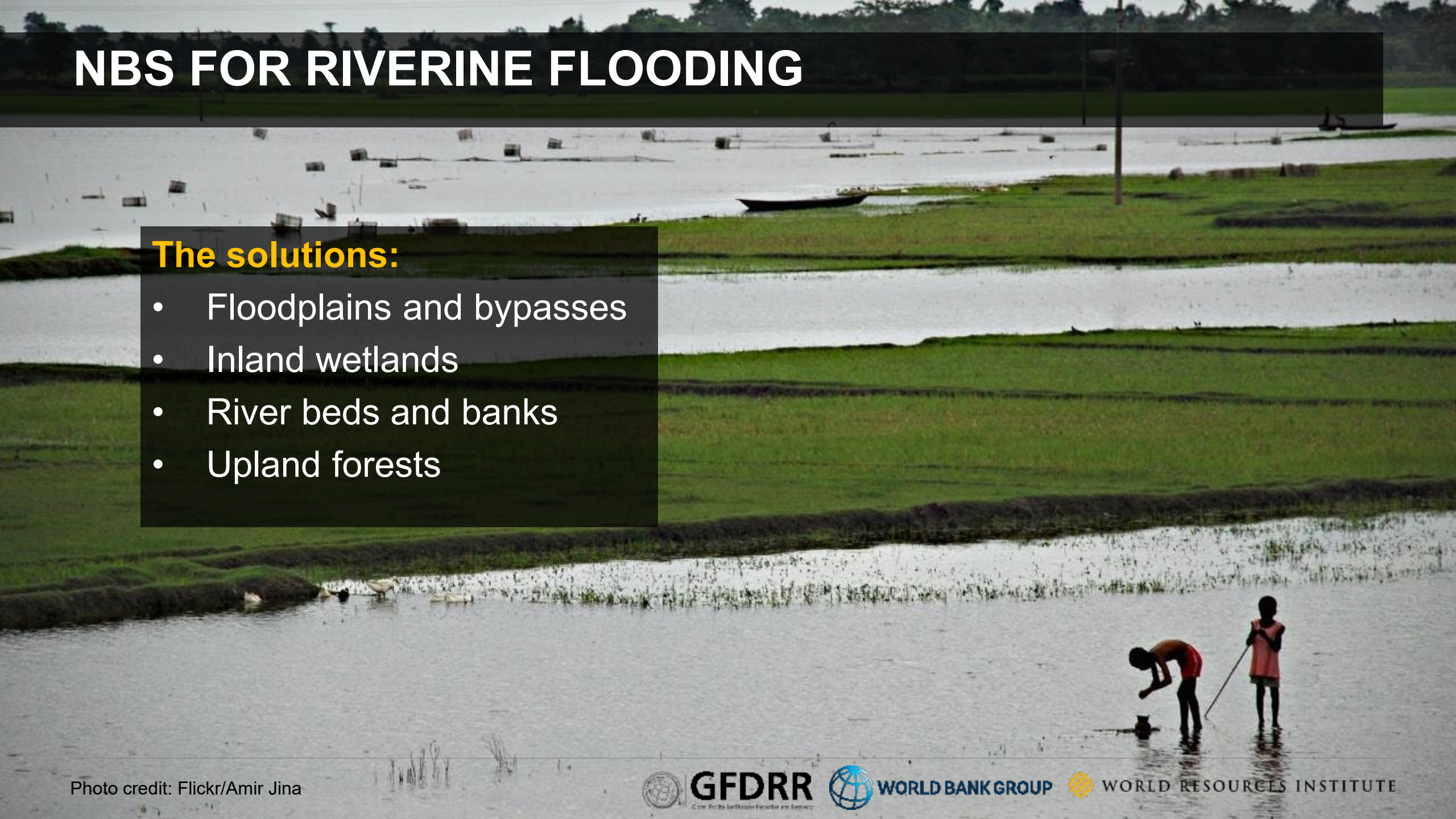

Photo credit: Flickr/Amir Jina

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RISK REDUCTION AND ADDITIONAL BENEFITS: RIVERINE FLOODING

River beds and banks

- Long-term flood risk reduction by restoring natural riverine processes (meandering, sedimentation, etc.)

Additional benefits

- Erosion control; fisheries; recreation and tourism

Floodplains and bypasses

- Significant water storage; flood risk reduction; water quality maintenance

Additional benefits

- Productive agriculture and fisheries; groundwater recharge; biodiversity

Photo credit: Flickr/South Florida Water Management District

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DISASTER RISK MANAGEMENT IN CURITIBA, BRAZIL
RECLAIMING THE IGUAZU FLOODPLAIN

- Problem: Urbanization and poor infrastructure led to a **six-fold increase in flooding**
- Solution: Integrated **floodplain reconnection and wetland restoration** into flood management systems

Benefits:

- **Mitigate flood damages**
- **Improve water quality**
- **Enhance public recreation**

Photo credit: Wikipedia/Francisco Anzola; Wikipedia/Ricardo Freitas

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ROOM FOR THE RIVER, THE NETHERLANDS

- Problem: Higher dikes no longer sufficient due to **climate change**
- Solution: New island and **river park**

- **US$ 460 million** to push dikes 350 m inland
- **Local participation and compensation** – essential to move forward with house demolitions

Photo credit: YouTube/GroeneSteden; Wikipedia/Roger Veringmeier

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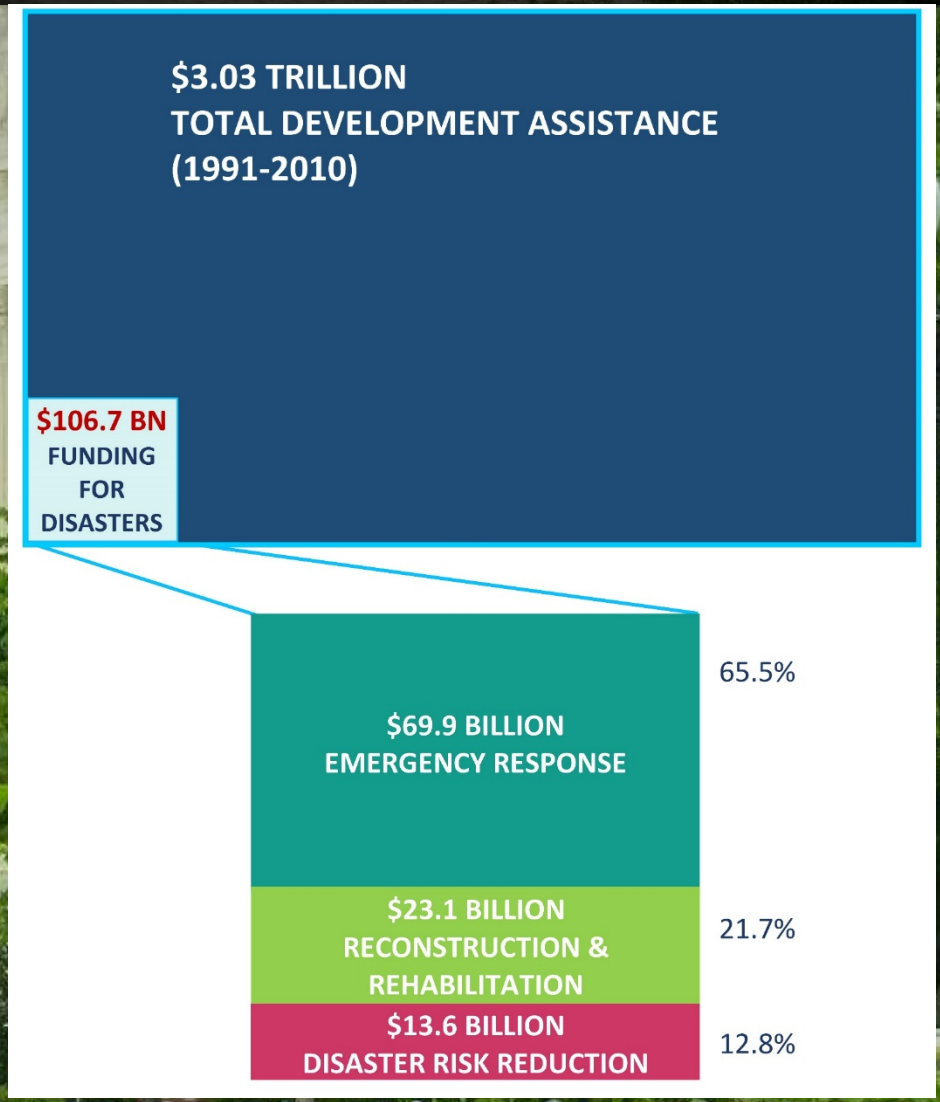
SOURCES OF FUNDING FOR NBS

Majority of funds from **public sources** (governments, international development agencies, etc.)

Philanthropic funds are important for shorter-term seed funding to support pilot projects that help promote NBS

NBS can **attract diverse base of investors** interested in different project benefits



Graphic: Kellett and Caravani 2013;
Photo credit: Flickr/Reinhard Link

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TRADITIONAL FINANCING STRATEGIES

Public sector sources:

- Taxes

Policy to raise funds for NBS:

- Water use fees
- Municipal bonds
- Environmental compensation funds

Philanthropic sources:

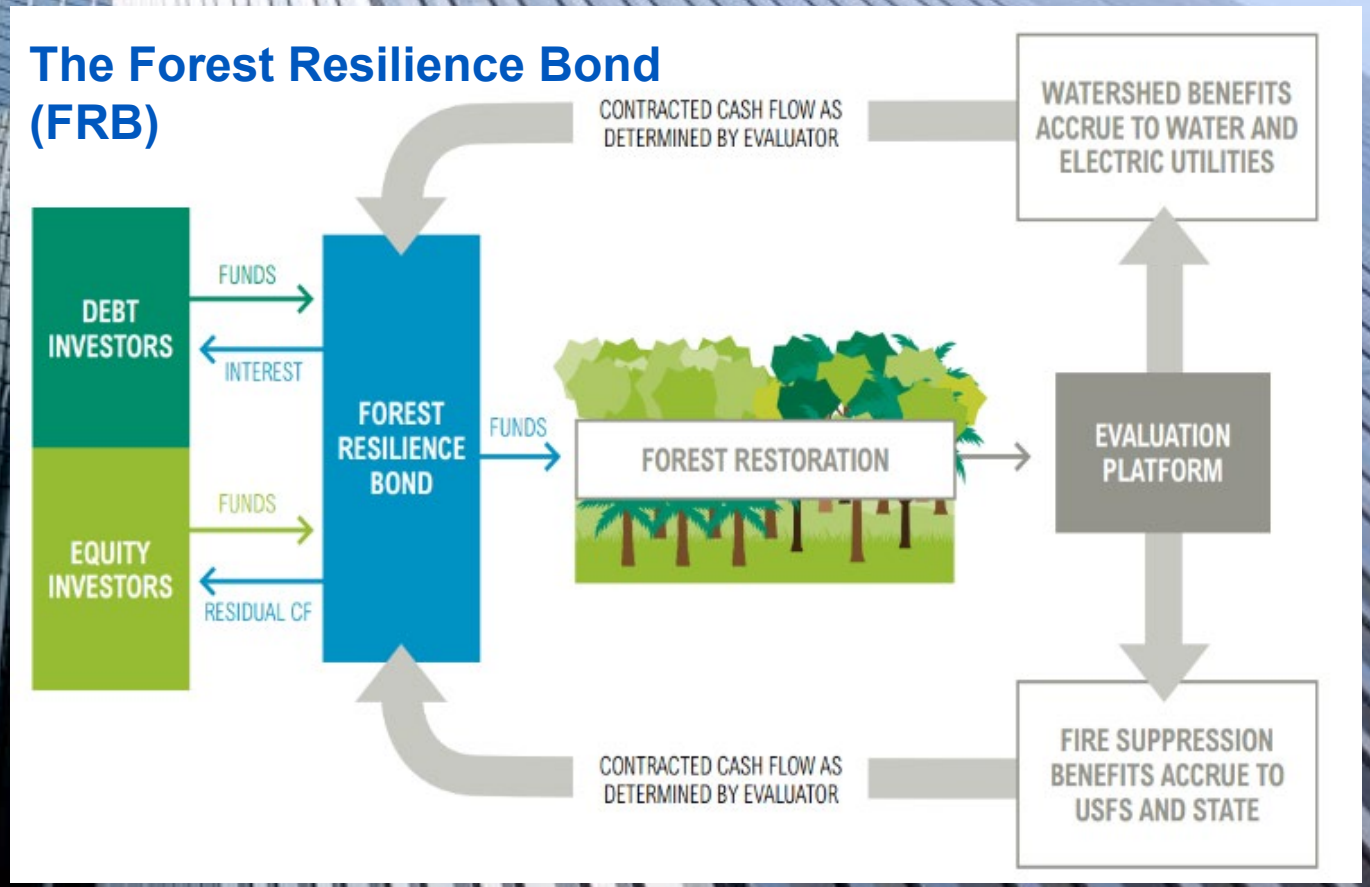
- Grants and donations
- Program-related investments

Photo credit: Flickr/S.L.

EMERGING FINANCING STRATEGIES

- Green bonds
- Pay-for-success
- Corporate stewardship
- Water Fund
- Insurance for risk reduction
- Public-private partnerships

Ex. Forest Resilience Bond
Investors pay upfront restoration costs for forest fire mitigation and water benefits. Beneficiaries pay FRB based on verified metrics.



Graphic: BFC 2017; Photo credit: Flickr/Alex Blanck

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CHANGING POLICY TO SUPPORT NBS

- Implement **environmental monitoring** and **sustainable land use planning**
- Engage **all stakeholders**
- Facilitate **cross-sector coordination**
- Behavioral change through **knowledge sharing**
- Encourage **supportive policy signals**

Photo credit: Flickr/WRI

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WASHINGTON, D.C., USA FINANCING URBAN GREEN INFRASTRUCTURE

- Problem: **2 billion gallons of sewage and stormwater** discharged into local waterways annually.
- One-third of DC's wastewater runs through a **single-pipe system built over 100 yrs ago**.
- Solution: **US$100 million** invested in bioretention areas, rain gardens, permeable pavement, and downspout reconnection.
- Financed by **environmental impact bond** (tax-exempt municipal bond) with **"pay for success"** payment model.

Photo credit: Flickr/Kghopkin; Flickr/Y Nakanishi; Flickr/EX22218 - ON/OFF

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IMPLEMENTATION OF NBS

Eight Steps To Guide Implementation

1. Problem, scope and objective
2. Financing strategy
3. Ecosystem and hazard assessments
4. Nature-based risk management strategy
5. Costs, benefits and effectiveness
6. Design the intervention
7. Implement and construct
8. Monitor and inform future practices

Photo credit: Flickr/thisisexcellent

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NBS IMPLEMENTATION CHALLENGES

Need to better understand:

- Risk reduction performance of NBS
- DRM-related benefits from local community to national levels
- Technical guidelines for NBS evaluation
- Integration of NBS with gray solutions
- Cost-benefit analysis

Photo credit: Wikipedia/Biplob Rahman-BD

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IMPLEMENTATION GUIDANCE BY THE WORLD BANK

Recent publications on NBS implementation

- Implementing Nature-based Flood Protection: Principles and Implementation Guidance (2017)
- The Role of Green Infrastructure Solutions in Urban Flood Risk Management (2016)
- Managing Coasts with Natural Solutions: Guidelines for Measuring and Valuing the Coastal Protection Services of Mangroves and Coral Reefs (2016)
- Mainstreaming Nature-based Infrastructure into the Development Agenda (WB and WRI. In Review)

Photo credit: Flickr/Penn State

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HOW NBS COMPLIES WITH THE WORLD BANK'S CORE MANDATES

- Twin goals: Reduce poverty, increase shared prosperity
- Climate Action Plan (2016)
- Environmental and Social Framework (ESF)

Photo credit: Wikipedia/Diego Delso

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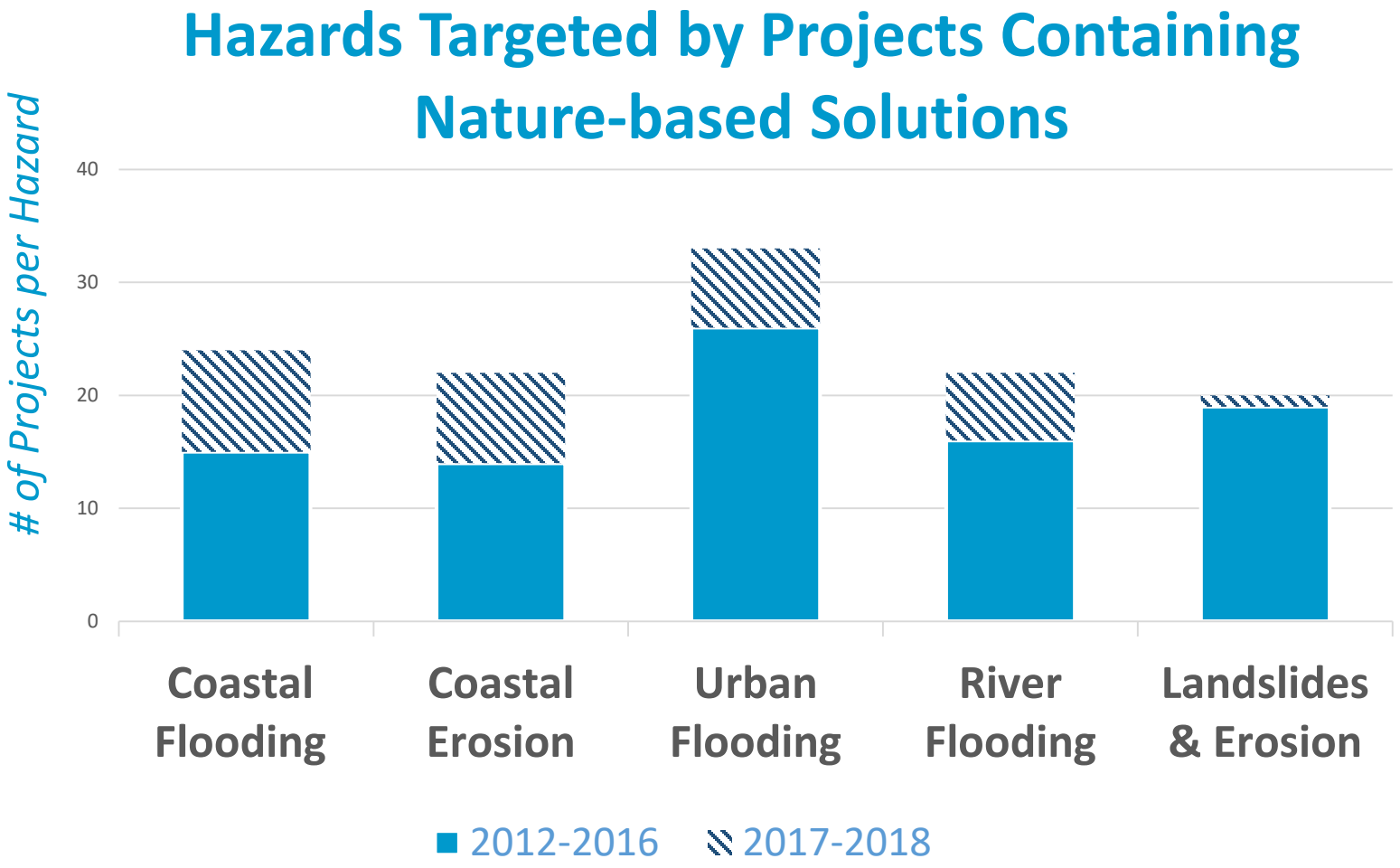
WORLD BANK PROJECTS WITH NBS COMPONENTS



76 DRM projects with NBS components have been approved for implementation since 2012

Coastal hazards (flooding and erosion) comprise the most # of projects

Source: World Bank

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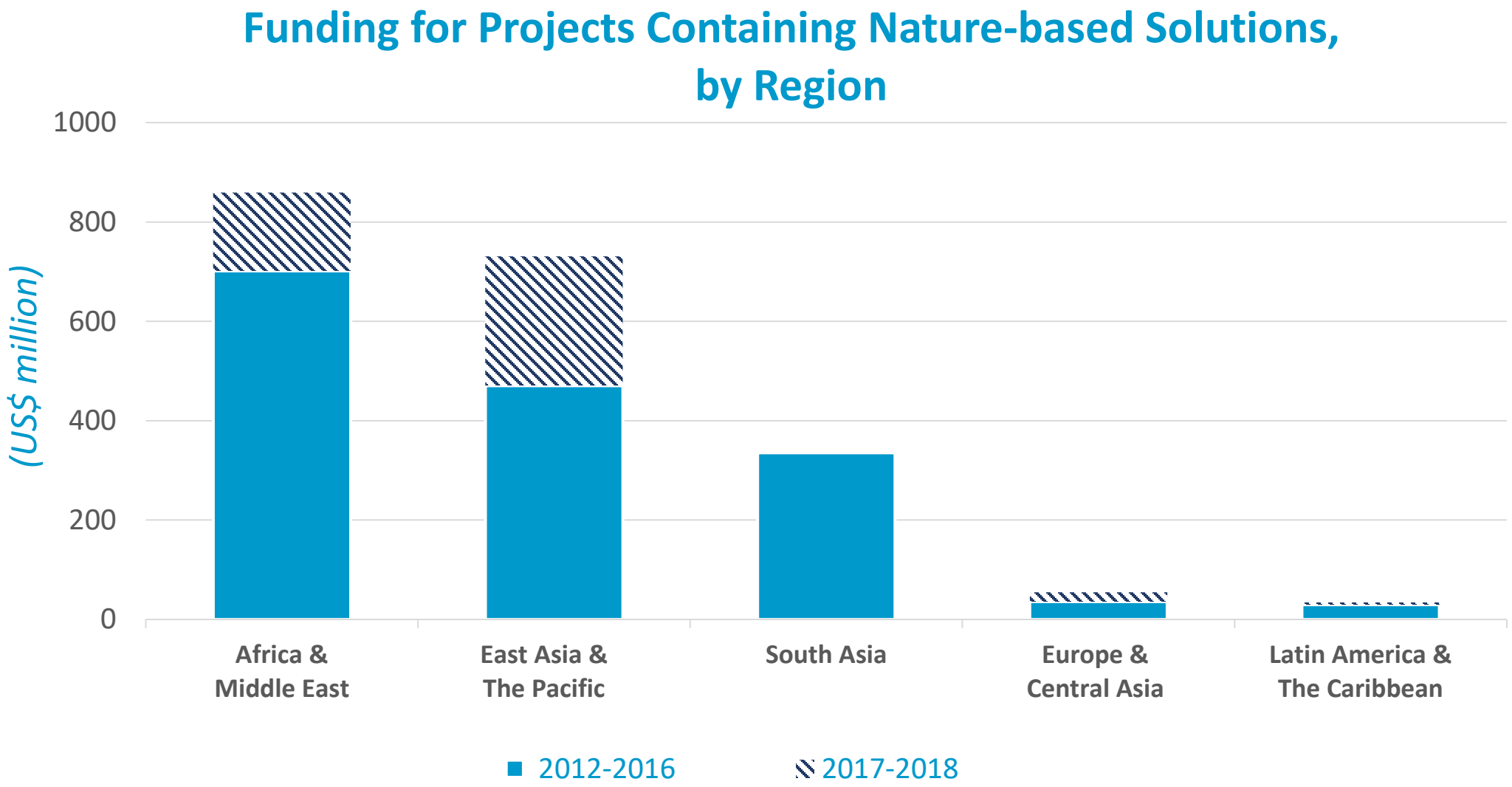
WORLD BANK PROJECTS WITH NBS COMPONENTS



Source: World Bank

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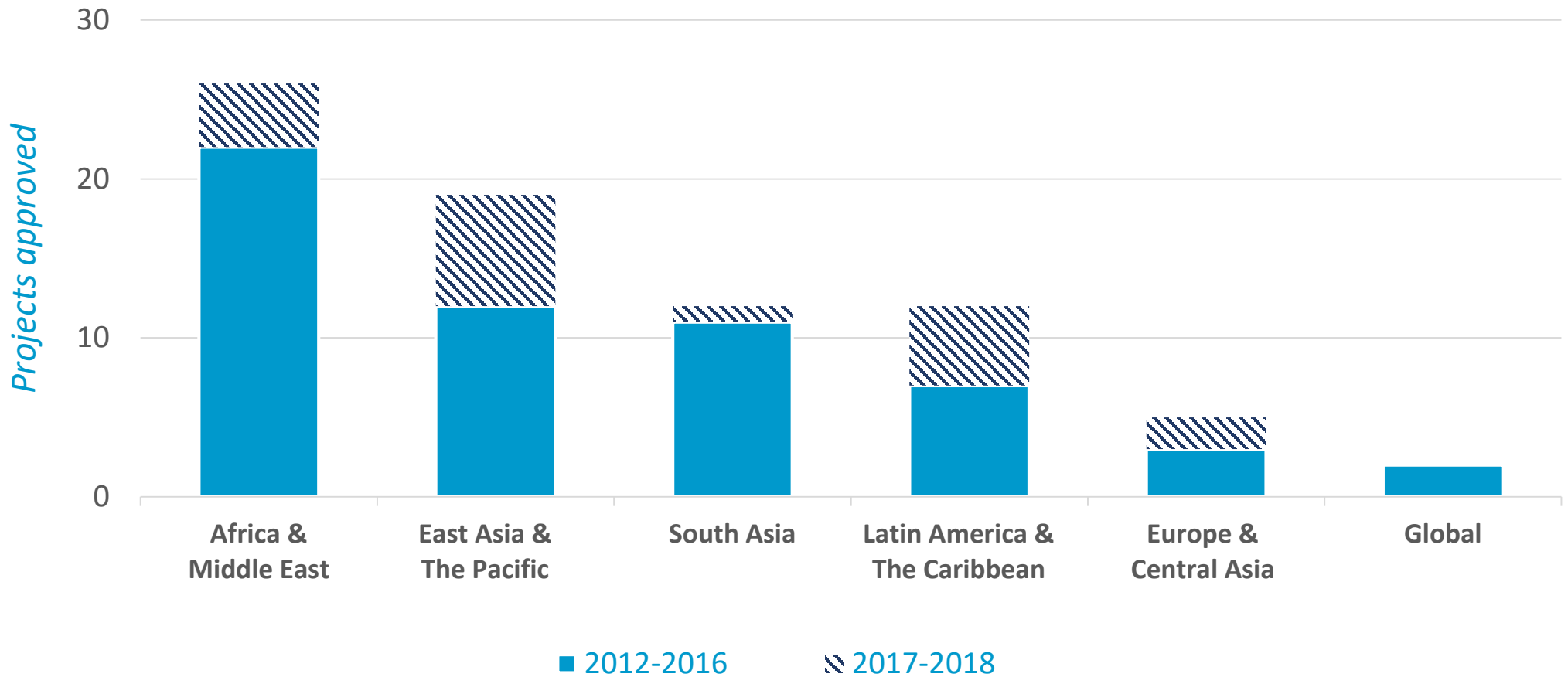
WORLD BANK PROJECTS WITH NBS COMPONENTS

Projects Containing Nature-based Solutions by Region



Source: World Bank

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WRAP UP AND HOW TO GET STARTED

Understand local site context

- Biophysical traits and compatibility with hazard reduction target
- Social, policy, and financial conditions
- Potential for co-benefits
- Variability in levels of performance

TO SUCCESSFULLY

- **Leverage regenerative and adaptive traits of NBS** for resilience
- **Understand spatial and time scales** to maximize benefits
- **Integrate** with current and future built infrastructure
- **Inform** implementation, management, and evaluation plans

Photo credit: Flickr/PNUD Panama

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THANK YOU

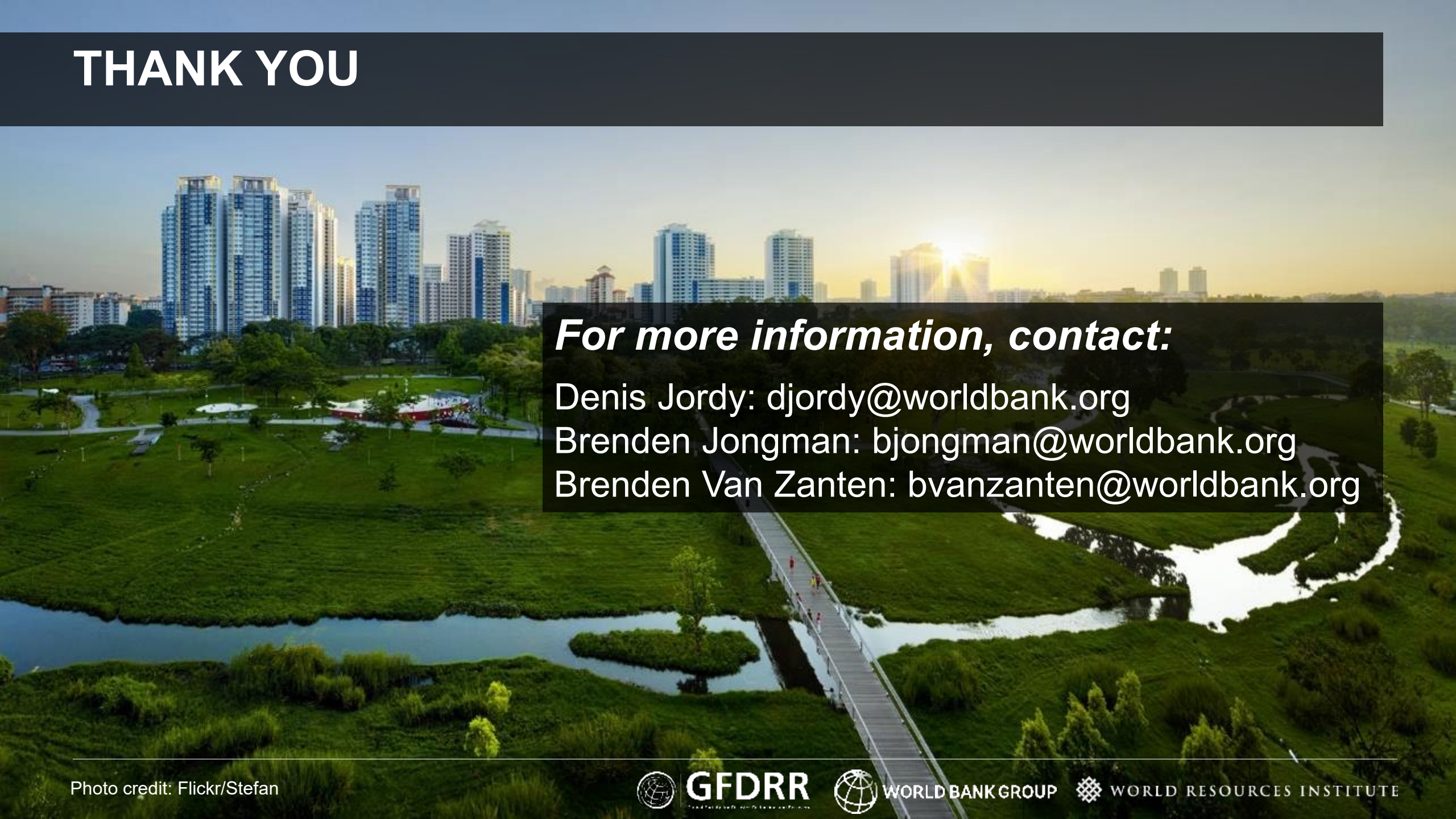

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Photo credit: Flickr/Stefan

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