Some lessons of the transboundary assessment of river basins climate change vulnerability and the development of a joint adaptation strategy: the Dniester River case study

Некоторые уроки трансграничной оценки уязвимости к изменению климата речного бассейна и выработка единой стратегии адаптации на примере Днестра

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The Dniester River: *Geographical location*

The river length – about 1350 km, transboundary part – 200 km; basin area – 72,100 km²

To the history of the research

The reported results were received in 2010-2013 in the framework of the joint Moldova-Ukraine project:

"Reducing vulnerability to extreme floods and climate change in the Dniester River Basin"

This project was one of pilot projects in the well-known program on adaptation to climate change in transboundary basins, realized under the UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention).

Main goals of the project:

1. ***To mitigate climate change risks in the Dniester basin, especially from floods, by reducing the vulnerability to them in both countries***
2. ***To expand and strengthen joint management of the Dniester's water resources in confronting the current and expected climatic impacts on its watershed***

The main challenges in project tasks resolving

- ***Uncertainties in estimations of likely changes in future climate of the basin and in the river hydrology, primarily in the transboundary aspect, caused by differences in national approaches to the assessments***
- ***Lack of a clear understanding of the concept of vulnerability to climate change in the river basin***
- ***Management of the Dniester reservoirs in the interests of individual water users, primary to hydropower ones, that leads to serious damages in the downstream natural and social systems***

Example 1. Differences in the sources and scenarios used for regional climate projections before the project

Ukraine		Moldova	
GCM	**Emissions**	**GCM**	**Emissions**
BCCR-BCM2.0	***SRES***	CGCM2	***SRES***
NCAR-CCSM3	***A1B***	CSIRO Mk2	***A2***
CGCM3.1 (T47)	***A2***	HadCM3	***B2***
CGCM3.1 (T63)	***B1***	ECHAM4	
ECHAM5/MPI-OM		GFDL R-30	
GFDL-CM2.1		CCSR-NIES	
MIROC3.2 (hires)		CGCM2	
MIROC3.2 (medres)			
MRI-CGCM2.3.2			
UKMO-HadGEM1			
BCCR-BCM2.0			

Example 2: Ensemble mean projections of change in key climatic variables

Moldova					Ukraine				
Years	Temperature, °C		Precipitation, mm		*Years*	Temperature, °C		Precipitation, %	
	A2	*B2*	*A2*	*B2*		*A2*	*B1*	*A2*	*B1*
Baseline period : 1961-1990					***Baseline period: 1961-1990***				
2020	1.7	2.0	-9	-17	**2010**	0.2	0.3	3.7	2.0
					2020	0.4	0.7	1.2	0.8
					2030	0.7	0.9	0.5	0.0
2050	3.4	3.2	-38	-11	**2040**	1.2	1.1	1.6	-0.3
					2050	1.7	1.4	1.1	2.2
					2060	2.2	1.7	1.8	2.3

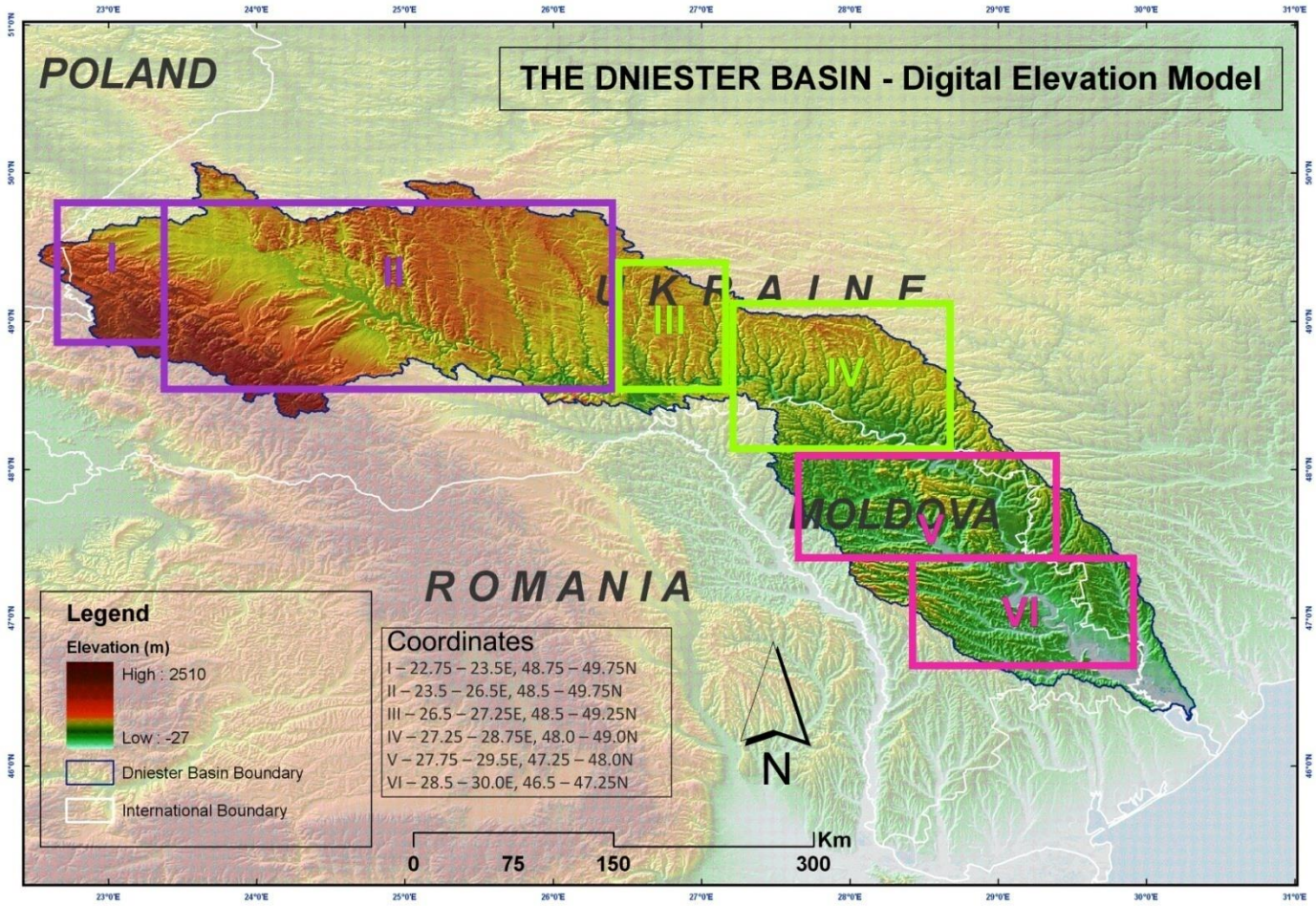
Example 3: Projections of relative change of the Dniester streamflow

Moldovaa			Ukraine
Scenarios of emission	***Time horizon***	***Change, %***	***General streamflow will change:*** **by 5-7% in the North; by 15-30% in the South of the basin**
SRES A2	2020s	-10	
	2050s	-22.8	
	2080s	-36.5	
SRES B2	2020s	-12.9	
	2050s	-18.4	
	2080s	-24.5	

The first step in the project activities was:

To transit to the transboundary approach in the development of scenarios of likely climate change and the Dniester streamflow

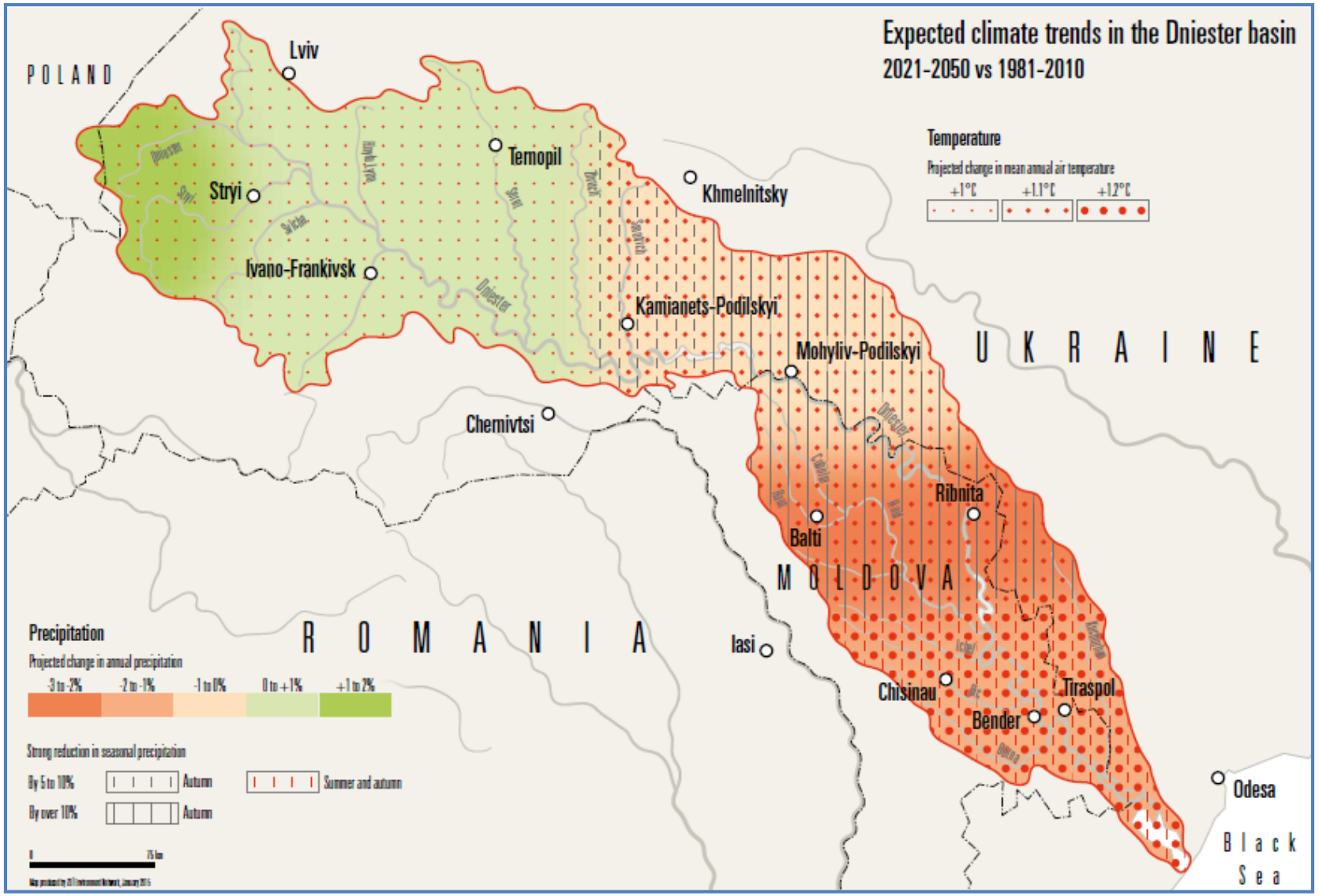
The breakdown of the Dniester Basin into individual reaches of climate change modeling



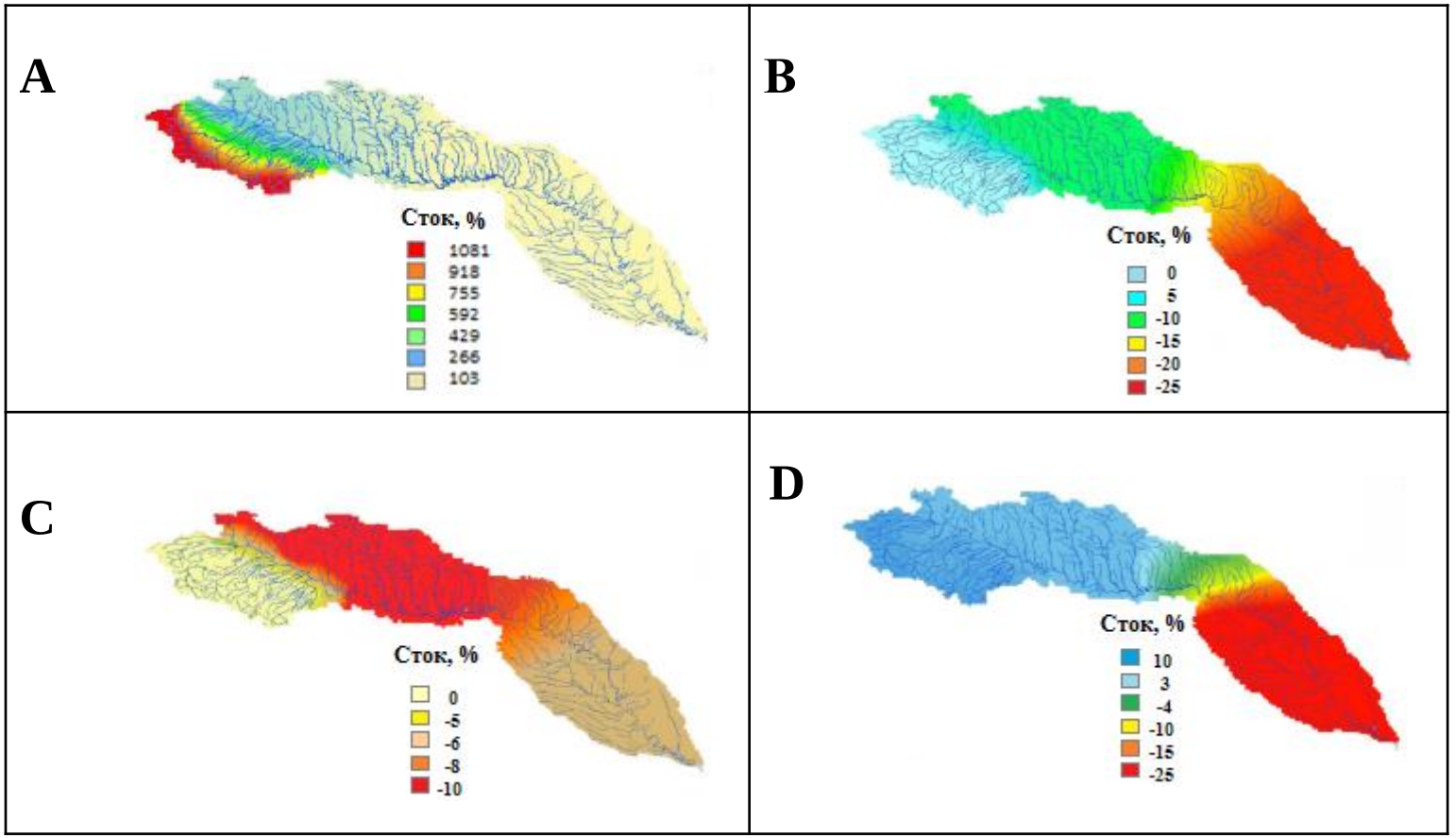
Projections of air temperature *(above)* and precipitation *(below)* change in the Dniester basin in 2021-2050 compared to 1971-2000 *(REMO RCM)*

	Basin as a whole	Upper	Middle	Lower
Year as a whole	+1,1°C +0,2%	+1,0°C +1,0…1,8%	+1,1°C -0,9%	+1,2°C -2,8…-1,7%
Winter	+1,2°C +9%	+1,1°C +10%	+1,2°C +6…+7%	+1,2°C +8…+11%
Spring	+0,7°C -0,6%	+0,7°C +0…1,5%	+0,7°C -1%	+0,8°C -3%
Summer	+1,0°C -1,0%	+1,0°C -1%	+1,0°C -1…-0,2%	+1,2°C -7…-4%
Autumn	+1,3°C -5,0%	+1,3°C -2,8…-1,5%	+1,3°C -10…-7%	+1,4°C -11…-6%

Spatial distribution of likely change in air temperature and precipitation in 2021-2050 vs. 1981-2010

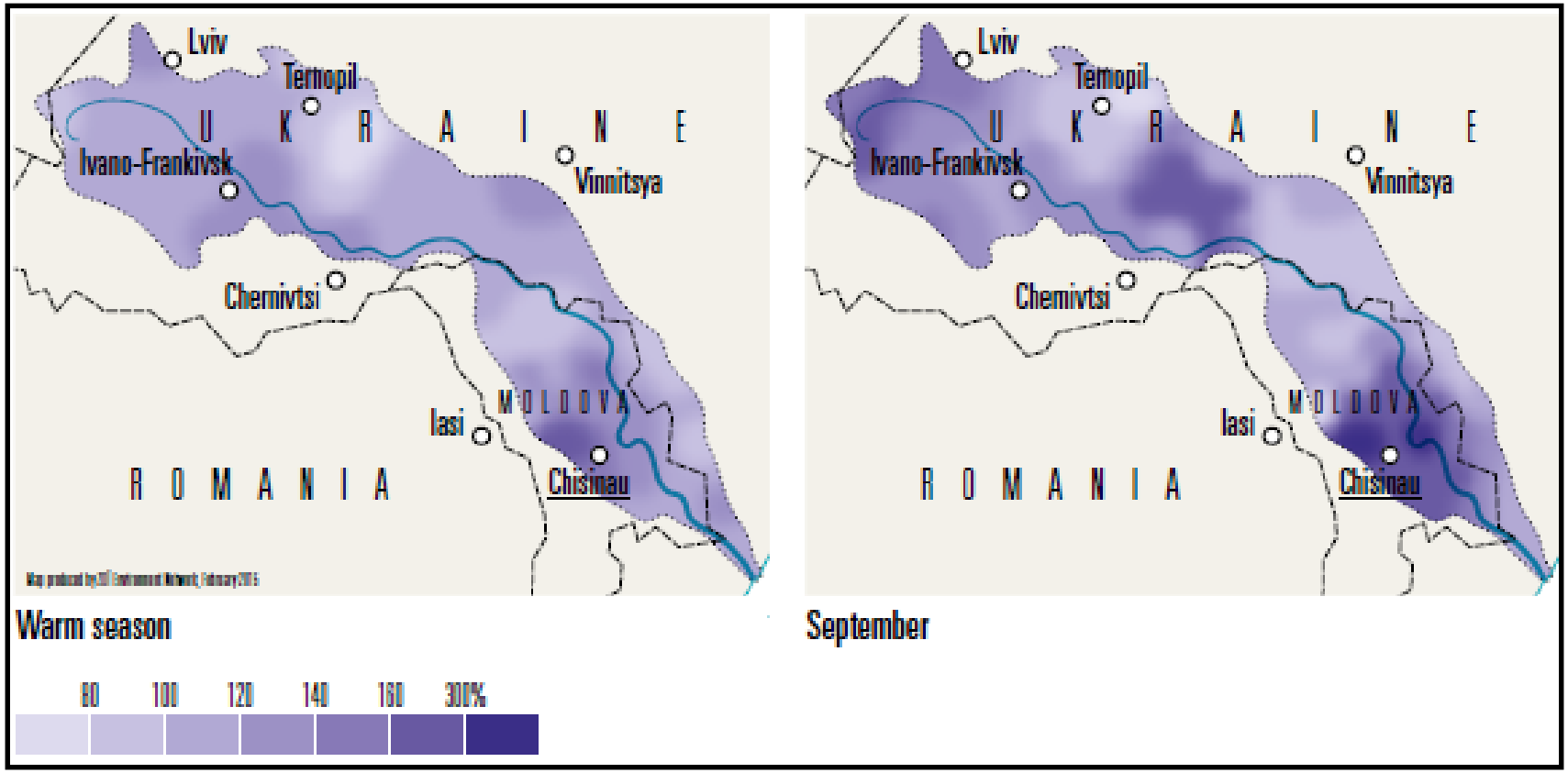


Dniester mean annual streamflow in 1971-2000 *(A)* and expected changes of its mean *(B)*, maximal *(C)* and minimum (*D)* values by the middle of the century



Projected changes in mean flood intensity in the Dniester basin

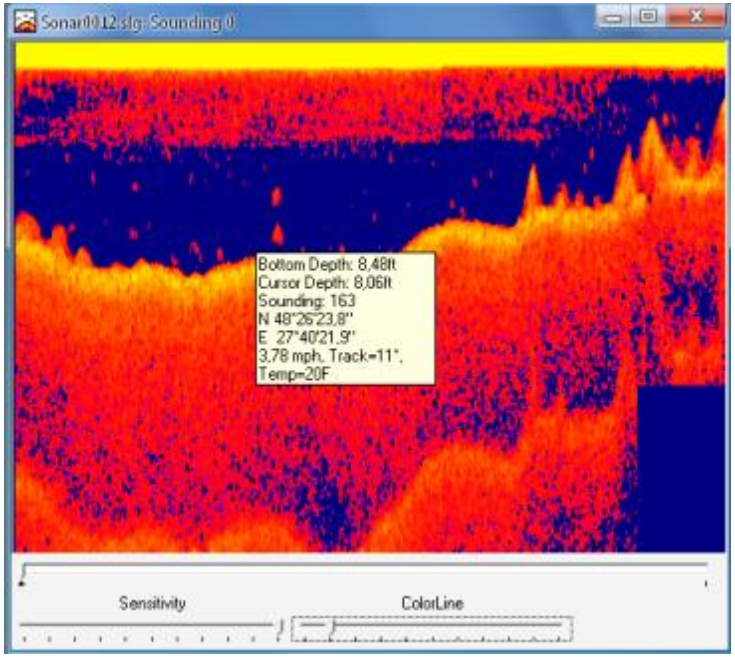
2021-2050 vs. 1971-2000



Transboundary approach to the floods risk assessment

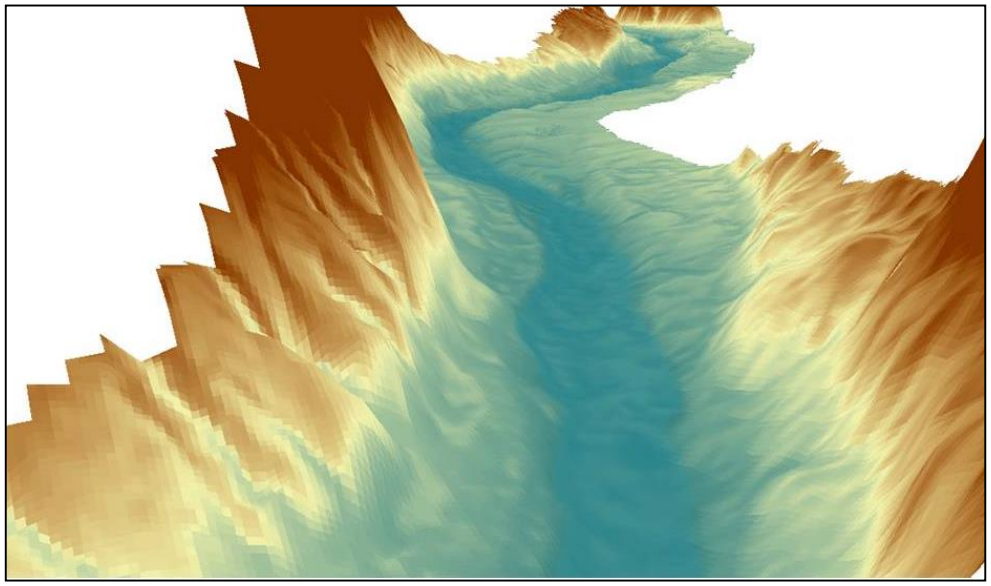
- ***Engineering modelling***
- ***Field works on the assessment of the state of flood protection***

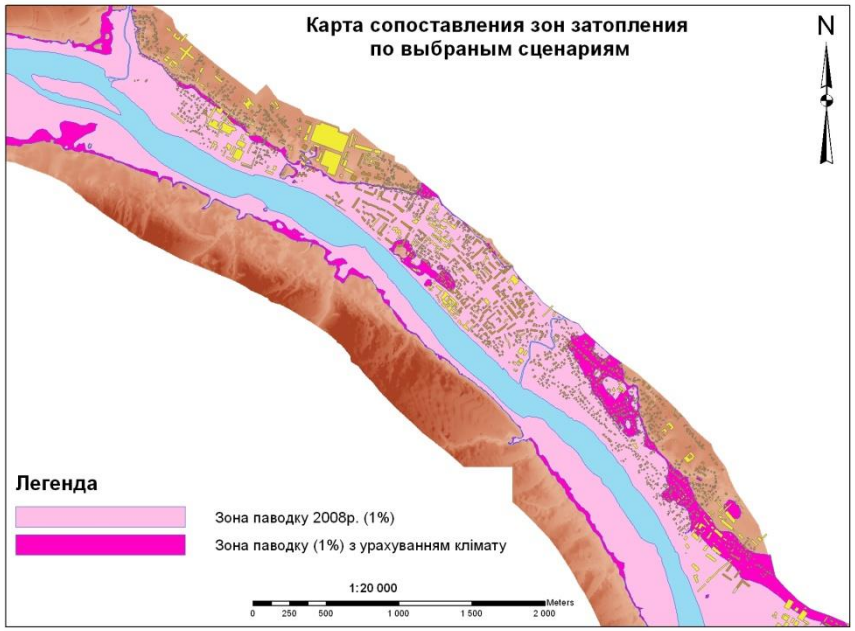
Engineering studies on the Dniester's reach Mogilev-Podolsky – Attacy (16 km)



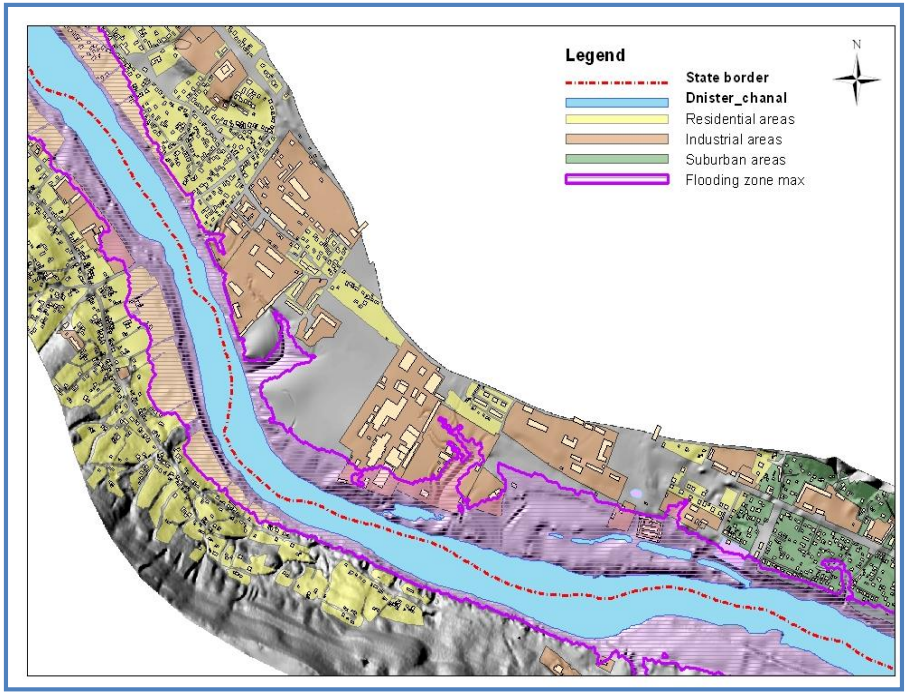
Hydro acoustics of the river channel

GIS-based cross-sections of the river channel





GIS mapping of the zones of 1% flooding for current and expected streamflow



Spatial analysis of flooding zones

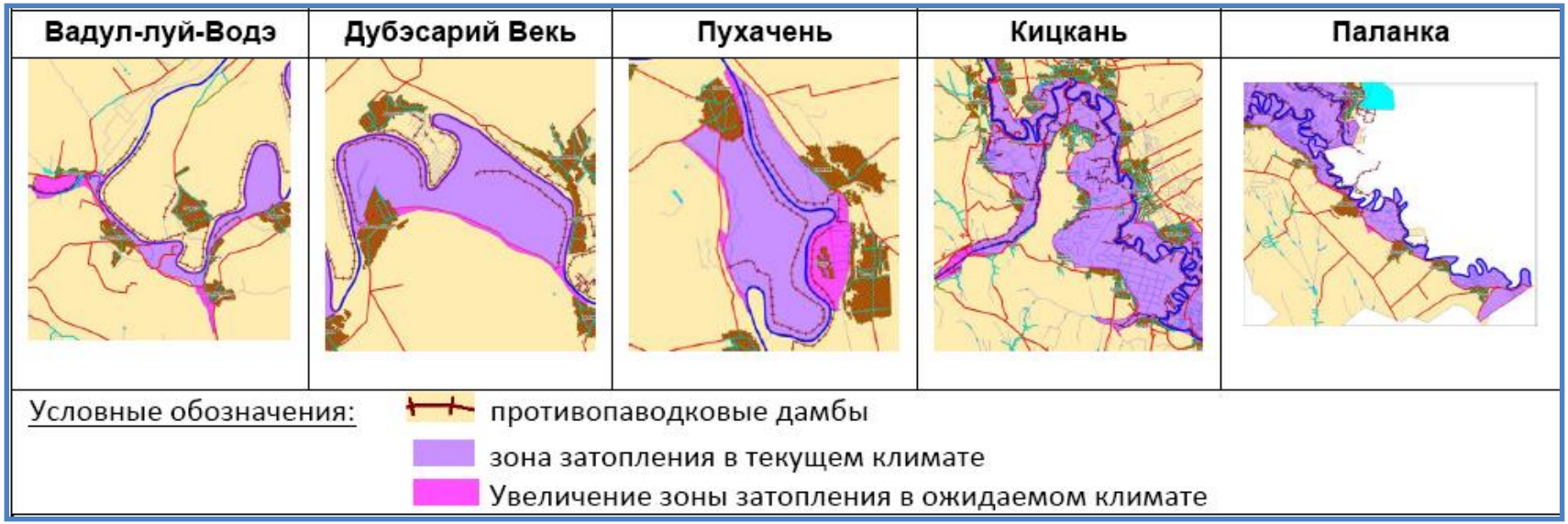
Flooded objects	
Living sector	19%
Industry sector	28%
Subborns	14%

Results of modeling

Створ	Удаление от Дубоссарской ГЭС, км	Берег Днестра	Ширина зоны 1 м затопления позади дамбы за весь период наводнения, км		
			Сценарий наводнения		
			2008 г	1%-е историче-ского климата	1%-е ожидае-мого климата
	128		7.14	15.59	19.89
Бычок-Парканы	129		11.39	22.02	27.06
	130	*Левый берег*	6.55	14.54	18.63
	131		1.19	4.63	6.83
	132			0.22	0.77
Варница-порт	133			0.00	0.00
	134			0.00	0.02
	135		0.05	1.22	2.35
	136	*Правый берег*	1.71	5.76	8.19
Бендеры 1	137		6.08	13.68	17.59
	138		3.52	9.29	12.45
	139		0.62	3.14	4.91

1-D modeling of extreme floods on the Lower Dniester

Areas of the maximum risk of flooding



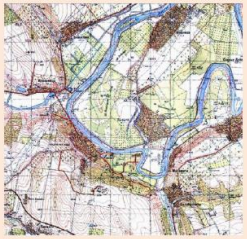
Examples of flood areas description

Участок 5 *Вадул-луй-Водэ*

Участок расположен в 23 км ниже Дубоссарского водохранилища. Ожидаемая зона затопления расположена на правом берегу Днестра, охватывая 5 населенных пунктов – *Кошерница, Вадул-луй Водэ, Бэлэбэнешть, Мэлэешть, Коржова*. Общая длина затопляемой зоны при Сценарии 1 составляет 18 км, максимальная ширина – 3 км. По Сценарию 2 размеры увеличиваются на 20%.

Космический снимок

Зона отдыха Ваду-луй-Водэ, исключающая защиту в виде заградительных дамб. Защита от наводнений и паводков обеспечивается адаптационными мероприятиями.

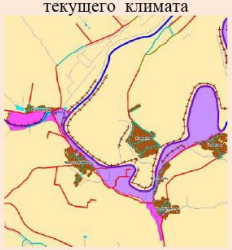


Топографическая карта масштаба 1:50 000

Высота подъема воды (светлая полоса) при наводнении 2008 г на удалении 200 м от меженного уреза воды

Зона 1%-го наводнения текущего климата

Новые коттеджи в зоне отдыха, построенные на сваях с учетом возможного наводнения (высота над уровнем земли 1,5-2,м)



Зона 1%-го наводнения ожидаемого климата

Участок 11 *Рэскэець – Тудора*

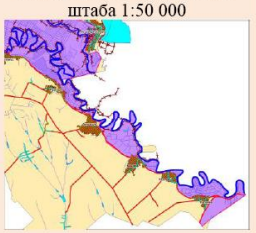
Участок расположен в 210 км ниже Дубоссарского водохранилища. Ожидаемая зона затопления расположена на правом берегу Днестра, охватывая 6 населенных пунктов – *Рэскэець, Пуркарь, Олэнешть, Крокмаз, Тудора, Паланка.* Общая длина затапливаемой зоны при Сценарии 1 составляет 87 км, максимальная ширина – 4 км. Прорыв левобережной дамбы в 2008 г привел к затоплению 15 тыс. га с.-х. угодий Украины. По Сценарию 2 размеры увеличиваются на 10 % и зона затопления соединится с Кицканской.

Космический снимок

Наращивание дамбы мешками с песком в 2008 г., т.к. она «расплылась» (не покрыта уплотняющим материалом). Необходим капитальный ремонт и наращивание до Олонешты.

Топографическая карта масштаба 1:50 000

Пример «индивидуальной» защиты от наводнения частного дома в 2008 г.



Зона 1%-го наводнения текущего климата

Приусадебный участок в паводкоопасной зоне. Экономически целесообразен вынос строений из зоны затопления и освобождение земель для заливных лугов и пастбищ

Зона 1%-го наводнения ожидаемого климата

Assessment of the Dniester basin general vulnerability to climate change

IPCC's new conception of vulnerability

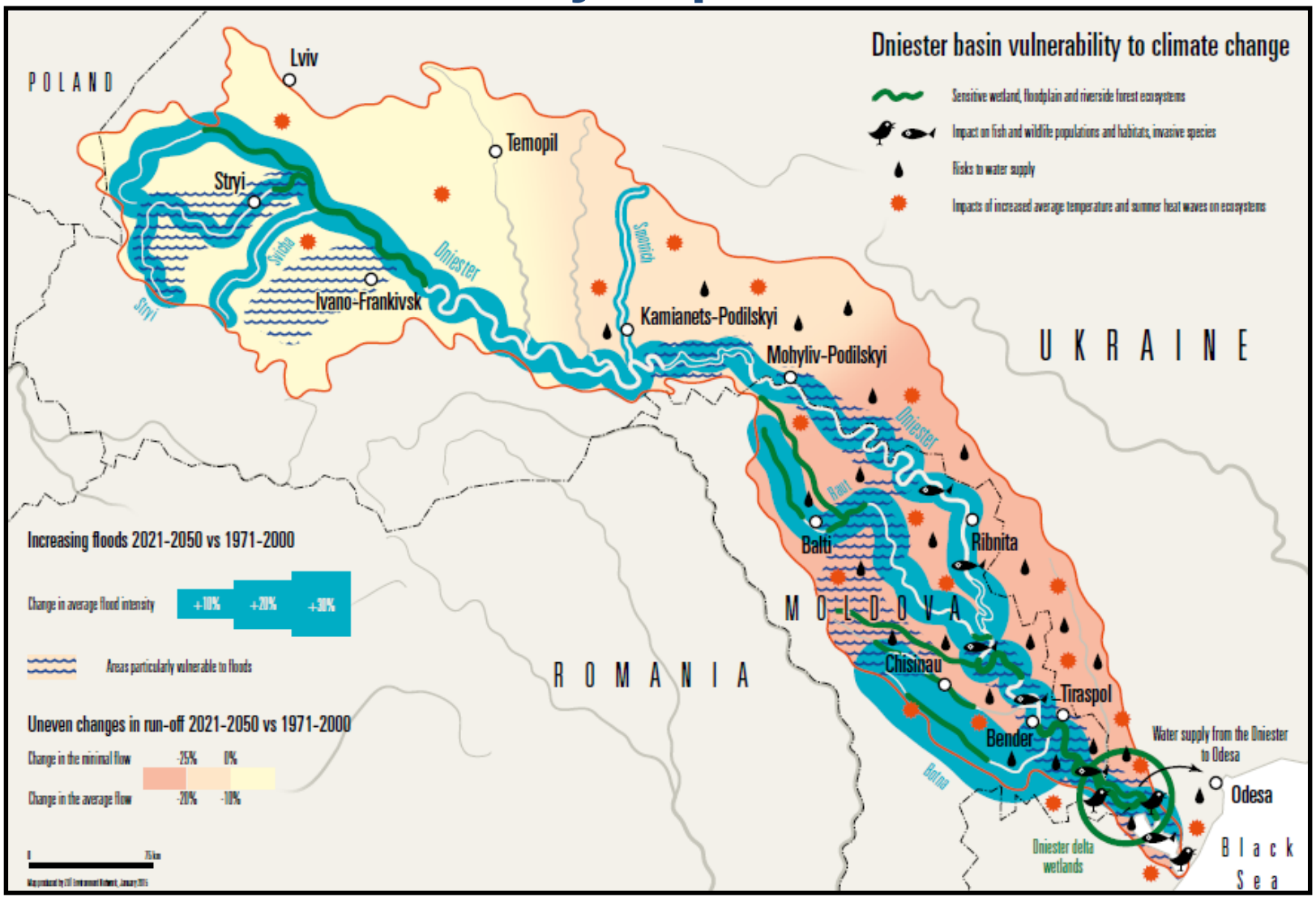
Vulnerability to climate change is *"The propensity or predisposition of a system to be adversely affected".*

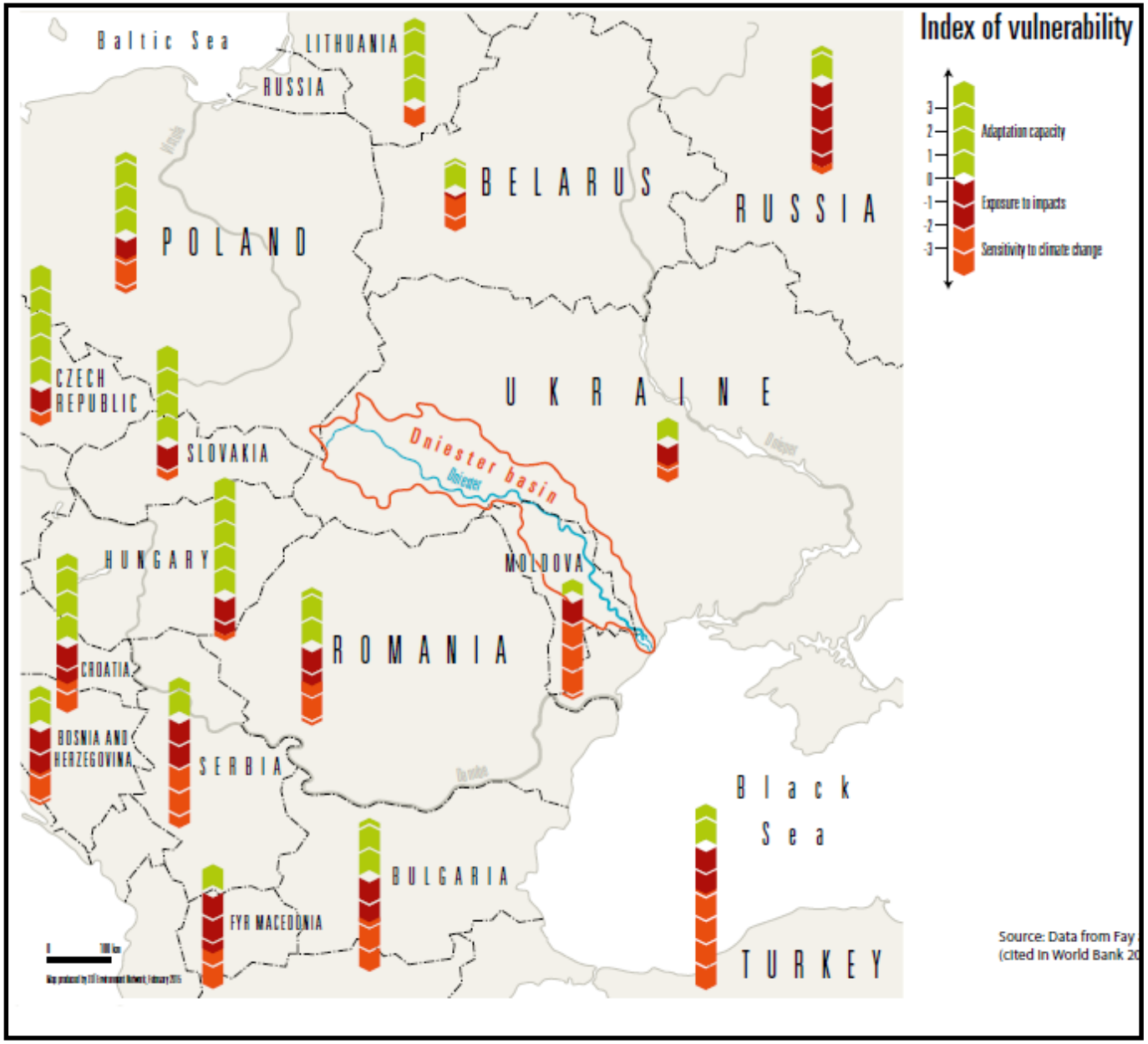
Here, predisposition is an internal characteristic of a person or system as well as the situation, in which they are located, to be affected.

Principal difference:

- ***the former definition:*** *the main causes of vulnerability are physical factors and their effects expressed as an exposure; the social context is expressed by sensitivity and adaptive potential.*
- ***new definition:*** *strengthening of a social component, independent from physical events. Different levels of vulnerability lead to different levels of damage in similar conditions of exposure to impacts.*

Dniester basin vulnerability to climate change as a function of likely impacts



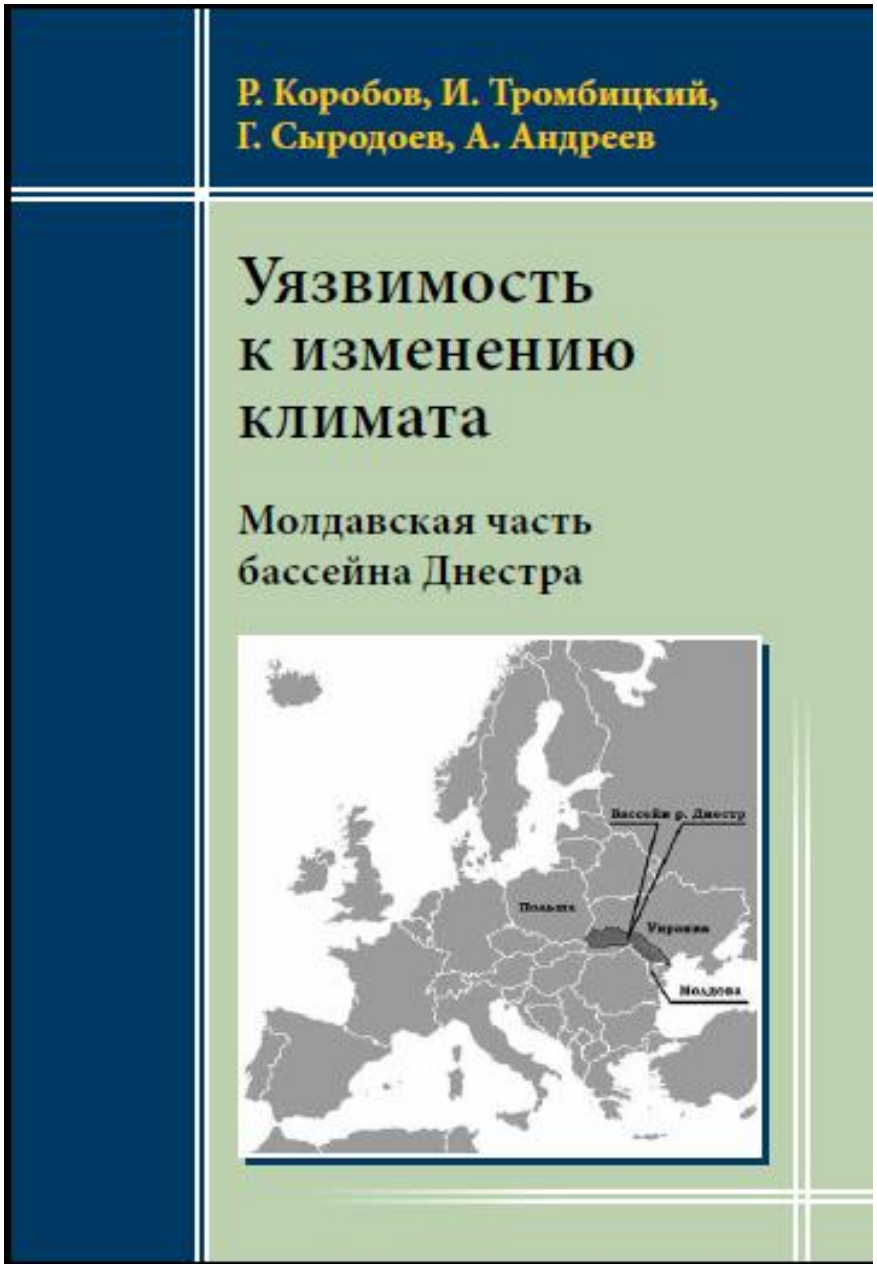


Vulnerability to climate change of Moldova and Ukraine on the pan-European background

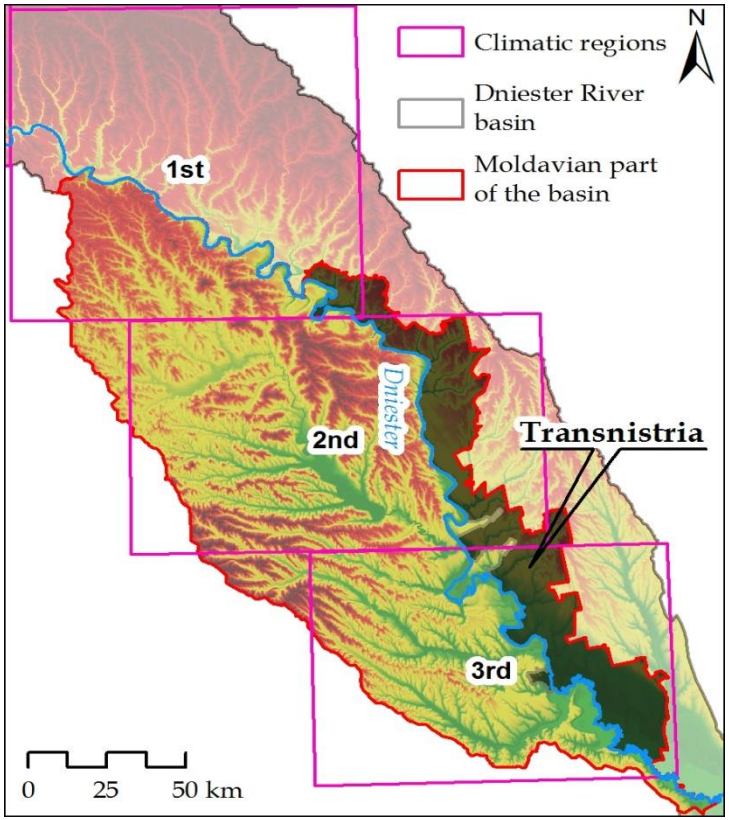
Practical conclusions:

- Avoiding a purely physical explanation of the climate risks formation and the attribution of their development and consequences
- Identification of social factors as an independent object of research.

Based on this conception a set of indicators for vulnerability assessment has been developed and realized for the Moldavian part of the Dniester basin



Realization of the new approach for the Moldavian part of the Dniester Basin



Climatic division of the study area for downscaling of Regional Climatic Models

Sector	Indicator		Functional relationships	Individual and average weights			
Exposure							
Climate	Temperature change in a warm season		Temperature↑ exposure↑	0.25		**0.5**	
	Humidity index in a warm season		Humidity index↓ exposure↑	0.25			
	Temperature change in a cold season		Temperature↑ exposure↓			**0.5**	
Sensitivity							
Physiographical sensitivity							
Land use (%)	Arable land		Area↑ sensitivity↑	2.0			
	Perennial plants		Area↑ sensitivity↓	1.0			
	Grasslands			1.5	**0.25**	***0.33***	**-0.5**
	Forests			2.0			
	Surface water			2.0			
Soils	Soil quality		Quality↓ sensitivity↑		**0.25**		
	Geomorphologic processes	Surface erosion	Area↑ sensitivity↑		**0.25**	***0.33***	
		Ravines		1.0	**0.25**		
		Landslides		2.0			
Construction	Built-up areas					***0.33***	
Social-economic sensitivity							
Population	Population density (no. of inhabitants per sq. km)		Density↑ sensitivity↑		**0.20**	**0.25**	**0.5**
	Urban population (%)		Share↑ sensitivity↑		**0.20**		
	Women (%)				**0.20**		
	Natural growth		Growth↓ sensitivity↑		**0.20**		
	Demographic load		Load↑ sensitivity↑		**0.20**		
Agriculture	Ratio of unprofitable vs. profitable enterprises		Ratio↑ sensitivity↑		**0.17**	**0.25**	
	Annual average yield of milk		Yield↓ sensitivity↑		**0.17**		
	Yields	potatoes			**0.17**		
		vegetables			**0.17**		
		fruits			**0.17**		
		cereals			**0.17**		
Labor force	Unemployment rate		Rate↑ sensitivity↑			**0.25**	
Crime rate	Total crime rate			0.5		**0.25**	
	Grave crimes			0.5			
Adaptive capacity							
Economics	Road density		Density↑ capacity↑		**0.20**	**0.25**	**0.5**
	Share of industrial workers		Share↑ capacity↑		**0.20**		
	Mobility of employees		Mobility↑ capacity↑		**0.20**		
	Investments in capital asset		Investments↑ capacity↑		**0.20**		
	Average monthly wage		Wage↑ capacity↑		**0.20**		
Agriculture	Milk production		Production↑ capacity↑		**0.33**	**0.25**	
	Slaughter of cattle and poultry				**0.33**		
	Use of mineral fertilizers (per 1 ha)		Optimal use↑ capacity↑		**0.33**		
Medical provision	No. of physicians per 10 thou. inhabitants		Number↑ capacity↑		**0.33**	**0.25**	
	No. of middle medical staff per. 10 thou. inhabitants				**0.33**		
	No. of beds in hospitals per 10 thou. inhabitants				**0.33**		
Housing	Building of new houses		Housing↑ capacity↑		**0.5**	**0.25**	
	Housing provision rate				**0.5**		

Evaluation scheme of the assessment of vulnerability to climate change

Ranks of Moldova's administrative-territorial units in the decreasing order of their sensitivity to climate change

No.	ATU	Sensitivity									Total rank
		Physiographical				Social-economic					
		Indicator's rank[a]			Intermediate rank	Indicator's rank[b]				Intermediate rank	
		a1	a2	a3		b1	b2	b3	b4		
(1)	*Anenii Noi*	15	9	11	***10***	3	11	22	9	***10***	7
(2)	*Bălți*	14	21	1	***12***	2	5	19	1	***2***	10
(3)	*Călărași*	20	1	13	***9***	6	15	14	21	***18***	16
(4)	*Căușeni*	8	12	20	***16***	22	8	7	3	***9***	18
(5)	*Chișinău*	18	18	2	***15***	4	4	18	2	***3***	5
(6)	*Criuleni*	4	17	6	***6***	8	3	15	12	***6***	6
(7)	*Donduşeni*	3	19	19	***17***	14	21	4	17	***17***	15
(8)	*Drochia*	1	14	10	***4***	9	13	12	13	***11***	3
(9)	*Dubăsari*	9	20	9	***14***	1	6	1	15	***1***	20
(10)	*Fălești*	2	11	3	***1***	16	14	5	20	***16***	2
(11)	*Florești*	17	8	18	***20***	12	18	10	20	***19***	17
(12)	*Ialoveni*	22	2	7	***8***	10	7	13	8	***8***	9
(13)	*Ocnița*	11	22	17	***22***	7	22	11	10	***13***	11
(14)	*Orhei*	21	6	16	***18***	5	17	21	19	***20***	14
(15)	*Rezina*	12	4	8	***2***	19	10	9	14	***15***	8
(16)	*Rîșcani*	6	10	12	***7***	13	16	6	16	***14***	4
(17)	*Sîngerei*	19	3	14	***13***	20	19	16	11	***22***	19
(18)	*Soroca*	7	13	4	***3***	11	12	3	7	***4***	1
(19)	*Străşeni*	13	7	15	***11***	15	9	20	4	***12***	12
(20)	*Şoldăneşti*	5	16	5	***5***	17	1	2	18	***7***	13
(21)	*ŞtefanVodă*	10	15	21	***21***	21	20	17	5	***21***	21
(22)	*Teleneşti*	16	5	22	***19***	18	2	8	6	***5***	22

a1: land use; a2: soil quality; a3: built-up area; b1: population; b2: agriculture; b3: unemployment; b4: crime rate.

Ranks of Moldova's administrative-territorial units by their adaptive capacity and general vulnerability to climate change

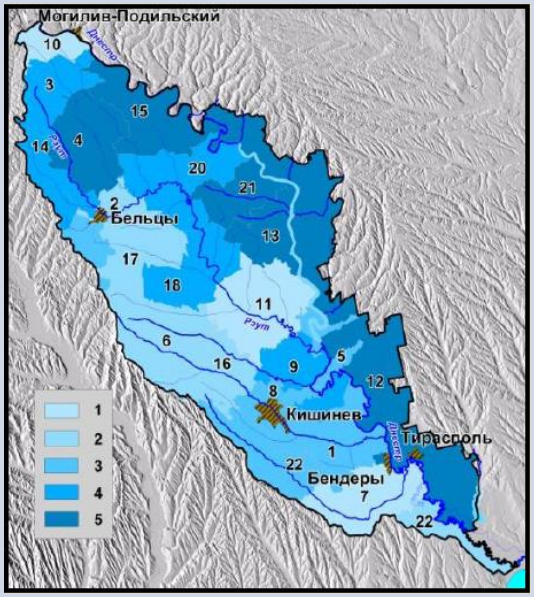
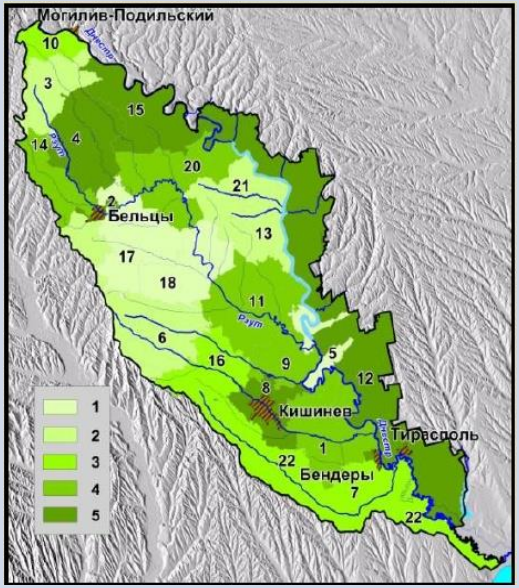
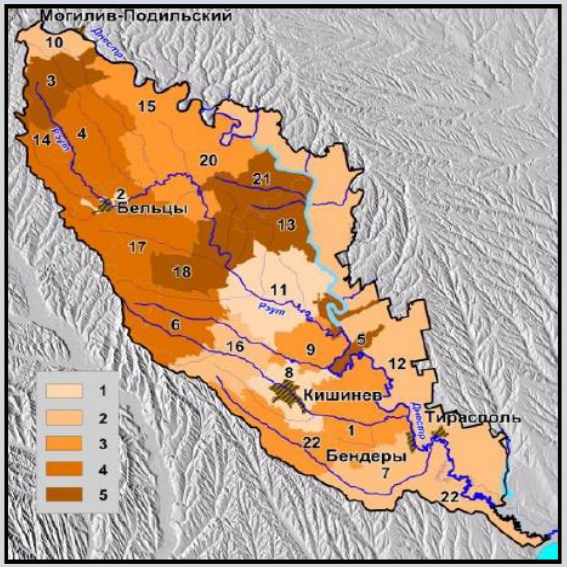
ATU	Indicator's rank				Rank
	1	2	3	4	
Anenii Noi	8	6	17	7	***9***
Bălți	3	22	1	14	***11***
Călărași	6	18	21	16	***18***
Căușeni	18	20	10	9	***15***
Chișinău	1	9	9	1	***1***
Criuleni	17	3	13	10	***12***
Donduşeni	11	8	6	13	***10***
Drochia	16	10	7	3	***5***
Dubăsari	14	19	22	20	***22***
Fălești	15	2	4	15	***6***
Florești	7	4	14	11	***7***
Ialoveni	4	15	20	8	***14***
Ocnița	12	5	2	4	***2***
Orhei	9	2	8	18	***8***
Rezina	5	17	16	22	***17***
Rîșcani	13	7	5	2	***4***
Sîngerei	20	21	19	12	***20***
Soroca	2	13	3	5	***3***
Străşeni	10	11	18	6	***13***
Şoldăneşti	22	14	12	19	***19***
ŞtefanVodă	19	12	11	17	***16***
Teleneşti	21	16	15	21	***21***

1: economics; 2: agriculture; 3: medical provision; 4: housing.

ATU	S	AC	Σ	Rank
Anenii Noi	7	13	20	***7***
Bălți	10	12	22	***10***
Călărași	16	5	21	***9***
Căușeni	18	8	26	***16***
Chișinău	5	22	27	***17***
Criuleni	6	11	17	***2***
Donduşeni	15	14	29	***19***
Drochia	3	16	19	***5***
Dubăsari	20	1	21	***8***
Fălești	2	17	19	***6***
Florești	17	18	35	***22***
Ialoveni	9	9	18	***4***
Ocnița	11	20	31	***21***
Orhei	14	15	29	***20***
Rezina	8	6	14	***1***
Rîșcani	4	19	23	***14***
Sîngerei	19	3	22	***13***
Soroca	1	21	22	***11***
Străşeni	12	10	22	***12***
Şoldăneşti	13	4	17	***3***
ŞtefanVodă	21	7	28	***18***
Teleneşti	22	2	24	***15***

S: rank of decreasing sensitivity; AC: rank of increasing adaptive capacity.

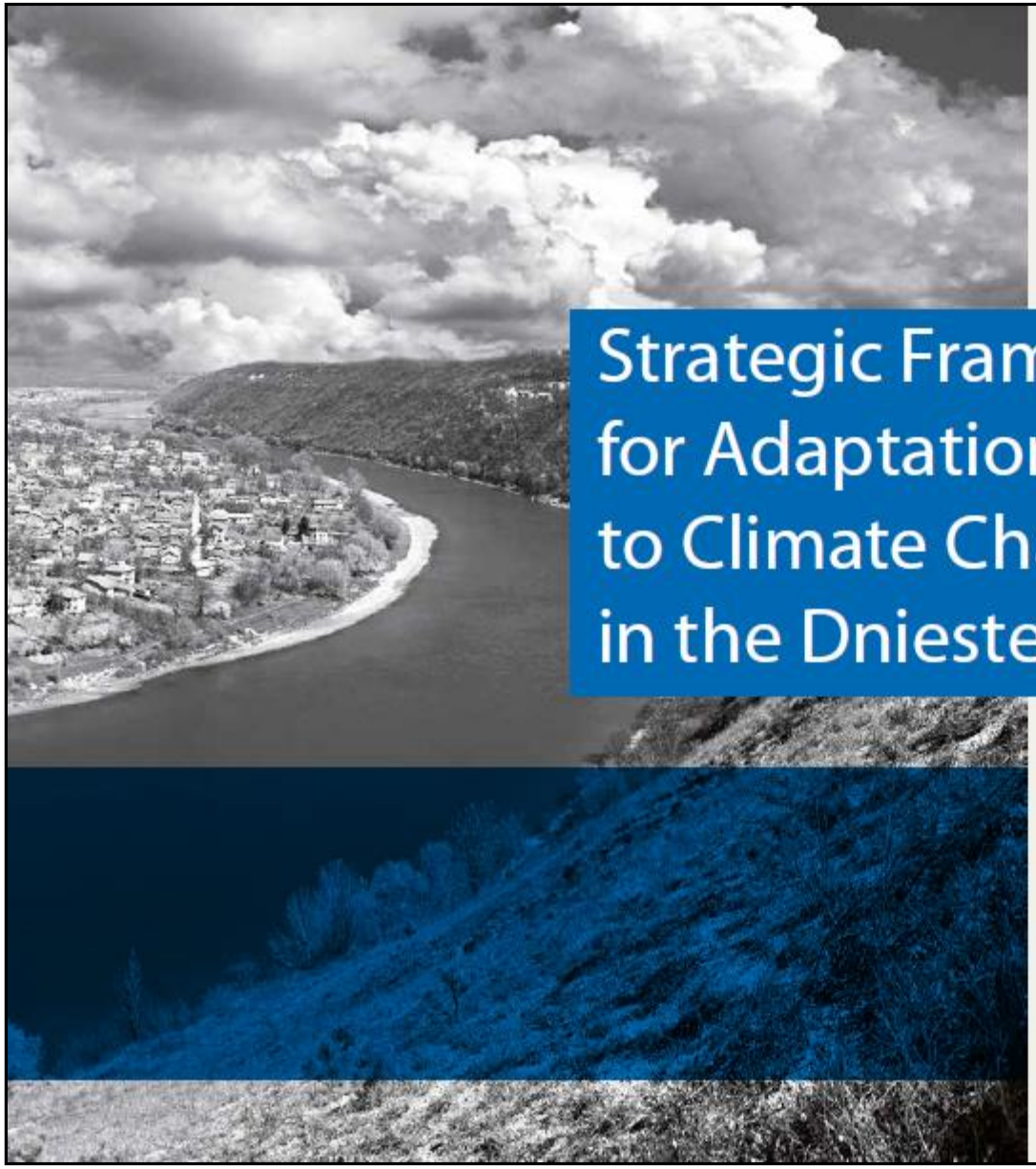
Mapping vulnerability to climate change of the Moldavian part of the Dniester Basin

Sensitivity	Adaptation capacity	Vulnerability
		

Adaptation of the Dniester basin to climate change

This activity has been realized within the context of the project *'Climate Change and Security in Eastern Europe, Central Asia and the Southern Caucasus'* as its component *'Climate Change and Security in the Dniester River Basin'.* It was also a part of the UNECE programme of pilot projects on adaptation to climate change in transboundary basins.

The project was carried out under *the Environment and Security Initiative (ENVSEC)*, with financial support from the Austrian Development Cooperation and the European Union's Instrument for Stability (IfS).



Strategic Framework for Adaptation to Climate Change in the Dniester River Basin

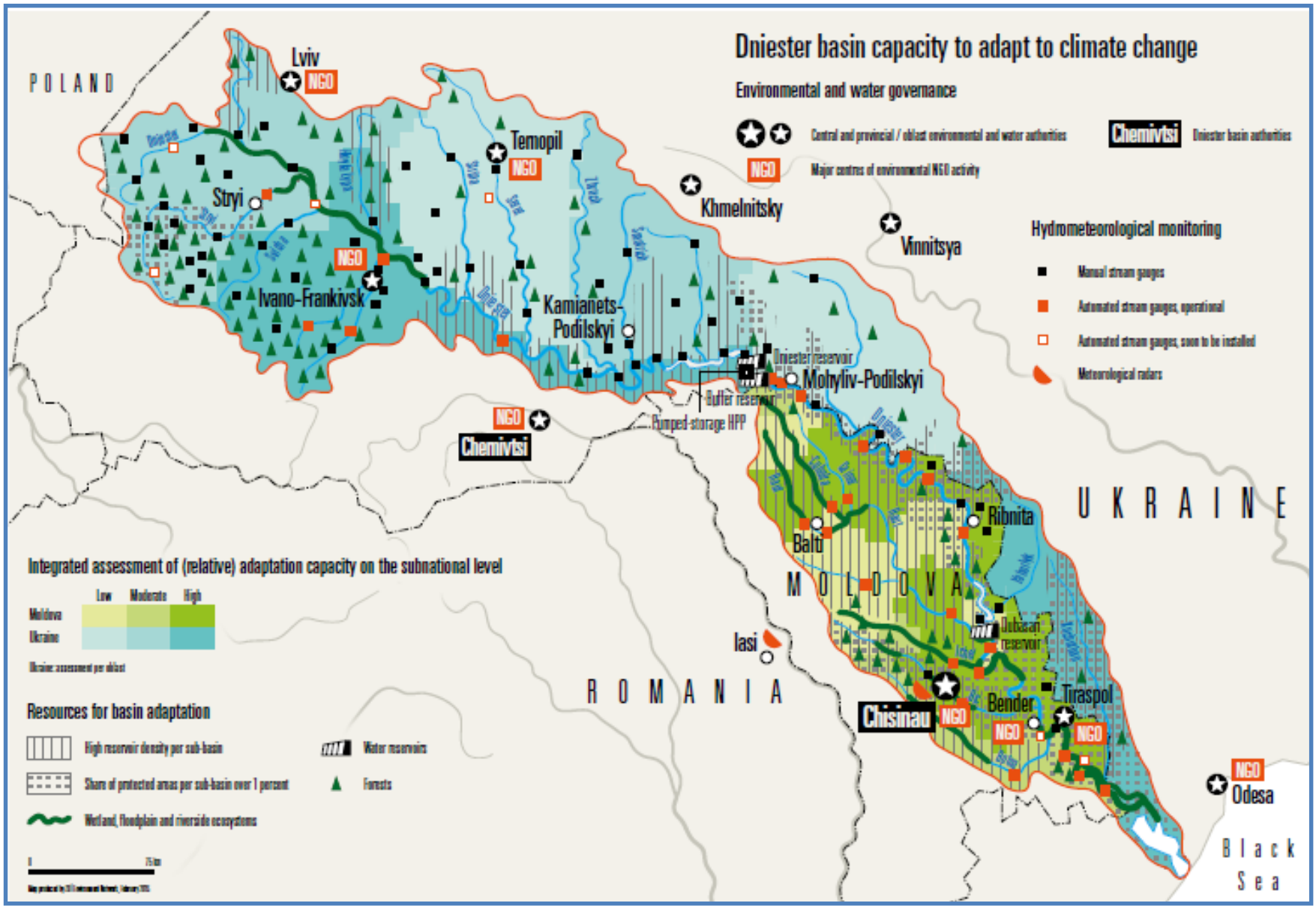
ENVSEC UNECE OSCE

The goal of developing the Strategic Framework

***To propose adaptation actions targeted at*:**

- *to reduce the climate change vulnerability of the Dniester Basin's natural environment, economy and population;*
- *to promote adaptation to climate change at the basin level, with wide participation of its all institutions;*
- *to involve in the implementation of adaptation measures the basin-wide coordination and cooperation mechanisms.*

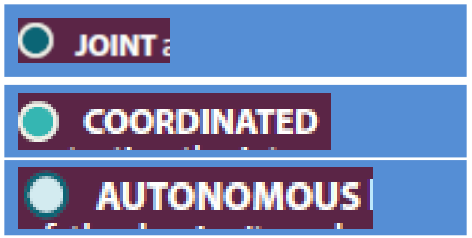
Contents of "*Strategic framework for adaptation to climate change in the Dniester River Basin*"


Dniester basin capacity to adapt to climate change
Environmental and water governance
Central and provincial / oblast environmental and water authorities
Chernivtsi
Dniester basin authorities
NGO
Major centres of environmental NGO activity
Hydrometeorological monitoring
Manual stream gauges
Automated stream gauges, operational
Automated stream gauges, soon to be installed
Meteorological radars
Integrated assessment of (relative) adaptation capacity on the subnational level
Low
Moderate
High
Moldova
Ukraine
Ukraine: assessment per oblast
Resources for basin adaptation
High reservoir density per sub-basin
Share of protected areas per sub-basin over 1 percent
Wetland, floodplain and riverside ecosystems
Water reservoirs
Forests
POLAND
ROMANIA
MOLDOVA
UKRAINE
Black Sea
Lviv
Stryi
Ivano-Frankivsk
Ternopil
Kamianets-Podilskyi
Khmelnitsky
Vinnitsya
Dniester reservoir
Buffer reservoir
Pumped-storage HPP
Chernivtsi
Moldyliv-Podilskyi
Balti
Ribnita
Iasi
Dubasari reservoir
Chisinau
Bender
Tiraspol
Odesa

Proposed adaptation measures

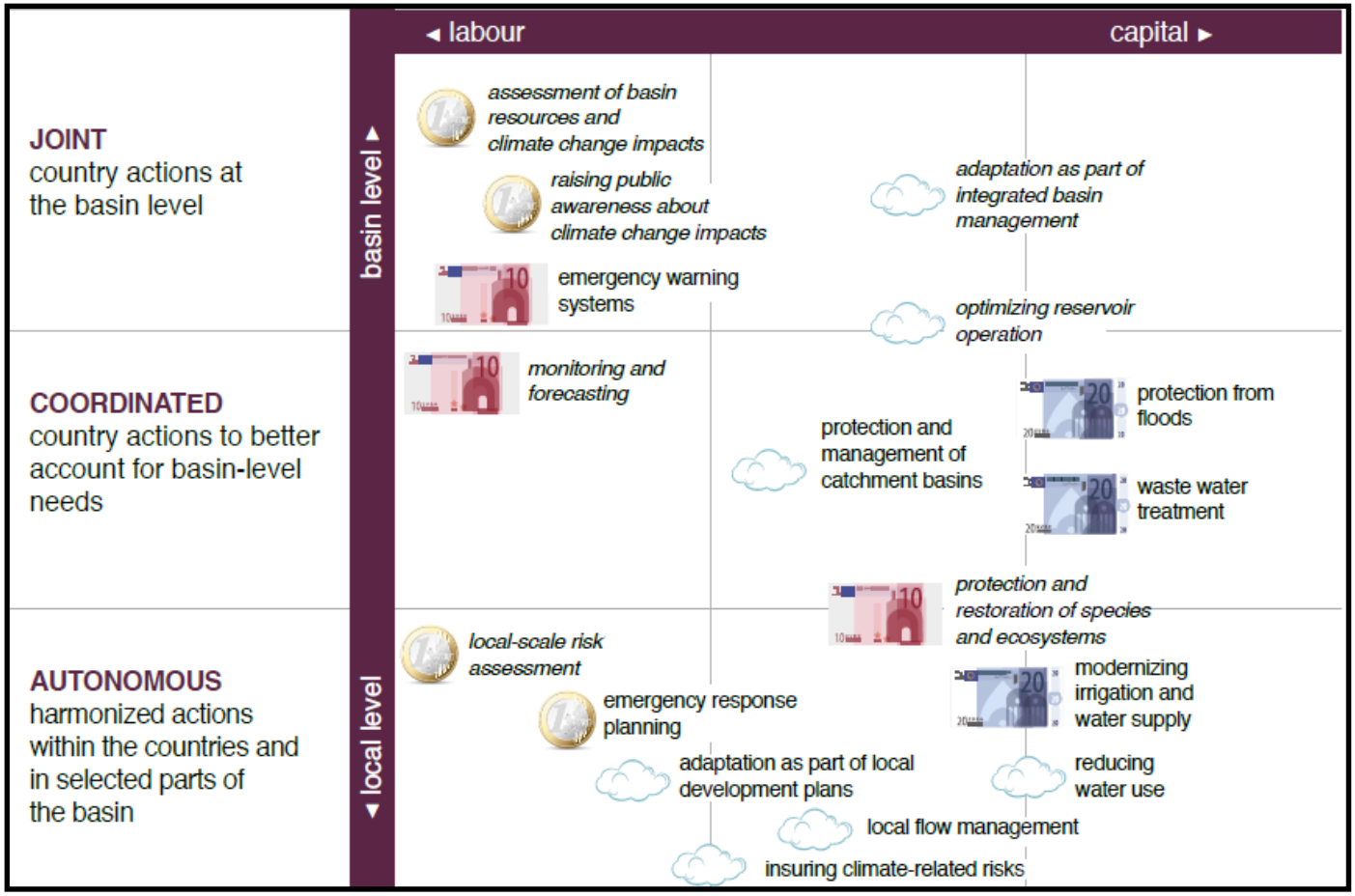
Risk forecasting and analysis measures	Risk prevention and reduction measures	Remediation measures
Reduction in losses from extreme flooding		
●● improved monitoring and forecasting of flow and information sharing ● inventory of flood protection infrastructure ○ analysis and mapping of flood risk	●● updating and observance of rules for the operation of the Dniester's system of reservoirs ● updating of flood protection plans ● restoration and optimization of the system of flood protection structures and culverts	●● providing the public and local authorities with timely information about the flood risk ○ updating and implementation of emergency response plans ○ insurance of risks (including insurance provided with government support)
Reduction in losses from water scarcity		
● analysis of the water balance in the basin ●● improved monitoring and forecasting of flow and information sharing ●● assessment and monitoring of the condition of forests	●● updating and observance of rules for the operation of the Dniester's system of reservoirs ● protection and restoration of forests and shoreline vegetation ○ optimization of the regulation of flow at the local level ○ reduction in water consumption and losses	○ modernization of irrigation systems ○ diversification and modernization of water supply systems for population centres ○ insurance of risks (including insurance provided with government support)
Reduction in losses from a deterioration in water quality		
●● improved monitoring and forecasting of flow and information sharing ● improved monitoring of water quality	● improvement of wastewater treatment systems ● protection and regulation of the use of catchment basins and water protection zones	○ improvement of water treatment and distribution systems ○ diversification and modernization of water supply systems for population centres
Support for and restoration of aquatic and wetland ecosystems and species		
● analysis of ecosystem services at the basin level ●● improved monitoring of ecosystems and biological resources and transboundary information sharing	●● updating and observance of rules for the operation of the Dniester's system of reservoirs ●○ regulation of activities within floodplains and wetlands ●○ expansion and strengthening of the network of protected areas and ecological corridors ●○ combating poaching and invasive species	●○ restoration of shoreline forests, meadows and wetlands ●○ restoration of habitats, spawning grounds and fish stocks
General measures for adaptation and development of cooperation in the basin		
● systematic analysis and forecasting of climate change and its impacts in the Dniester basin	● consideration of adaptation needs in long-term Integrated Water Resources Management (IWRM) plans ● providing information about climate change problems in the basin ○ inclusion of adaptation needs in socioeconomic development plans for sectors and territories	

Mechanisms for implementation



Classification of adaptation measures by target area, category and approximate cost

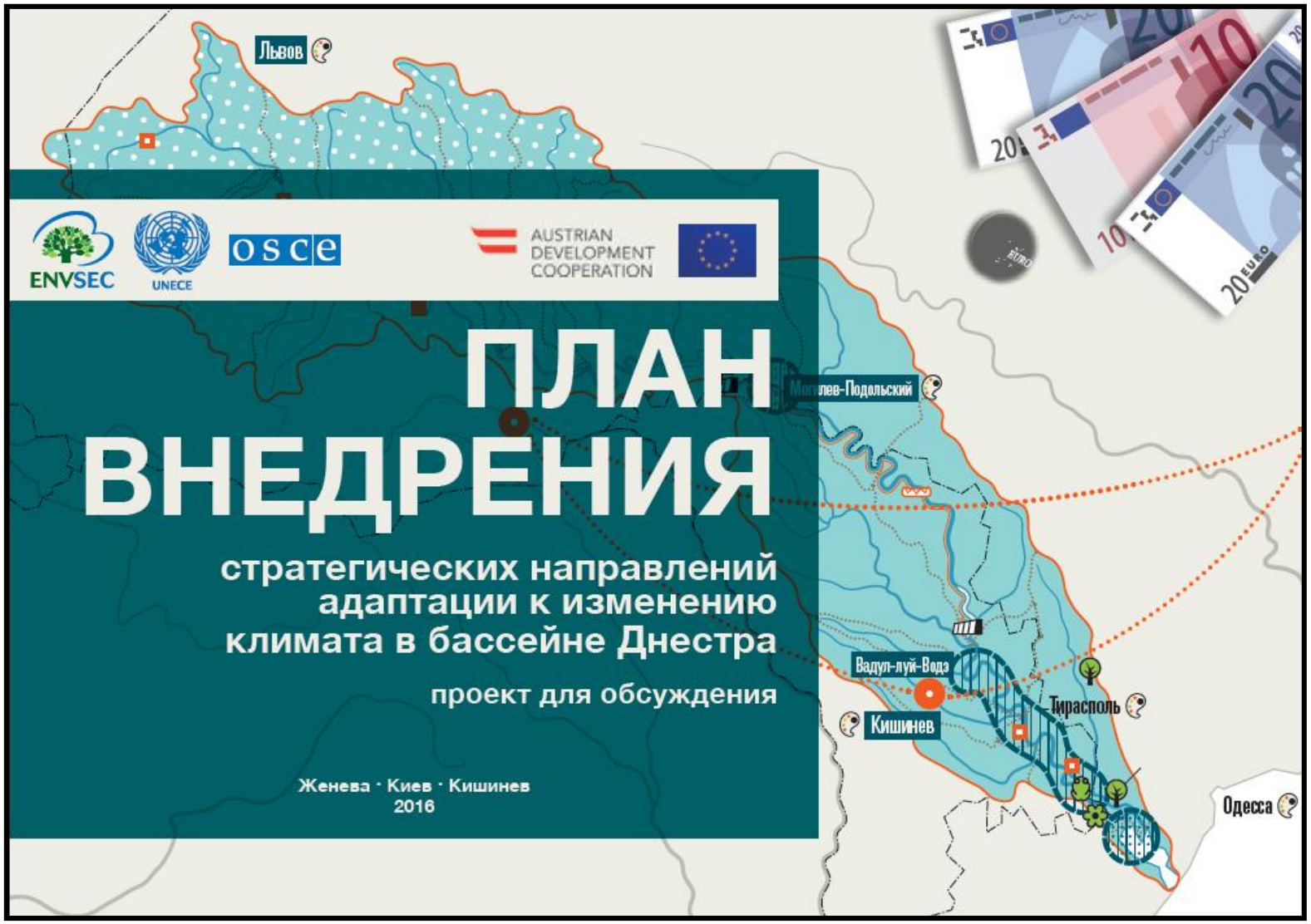
Implementation	Informational	Organizational	Investment



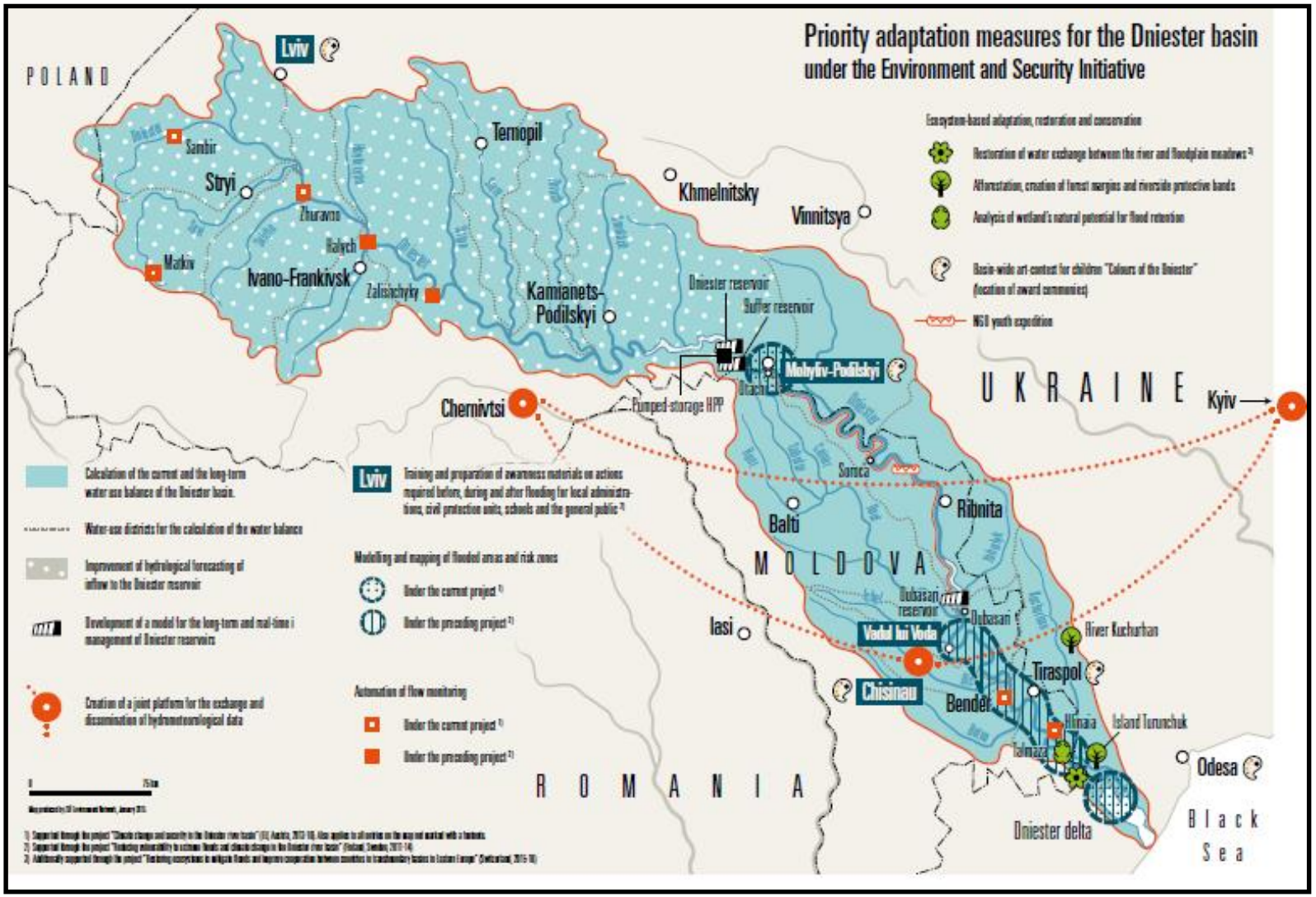
Approximate cost of basin-focused adaptation

< 1 mln. €
1-10 mln. €
> mln. €
Need in information

Plan of the Strategic Framework implementation



From climate adaptation to climate security



Many thanks for your kind attentions!

https://ehlm.unece.org/display/ClimateChange/Dniester