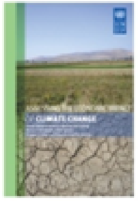
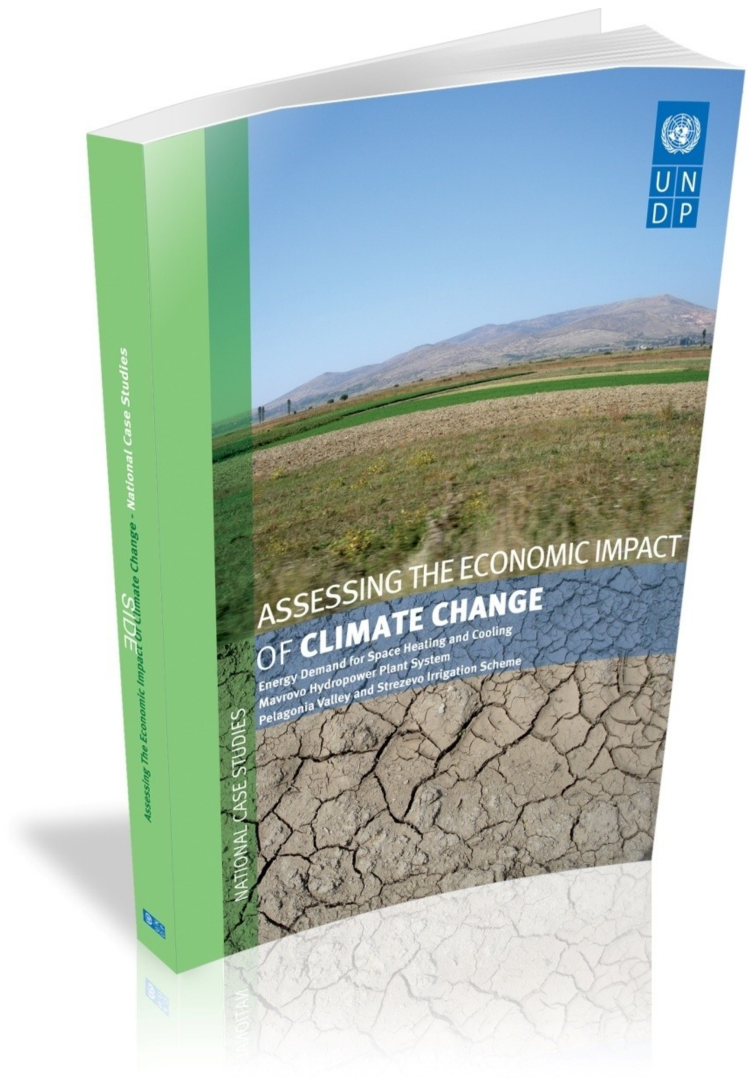


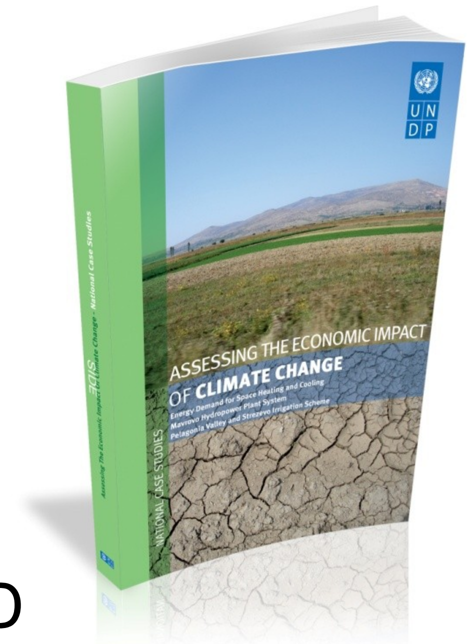
Public presentation and discussion of the findings from the Report

ASSESSING THE ECONOMIC IMPACT OF CLIMATE CHANGE: NATIONAL CASE STUDIES



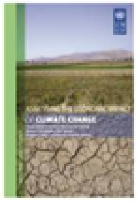
Public presentation and discussion of the findings from the Report

ASSESSING THE ECONOMIC IMPACT OF CLIMATE CHANGE: NATIONAL CASE STUDIES



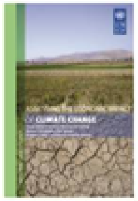
Ms. Natasa Markovska, PhD

Energy Demand for Space Heating and Cooling



Objective

- To estimate
  - the economic value of climate change **damages** due to changes in the electricity demand
  - the benefits and costs (net benefits) of **adaptation** by changing the type and amount of generating capacity needed to cope with the changes in the electricity demand



Modeling (1/3)

Business as usual developmental pathways

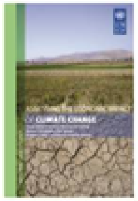
↓ **Demographic and Economic drivers**

MARKAL Model

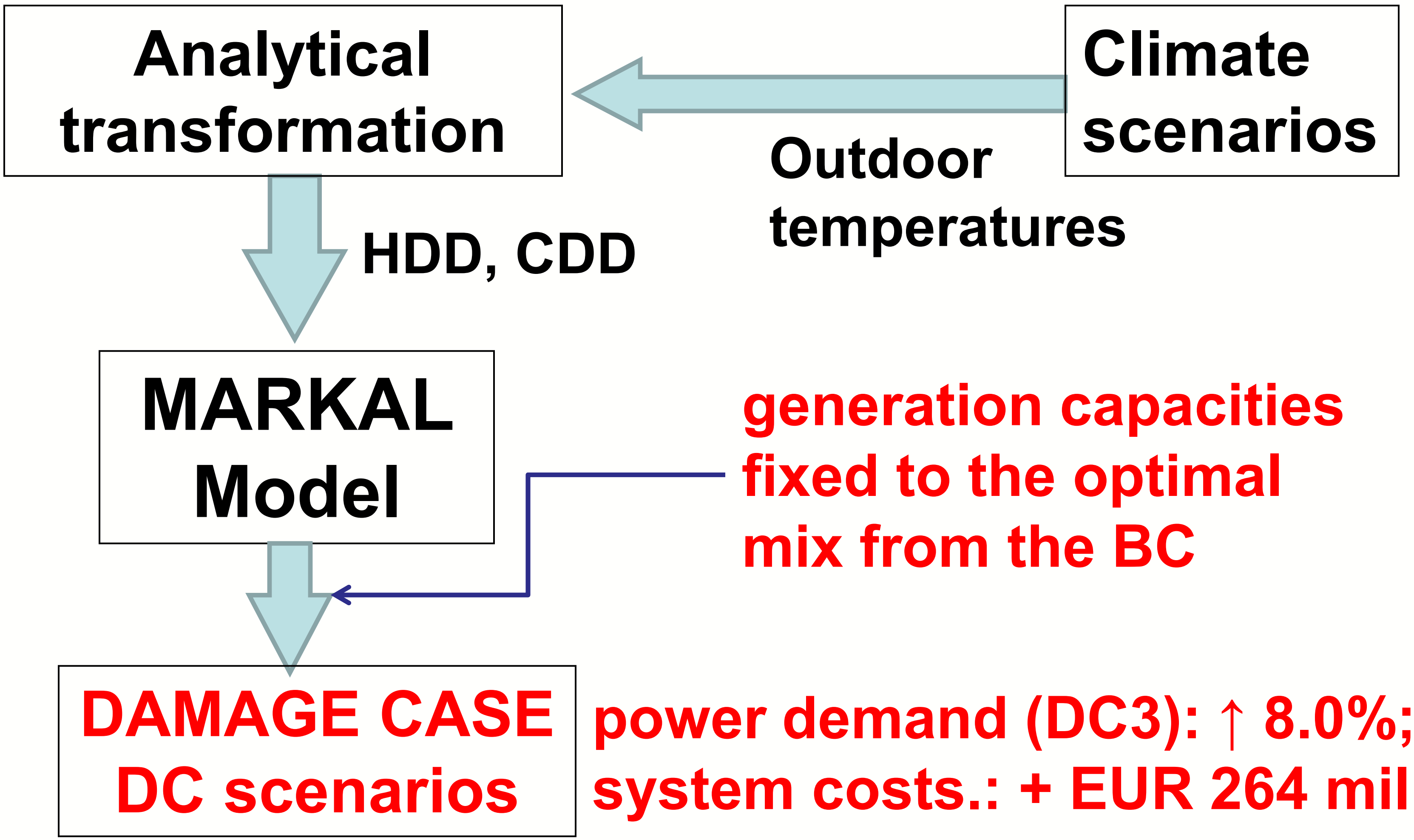
↓

BASE CASE BC scenario

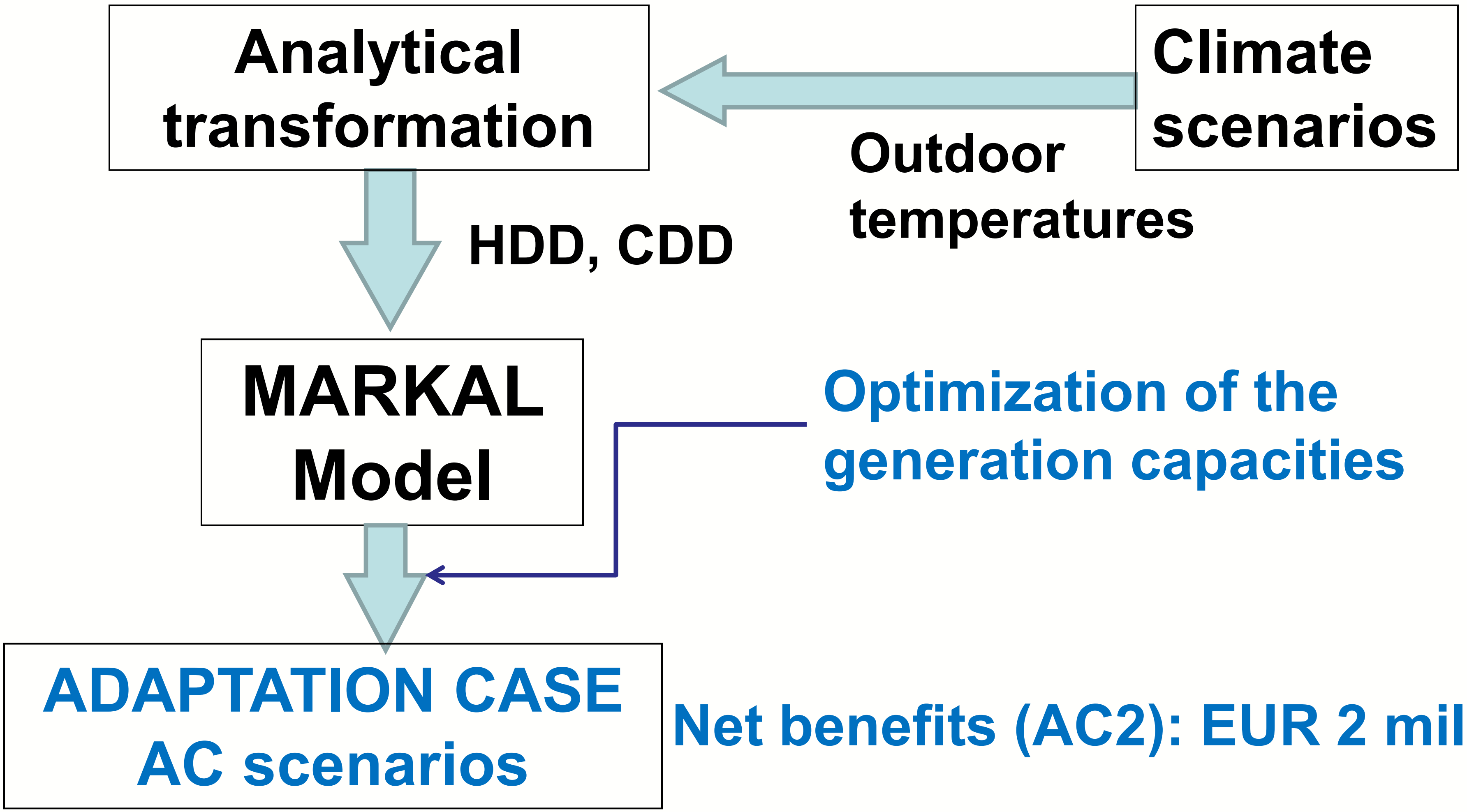
total discounted system cost : EUR 14.87 billion

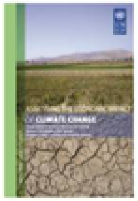


Modeling (2/3)


Analytical transformation
Climate scenarios
Outdoor temperatures
HDD, CDD
MARKAL Model
generation capacities fixed to the optimal mix from the BC
DAMAGE CASE DC scenarios
power demand (DC3): ↑ 8.0%;
system costs.: + EUR 264 mil.

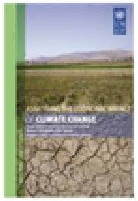
Modeling (3/3)


Analytical transformation
Climate scenarios
Outdoor temperatures
HDD, CDD
MARKAL Model
Optimization of the generation capacities
ADAPTATION CASE
AC scenarios
Net benefits (AC2): EUR 2 mil.



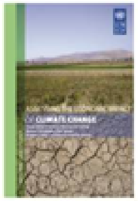
Key findings (1/2)

- Climate change damages, as measured by the rise in total system cost, have increased over time with the demand for electricity, but were still are relatively small.
- Allowing the electricity supply system to adjust capacity "optimally" to climate change did not always reduce total system costs.



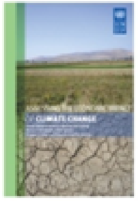
Key findings (2/2)

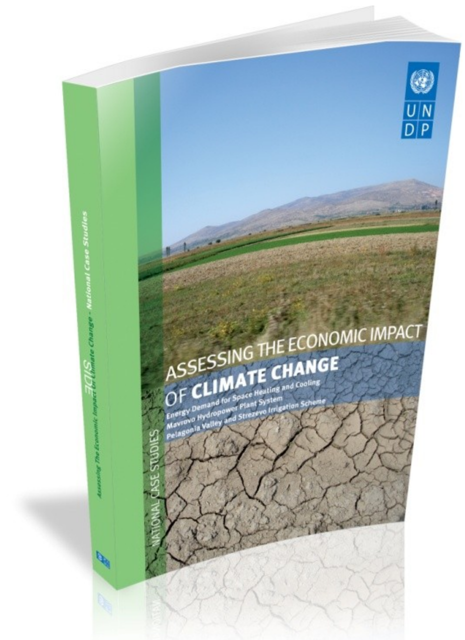
- The study could help filling an important analytical gap in the country.
- The study demonstrated in a very positive manner that the tools and expertise, for the most part, are already in place.



Challenges

- Adding Price-Sensitive Demand Functions to MARKAL
- Extending the MARKAL Planning Horizon Beyond 2030.
- Make the Analysis “Comprehensive”.
- Adding Additional Adaptation Technologies on the Demand and Supply Sides of MARKAL.





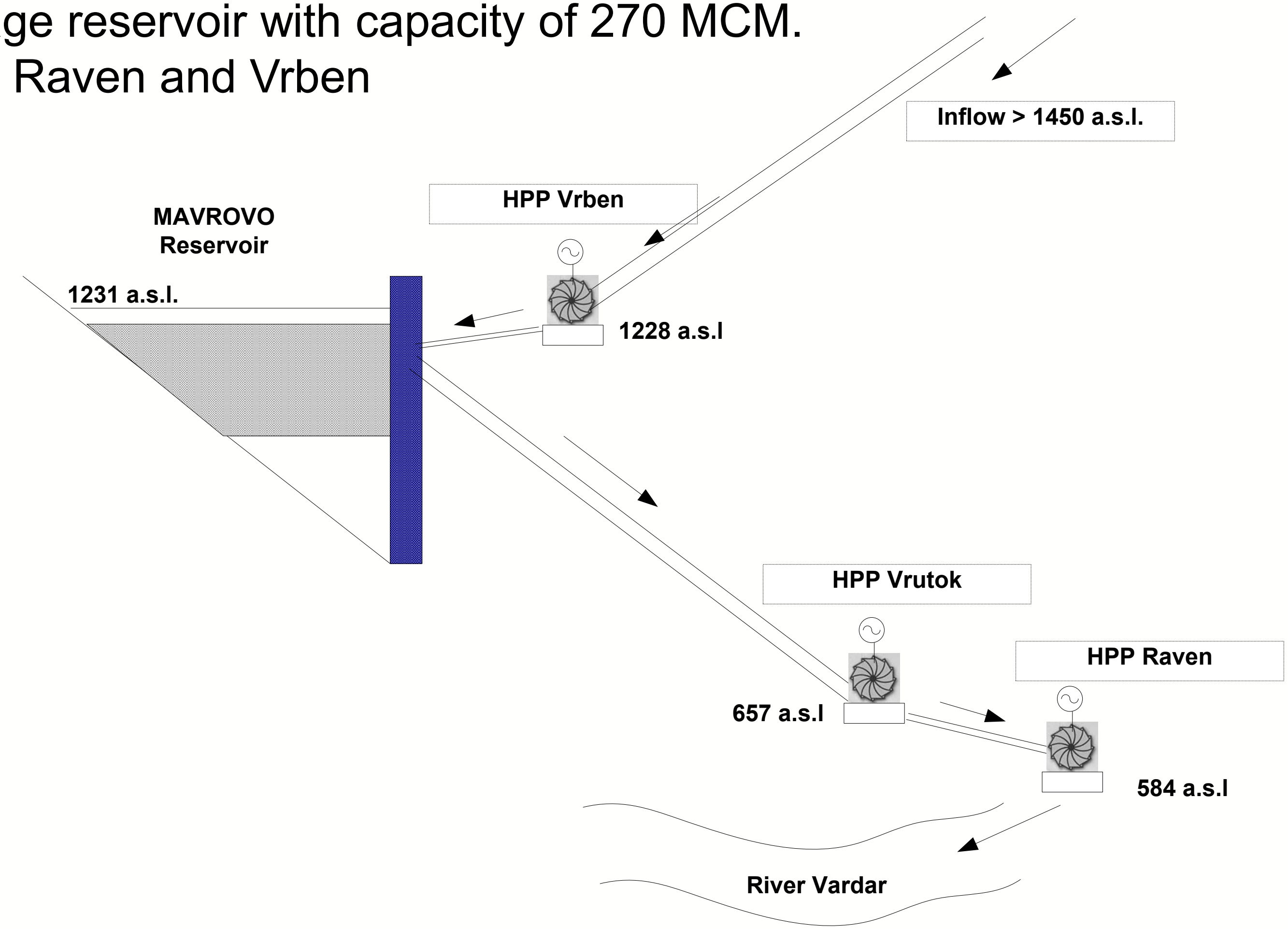
Mr. Anton Causevski, PhD

Mavrovo Hydropower Plant System

Background and Objectives

Possible impacts from climate change on Mavrovo Hydroenergy system

Large, multi-year, storage reservoir with capacity of 270 MCM.
Consist of HPP Vrutok, Raven and Vrben



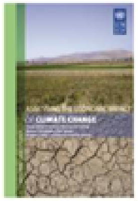
Methodology;

- Developing Base Case data; Estimated for 2050 and 2100
- Introducing climate change in the analysis (electricity production)
- Estimating the economic value of climate change damages.

Relationship between:

- Changes in temperature and precipitation on runoff into the HPP reservoirs;
- Changes in runoff and reservoir storage (water elevation);
- Changes in storage (water elevation) and power generation; and
- Changes in hydro-electric power generation and the cost and supply of additional power from other generating units in the system.

Using OPTIM software tool



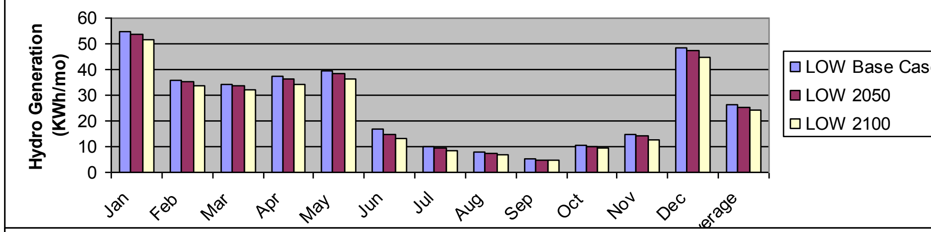
Public presentation and discussion of the findings from the Report

ASSESSING THE ECONOMIC IMPACT OF CLIMATE CHANGE: NATIONAL CASE STUDIES

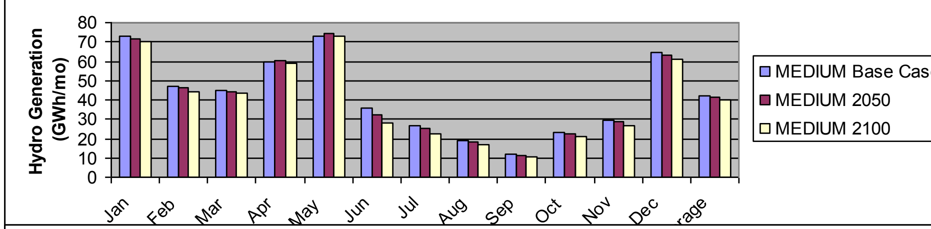
Brief overview of data and results

Case	Monthly Average Runoff (m3/sec)	% Change
Low		
Base	6.03	--
2050	5.81	-3.53%
2100	5.45	-9.58%
Medium		
Base	9.66	--
2050	9.51	-1.52%
2100	9.12	-5.56%
High		
Base	13.15	--
2050	13.24	0.63%
2100	12.96	-1.45%

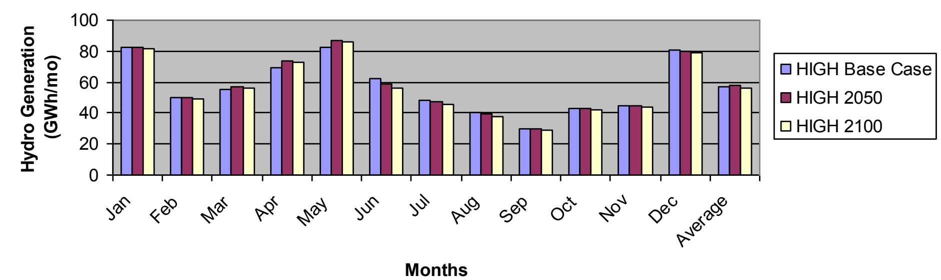
Average Monthly Power Generation from the Mavrovo Power Plant for Low Precipitation Conditions in the Base Case with No Climate Change and 2050 and 2100 with Climate Change

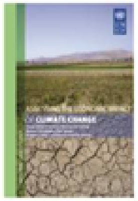


Average Monthly Power Generation from the Mavrovo Power Plant for Medium Precipitation Conditions in the Base Case with No Climate Change and 2050 and 2100 with Climate Change

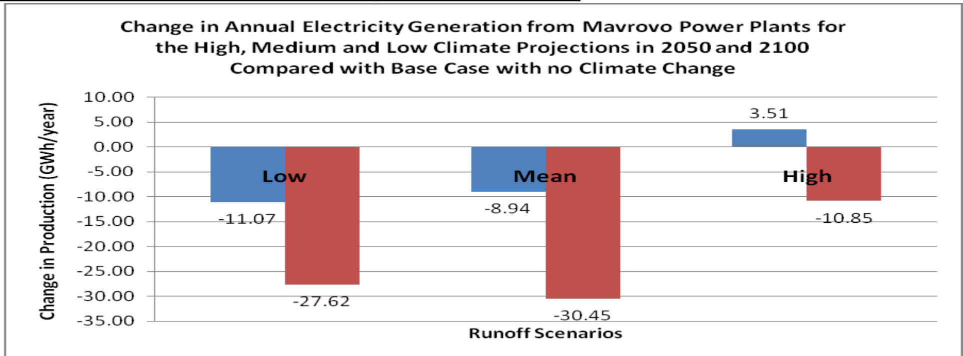


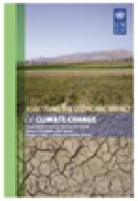
Average Monthly Power Generation from the Mavrovo Power Plant for High Precipitation Conditions in the Base Case with No Climate Change and 2050 and 2100 with Climate Change





Case	Monthly Average Power Generation GWh	Annual Average Power Generation GWh	% Change
Low			
Base	26.28	315.32	--
2050	25.35	304.25	-3.51%
2100	23.98	287.70	-8.76%
Medium			
Base	42.22	506.62	--
2050	41.47	497.69	-1.76%
2100	39.68	476.18	-6.01%
High			
Base	57.37	688.39	--
2050	57.66	691.91	0.51%
2100	56.46	677.54	-1.58%

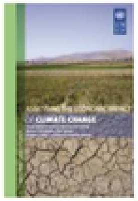




Plant Type	Generation Cost (EUR/kWh)	Total Cost (EUR/kWh)
Coal-Fired	0.04	0.100
Gas-Fired	0.058	0.118
Nuclear	0.053	0.115
Import	>0.055	>0.115
Wind Power	0.089	0.152
PV Systems	0.260	0.350

Economic impact Replacement

Condition	2050		2100	
	Generation	Total	Generation	Total
	Coal			
Low	-0.443	-1.107	-1.100	-2.751
Medium	-0.358	-0.894	-1.218	-3.045
High	0.141	0.352	-0.434	-1.084
	Gas			
Low	-0.642	-1.306	-1.596	-3.246
Medium	-0.519	-1.055	-1.766	-3.593
High	0.204	0.415	-0.629	-1.279
	Nuclear			
Low	-0.587	-1.273	-0.575	-3.164
Medium	-0.474	-1.028	-1.614	-3.502
High	0.187	0.405	-0.575	-1.247



Projected Increase in Annualized Total System Cost in 2050 and 2100 due to Reductions In Runoff from Climate Change for Mavrovo Hydro System

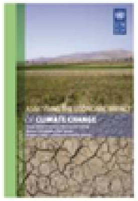
Precipitation Conditions	2050-Base (10^6 EUR)	2100-Base (10^6 EUR)
Low	2.540	7.140
Medium	1.210	4.010
High	2.070	5.380

Up to 2.54 million by 2050
Up to 7.14 million by 2100

Conclusion

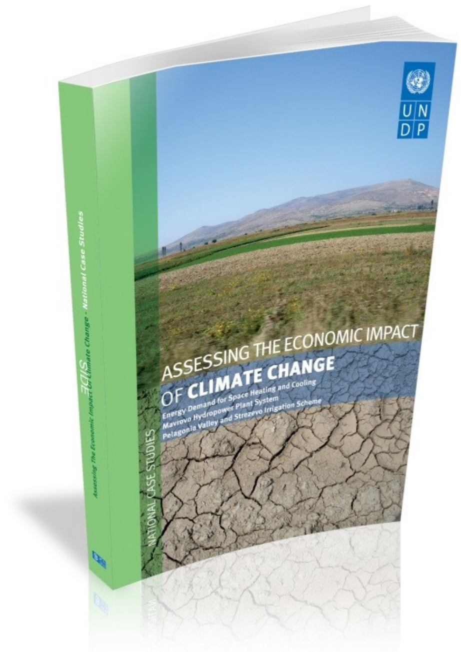
- Capacity of national experts and institutions to estimate the economic value of CC damages associated with reductions in runoff that reduce the capacity of HPPs to generate electricity
- Benefits and costs of adaptation measures to avoid some of these damages.
- How to fill these capacity gaps in the short and longer term

- **Need of models to simulate Long-Run Physical Impacts and Adaptation**
- **Improving the methodology for the Effects of Climate Change and Economic Development on Climate Change Damages**



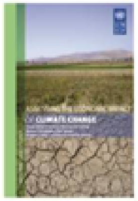
Public presentation and discussion of the findings from the Report

ASSESSING THE ECONOMIC IMPACT OF CLIMATE CHANGE: NATIONAL CASE STUDIES



Mr. Ordan Cukaliev, PhD

Pelagonija Valley and Strezevo Irrigation Scheme

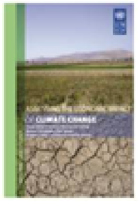


Agriculture: Background and objectives

- Climate change is expected to reduce the yields of most crops.
- The Second National Communication to the UNFCCC estimates annual losses of ~29 million by 2025 due to reductions on yields
- Losses are projected to increase over time.
- Without adaptation, climate change damages may jeopardizing the economic sustainability of farming in some areas.
- Even for irrigated crops there are likely to be losses, though these losses are projected to be less than for non-irrigated crops.
- Additional measures such as soil and water conservation, new more tolerant crops and varieties, new cropping pattern and changing farm management techniques can also improve performances.

Agriculture: Background and objectives

Our future in agriculture NO ADAPTATION

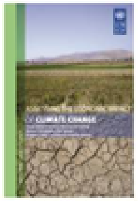


Agriculture: Background and objectives

Or

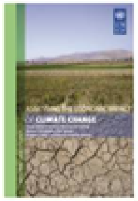
Agriculture: Background and objectives

Our future in agriculture WITH ADAPTATION



Agriculture: Background and objectives

- To identify the data and state-of-the-art models and methods needed to estimate the economic impacts of climate change and the benefits and costs of adaptation in agriculture;
- To assess the extent of the capacity in-country to develop and apply these data, models and methods to the country's situation;
- To use existing data, models and methods available to make some highly preliminary estimates of the economic value of the physical impacts that were identified in the National Communications; and
- To suggest ways in which the existing analytical and institutional capacity to estimate the economic impacts of climate change and the benefits and costs of adaptation in the country can be improved.



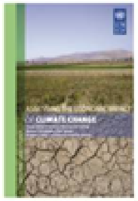
Agriculture: Methodology

Bottom-up approach was used for valuing the economic losses associated with yield reductions

It start with the effects of climate on crop yields and then work up to farm level production and further to market and sector level production.

The Methodology for this study consisted of three parts:

- Developing the Base Case,
  Based on present data of areas, yield and crop budgets
- Developing the Climate Change Case, and
  Based on predicted losses in crop yield due to water deficit no adaptation for year 2050 and 2100
- Developing the Adaptation/Adjustment Case.
  The adaptation was based to supplementary irrigate areas to achieve base case yield and spreading the irrigated areas up to maximum available water



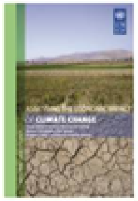
Agriculture: Methodology

Adaptation Cases:

1. Supplying the existing irrigated area with enough water to restore the Base Case yields;

2. Supplying the agriculture area with supplemental irrigation water for their crops; and/or

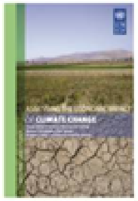
3. Expanding and refurbishing the irrigated area to the maximum available area, subject to the availability of water supply from the reservoir.



Agriculture: Methodology

Evaluating damages in the Climate Change Case:

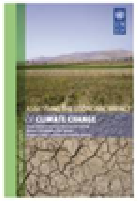
- For rain-fed crops, soil water availability was determined by projected precipitation, whereas for irrigated crops, this was determined by the availability of irrigation water and rainfall.
- Crop yields for both types of crops were calculated for the Climate Change Case using the empirical formula FAO Crop Yield Response to Water Deficit / CROPWAT.
- The net income from the production of irrigated and rain-fed crops was calculated using the yield information from CROPWAT and the budget data.
- The yields and net income estimates were compared to the Base Case values to determine the extent of the yields reductions and net income losses (climate change damages) due to climate change.



Agriculture: Methodology

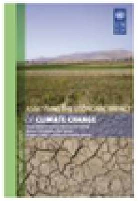
The following steps were carried out to evaluate damages in the Adaptation Case:

- The FAO CROPWAT model was used to determine the full and supplemental irrigation water requirements of all crops, consistent with achieving the Base Case yields.
- Crop yields were not optimized in economic terms, but this can be done with a bit more time and data manipulation.



Agriculture: Methodology

- Available water supply was calculated for each of the climate scenarios (high, medium and low for 2050 and 2010) by reducing the existing irrigation capacity of the system by the per cent reduction in precipitation in each scenario.
- Estimates of adaptation benefits and costs were calculated taking into account refurbishment and additional water costs as well as the improvement in yields due to the adaptation. These were estimated to show the net reduction in climate change damages that could be achieved through each of the measures.



Agriculture: Brief overview of data and results

Base Case and Climate Projections for Average Monthly Temperature and Precipitation for the "Medium" Climate Change Scenarios

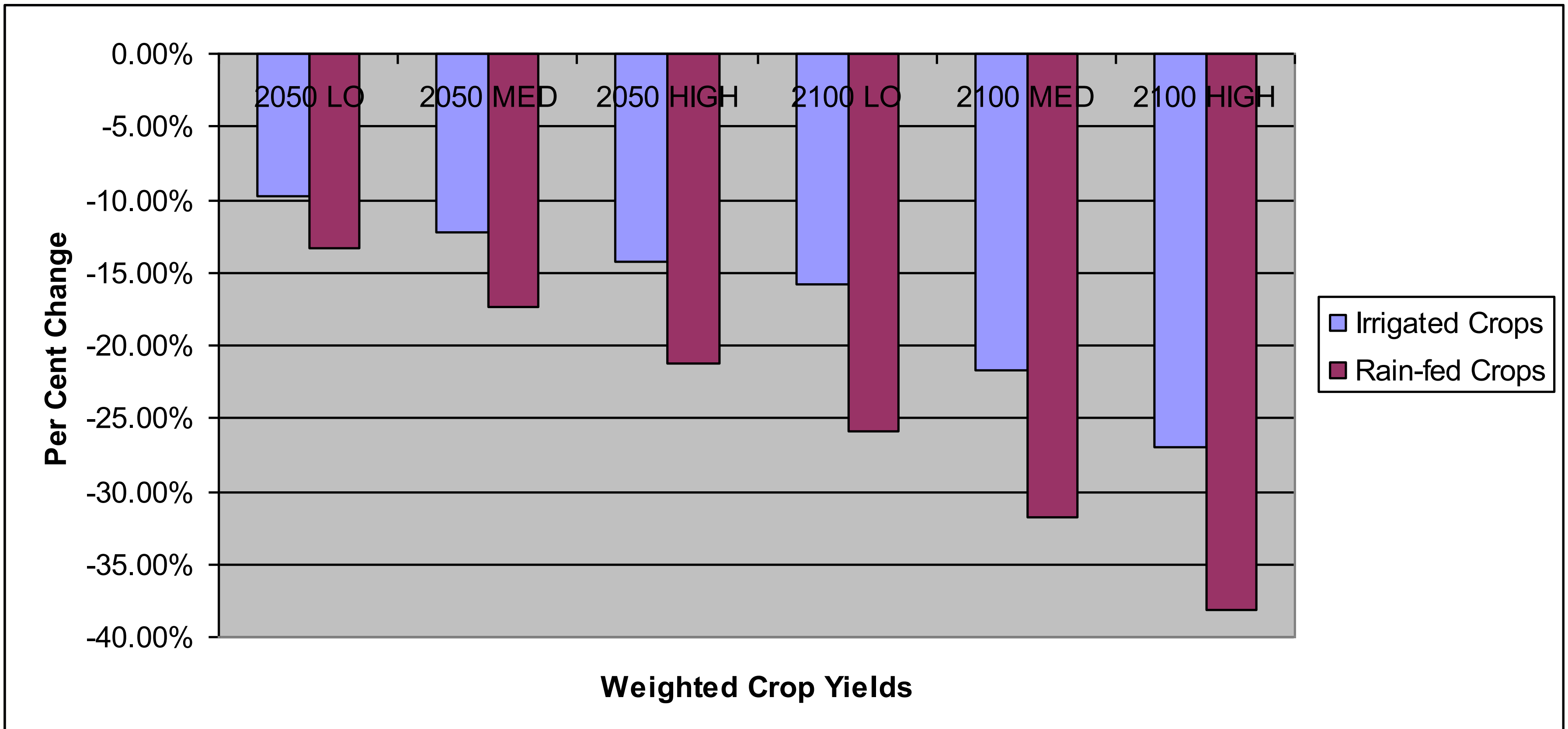
	Average Monthly Temperature in Degrees C by Month													% change
Case	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Annual
Base	-0.8	2.1	6.2	10.9	15.7	20.1	21.9	21.3	17.1	11.4	5.6	1	**11**	-
CC2050	1.9	4.8	8.5	13.2	18	22.8	24.6	24	19.2	13.5	7.7	3.7	**13.5**	**22.24**
CC2100	4.7	7.6	11	15.7	20.5	25.8	27.6	27	21.6	15.9	10.1	6.5	**16.2**	**46.49**
	Average Monthly Precipitation in mm by Month													
Base	47	53	47	50	56	37	39	37	41	64	75	65	**611**	**0**
CC2050	47	52	44	47	52	33	34	33	39	61	71	64	**576**	**-5.72**
CC2100	46	51	40	43	48	29	30	29	35	54	64	63	**533**	**-12.8**

Agriculture: Case study

- Strezevo Irrigation scheme was chosen as a case study area
- There is 20200 ha that can be irrigated,
- About 5700 ha are actually irrigated
- The reservoir can supply enough water for irrigation of whole area
- The area is of high importance for national food sustainability (production of cereals, industrial crops and animal husbandry)

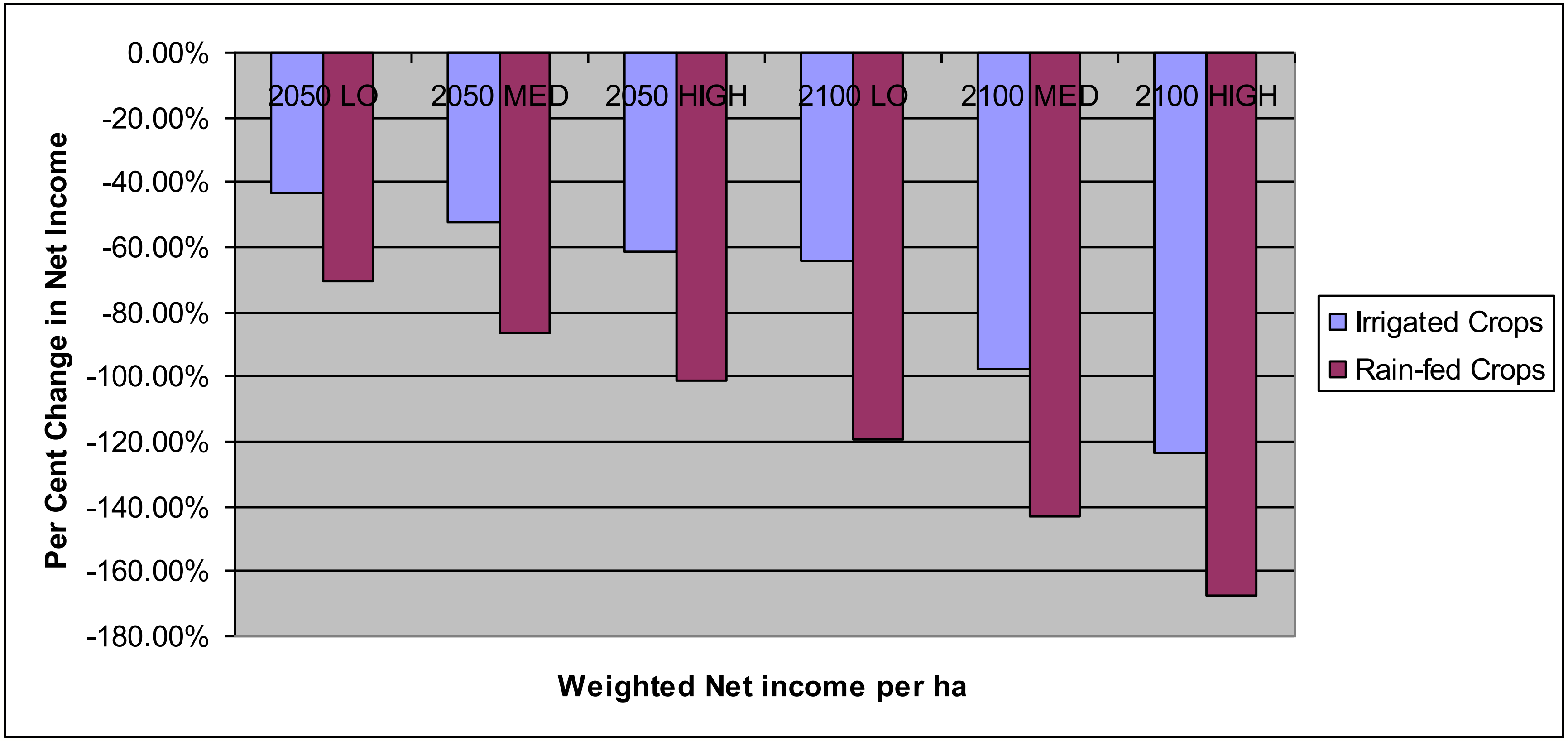
Agriculture: Case study – No adaptation

Per Cent Reduction in Area-Weighted Crop Yields due to Low, Medium and High Climate Change Projections for 2050 and 2100



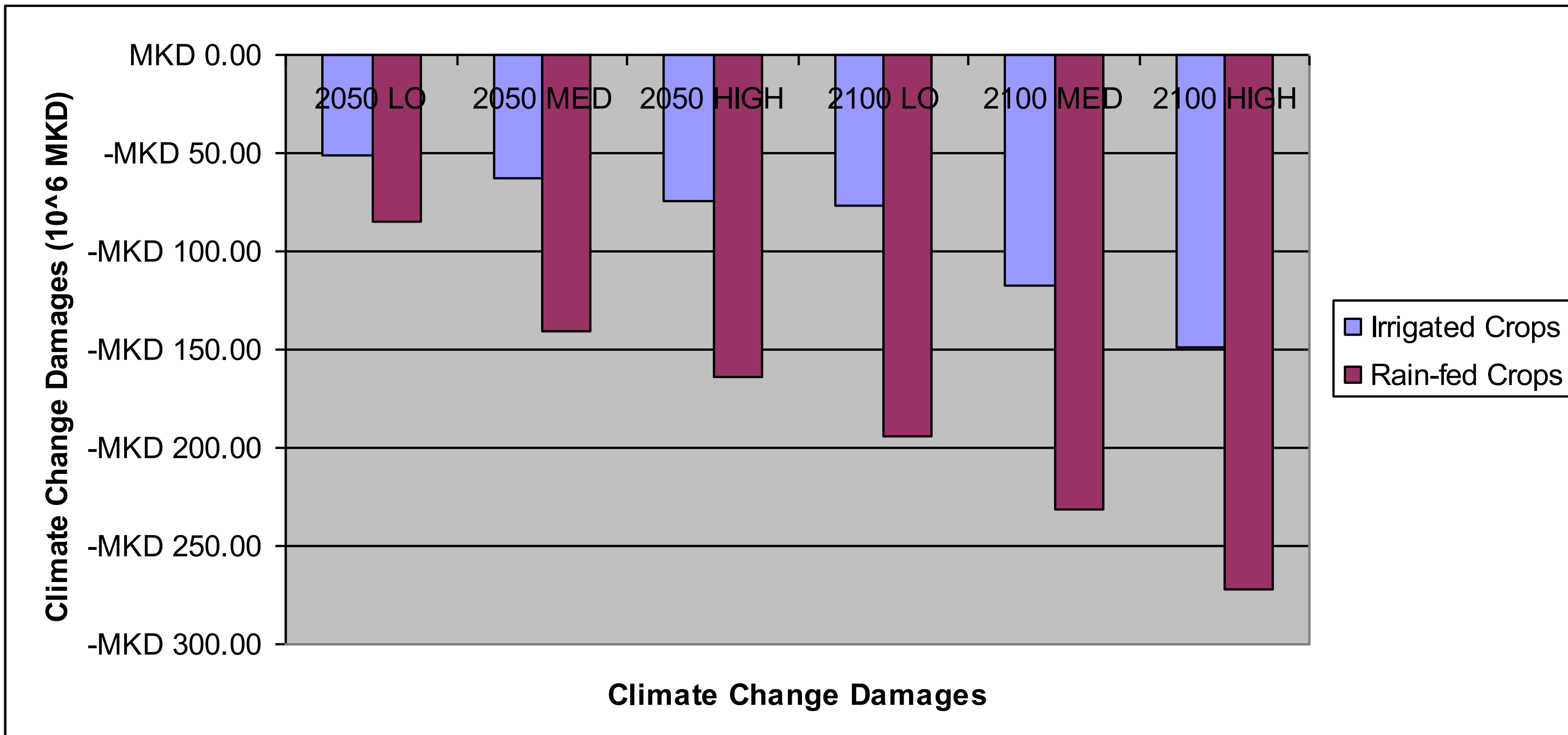
Agriculture: Case study – No adaptation

Per Cent Reduction in Area-Weighted Net Income/ha from Crop Production due to Low, Medium and High Climate Change Projections for 2050 and 2100



Agriculture: Case study - No adaptation

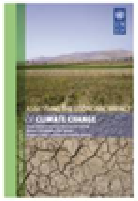
Climate Change Damages due to Low, Medium and High Climate Change Projections for 2050 and 2100



Agriculture: Case study – With adaptation

Economic Values for Climate Change Damages, Net Benefits of Adaptation and Residual Damages Associated with Low, Medium and High Climate Change Projections for 2050 and 2100 for **Restoring Full Yields to Irrigated Land and Supplemental Irrigation of Rain-fed Lands**

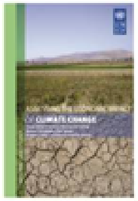
	Irrigated Crops			Rain-fed Crops		
Cases	Climate Change Damages (10^6 MKD)	Net Benefits of Adaptation (10^6 MKD)	Residual Damages (10^6 MKD)	Climate Change Damages (10^6 MKD)	Net Benefits of Adaptation (10^6 MKD)	Residual Damages (10^6 MKD)
2050 MED	-63.35	48.60	-14.75	-140.21	38.26	-101.95
2100 MED	-117.80	85.82	-31.98	-231.83	78.81	-153.02



Agriculture: Case study – With adaptation

Economic Values for Climate Change Damages, Net Benefits of Adaptation and Residual Damages Associated with Medium Climate Change Projections for 2050 and 2100 Comparing **Full Irrigation + Refurbishment on All Lands** with **Full Irrigation on Irrigated Land + Supplemental Irrigation on Rain-fed Lands**

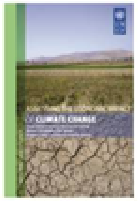
Cases	Restore water to irrigated land + supplemental irrigation for rain-fed land			Restore water to irrigated land + refurbish rest of area for full irrigation*		
	Climate Change Damages (10^6 MKD)	Net Benefits of Adaptation (10^6 MKD)	Residual Damages (10^6 MKD)	Climate Change Damages (10^6 MKD)	Net Benefits of Adaptation (10^6 MKD)	Residual Damages (10^6 MKD)
2050 MED	-203.56	86.86	-116.7	-203.56	156.33	-47.23
2100 MED	-349.63	164.63	-185	-349.63	258.99	-90.64



Agriculture: Key-findings and recommendations

The key findings of the analysis were:

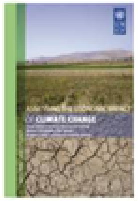
1. **Without adaptation, climate change is expected to reduce crop yields due to temperature changes and water cycle changes.**
2. **Without adaptation, climate change damages may grow to become approximately the same size or bigger than current net income – jeopardizing the economic sustainability of farming in some areas.**
3. **In the case study developed for the Strezevo irrigation preliminary analysis indicates that – if water is not the limiting factor – adaptation through irrigation may be a cost-effective measure even without climate change. This must be analysed on a case-by-case basis.**



Agriculture: Key-findings and recommendations

The key findings of the key study were:

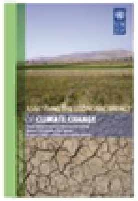
- In the Strezevo case there is sufficient water to meet increased demands if the areas irrigated are expanded. This is due to significant amounts of land which are not under irrigation.
- Without any adaptation, net income reductions (climate change damages) are expected for irrigated crops in the Strezevo irrigation area.
- These are projected to range between EUR 840,000 and 1.2 million per year by 2050 – depending on the severity of climate change.
- By 2100, these damages are expected to rise to between EUR 1.25 and 2.4 million.



Agriculture: Key-findings and recommendations

The key findings of the key study were:

- Without any adaptation, net income reductions (climate change damages) are expected for non-irrigated rain-fed crops in the Strezevo irrigation area.
- These are projected to range between EUR 1.37 and 2.66 million per year by 2050 – depending on the severity of climate change.
- By 2100, these damages are expected to rise to between EUR 3.14 and 4.41 million.
- Without adaptation, these climate change damages may grow to become approximately the same or bigger than current net income – jeopardizing the economic sustainability of farming in some areas.



Agriculture: Key-findings and recommendations

The capacity to simulate the impacts of climate change on crop yields is quite limited in the country.

Recommendation: Capacity building for use of CERES or EPIC (HIGH PRIORITY)

The capacity to estimate reductions in crop yields on resource allocation and net income at the farm level exists, but is not focused on climate change analysis..

Recommendation: A next step is to integrate their use into climate change and adaptation assessments and to blow up the scale of these models from the typical farm to the regional and national levels.

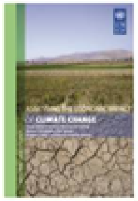
The capacity to simulate how climate change will affect the hydrologic cycle in catchments is not well developed.

Recommendation: Capacity building for rainfall runoff models as MIKE SHE (HIGH PRIORITY)

Agriculture: Key-findings and recommendations

The capacity to simulate how climate change will affect the soil water balance for crops is adequate enough for the time-being,
Recommendation: this capability is better integrated into simulation models that look at the whole plant response to climate, linking together major plant development processes (which CROPWAT does not do that well).

The capacity to estimate the benefits and costs of additional irrigation water supplies from the bottom-up is well developed, but the capacity to do this, conceptually, in a climate change framework, is quite limited.
Part of this is due to the need for more interaction between physical scientists and economists and part due to the intervention of outside experts who often circumvent and undervalue local capacity. Capacity Building



Agriculture: Key-findings and recommendations

OTHER LOW PRIORITY ISSUES RELATED TO MAFWE

- Developing sub-regional and national models of agricultural production in the context of the sector as a whole in any given area.
- Stand management models (and support data) for forests that include growth models to simulate the impacts of climate change and forest disturbances on the growth of managed forest types.
- A dynamic, two sector model of the agriculture and forest sector, for example through integration with EUFASOM.