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Economics of Climate Change

Climate Change Adaptation

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Presentation outline

- Market failures and climate change
- Valuation of CC impacts
- Decision making and CBA
- Case Study

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Climate change…

- An ethical concern?
  - Inequality
  - Poverty
  - Social impacts
  - Responsibility
- An economic concern?
  - Values
  - Costs
  - Benefits

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Some economic concepts

- Externalities
- Market failure
- Public Goods
- Marginal costs
- Public Policies
- Welfare
- Cost benefit analysis

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Climate change – A market failure

- Climate is a public good:
  - those who fail to pay for it cannot be excluded from enjoying its benefits and one person's enjoyment of the climate does not diminish the capacity of others to enjoy it too.
- Climate change is an externality:
  - Those who produce greenhouse-gas emissions are bringing about climate change
  - Costs on the world and on future generations
  - Who face the full consequences of the costs of their actions?
  - No economic incentive to reduce emissions
  - Not 'corrected' through any institution or market, unless policy intervenes.

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What type of externality

- Global
- Persistent and escalating impacts
- Uncertainties
- Impact on global economy

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Welfare and climate change

- Inequality:
  - poor countries, and poor people in any given country, suffer the most
  - the rich countries are responsible for the bulk of past missions.
- Ethical issues
  - how people in one country or region should react to the impacts of their actions on those in another.
  - how consequences for people in very different circumstances should be aggregated must be faced directly.

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Valuing the impacts of climate change

- Some issues:
  - Scale
  - Costs
  - Benefits
  - Methods
  - Discounting
  - Decision making
  - Investing

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Scale of Impacts

- Extreme weather events
- Health
- Agriculture
- Poverty

- Local vs global
- Developing countries vs Developed countries

- Growth and GDP

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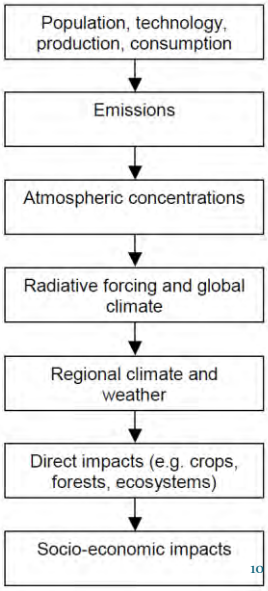
Global impacts of CC

- Integrated Assessment Models (IAMs)
- Uncertainty and risk
- Time value of money
- Market values vs Non-Market values
- Comparing cost of CC with Cost of Adaptation and Mitigation
- Different Models



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Some assessments (Stern, 2006):

- Using an Integrated Assessment Model, we estimate the total cost of Business As Uusal climate change to equate to an average reduction in global per-capita consumption of 5%, at a minimum, now and forever.
- But:
  - Including direct impacts on the environment and human health ('non-market' impacts) increases the total cost of BAU climate change from 5% to 11%, although valuations here raise difficult ethical and measurement issues. But this does not fully include 'socially contingent' impacts such as social and political instability, which are very difficult to measure in monetary terms;
  - Some recent scientific evidence indicates that the climate system may be more responsive to greenhouse gas emissions than previously thought, because of the existence of amplifying feedbacks in the climate system. Our estimates indicate that the potential scale of the climate response could increase the cost of BAU climate change from 5% to 7%, or from 11% to 14% if non-market impacts are included. In fact, these may be only modest estimates of the bigger risks – the science here is still developing and broader risks are plausible;
  - A disproportionate burden of climate change impacts fall on poor regions of the world. Based on existing studies, giving this burden stronger relative weight could increase the cost of BAU by more than one quarter.

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Valuing The Environment

- What does 'economic value of the environment' mean?
- How do we measure it, in principle?
- Why measure environmental values?
- Which methods to be used?

Why Measure Environmental Values?

- Use in environmental cost-benefit analysis for *policy* and *project* appraisal
- environmental management: e.g. coastal management increases recreational visits
- eco-tax setting: e.g. landfill tax, quarrying tax, carbon tax
- use in environmental adjustments to national accounts
- damage assessments

"Investing" in the climate

- Governments protect the environment in a number of ways
- Laws and regulations
- Environmental standards for production
- But how much should we spend on environmental protection?
  - Cost vs Benefits

Costs & benefits of environmental protection

- Cost-benefit analysis (CBA)
- Decision making tool to identify investments
- E.g. building new roads, hospitals or schools
- But also: to spend on environmental protection e.g. water quality standards, or protected areas
- Do benefits outweigh costs?

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Challenges…..

- What challenges do we face in measuring costs and benefits ?
- A hospital : costs?
- But what are the benefits ?
- A school: costs/benefits?
- A new road: costs/benefits?
- Protecting an existing wetland: costs/benefits?
- The environment : non-market impacts

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The environment : non-market benefits

- Most environmental projects deliver non -market goods e.g. biodiversity, clean environments, good health
- These are non-market goods
- Fish, timber, drinking water – these are market goods – e.g. prices exist to value them

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Measuring Environmental Values: Principles

- Theory behind environmental valuation is the same as that used to identify and understand demand curves for market goods
- What we measure:
  - Willingness to pay (WTP): the most you would be willing to give up to have something good (or avoid something bad)
  - Willingness to accept compensation (WTAC): the least you would accept in compensation to forego something good (or put with something bad)

What valuation method to use?

- You will often be able to identify some environmental impacts that can be related directly to market prices (e.g. lost fish catch , timber harvesting or non timber forest products.
- More elaborate valuation methods may be required for bigger projects;

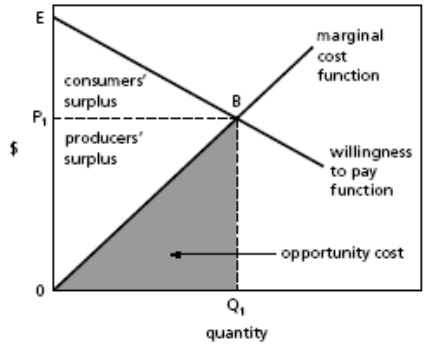
Keep it simple!

What is value?

- First, the economic view of "value" is anthropocentric.
- This means value is determined by people and not by either natural law or government.
- Second, value is determined by peoples' willingness to make trade-offs.
- When an individual spends money on one good, there is less available for other goods.

Value for market goods

- For market goods, the demand and supply curves can be observed and derived
- Consumers surplus and producer surplus
- Net value for a market good is equal to the sum of CS + PS



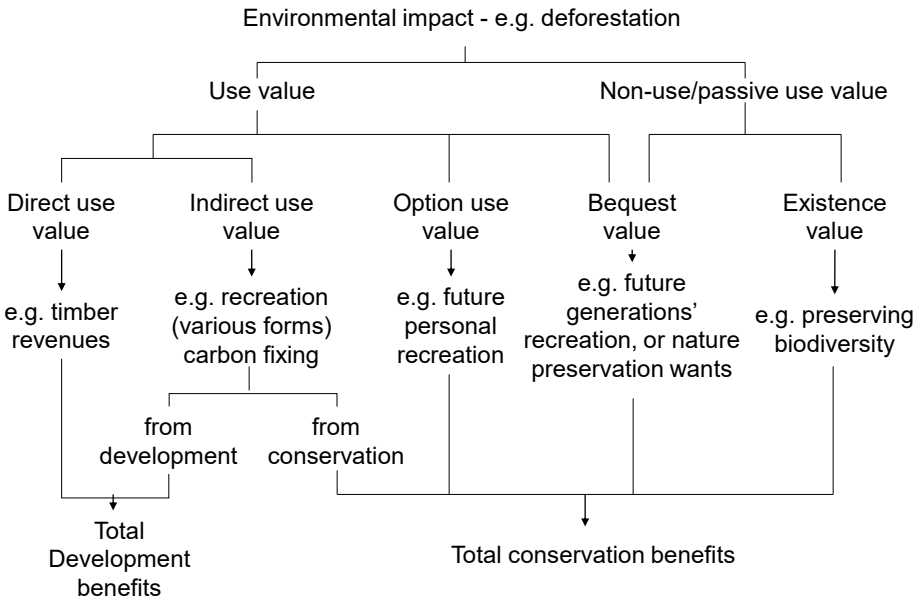
Value and Non-market Goods

- We do not observe prices for non-market goods, so it is hard to estimate supply/demand functions
- Non-market goods may have both direct use, indirect use and non use values.
  - Direct use values are associated with tangible uses of environmental resources
  - Indirect use values are associated with indirect benefits from ecological services
  - NUV are those associated with more intangible uses of the environment
  - Not mutually exclusive

Non-use values

- Bequest values
  - Bequest value refers to the fact that an individual values having an environmental resource or general environmental quality available for his/her children or grandchildren to experience.
- Existence value
  - Existence value refers to the fact that an individual's utility may be increased by the knowledge of the existence of an environmental resource even though the individual has no current or potential direct use of the resource.
- Altruistic value
  - Altruistic value occurs out of one individual's concern for another. A person values the environment not just because that person benefits from the environmental quality but because the person values the opportunity for other people to enjoy high environmental quality.

ECONOMIC VALUE OF THE ENVIRONMENT



Techniques for Measuring the Value of Non-market Goods

- 3 major categories for measuring the value of non-market goods include:
  - Revealed preference techniques, which look at decisions people make in reaction to changes in environmental quality.
  - Stated preference techniques, which elicit values directly through survey methods.
  - Benefits-transferred techniques, which look at existing studies for value of analogous environmental change.

Revealed Preference Approaches- 1. Hedonic Pricing Technique

- Market prices - many environmental goods can have a market price (e.g. Fish catch)
- Hedonic pricing techniques are based on the theory of consumer behavior that suggests that people value a good because they value the characteristics of that good rather than the good itself.
- An examination of how the price of the good varies with change in the levels of these characteristics can reveal the prices (value) of the characteristics.

Hedonic Pricing Technique

- Assume that all the characteristics of houses and neighborhoods are the same throughout the city.
- Houses with higher air quality would have higher prices.
- This positive relationship can be represented by the following equation:
  - H = a + bQ,
  - where H is housing price, Q is air quality and "b" tells the researcher how many units H will increase with each unit of air quality.

Revealed Preference Approaches- 2. Travel Cost Model

- The travel cost model is a method for valuing environmental resources associated with recreational activity and was first proposed by Harold Hotelling in 1947.
- The basic premise is that travel cost to a site can be regarded as the price of access to the site.
- Multiple observations on travel cost and quantity of visits can be used to estimate a demand curve.
- Composition of a demand curve for visits to the area

Travel Cost Model

- Methodological issues :
  - How to incorporate the opportunity cost of travel time.
  - How to properly account for substitutes (multiple sites).
  - How to account for a variety of sampling biases (over-response by frequent visitors, under-response by infrequent visitors)
  - How to properly measure recreational quality and relate this to environmental quality.

Stated Preference Techniques-
1. Contingent Valuation

- The questions used in contingent valuation can take both open-ended and close-ended form.
- In open-ended questions, respondents are asked to state their maximum WTP.
- In close-ended questions, respondents are asked to say whether or not they would be WTP a particular amount.
- The questions must also specify the mechanism by which payment will be made.

Contingent Valuation: Problems

- Information is provided about cause and effect.
- The payment vehicle is clearly stated and is appropriate to the particular problem.
- Care must be taken so that the contingent valuation exercise does not become a referendum on the payment vehicle, for example the choice to raise taxes.
- WTP vs WTA
- Carefully consider the responses

Stated Preference Techniques- 2. Choice experiments

- Determining individual preferences across different levels of characteristics of a multi-attribute choice.
- Consumers are asked to state which of 2 hypothetical goods they prefer, each having a stated level of different characteristics.
- These choices can be made in a pair-wise fashion or by ranking a number of alternatives.
- Statistical techniques are used to establish a relationship between characteristics and preference.

Benefit Transfer Approaches

- The process of estimating values using revealed preferences or stated preferences approaches can be quite expensive.
- Taking values from studies that were previously completed in other areas, and applying them to the area where the new decision must be made.
- It is important to use a reference study that is congruous.
- If many reference studies are available, the process becomes much easier.
- The appropriate reference study can be chosen, or a weighted average of the values can be employed, where weights are chosen according to similarity between the reference study and the problem at hand.

Non-willingness to Pay Based Value Measures

- Avoidance cost – the cost people incur to avoid the negative consequences of an environmental change.
- Replacement cost – the cost of recreating what was lost to environmental change.
- Restoration cost – the cost of repairing the environmental damage.

Stages of CBA

- Definition of Project
- Identification of project impacts
- Physical quantification of relevant impacts
- Which impacts are economically relevant? .
- Monetary valuation of relevant effects
- Discounting the cost and benefit flows
- Applying the Net Present Value Test
- Sensitivity Analysis

CBA for Climate change action

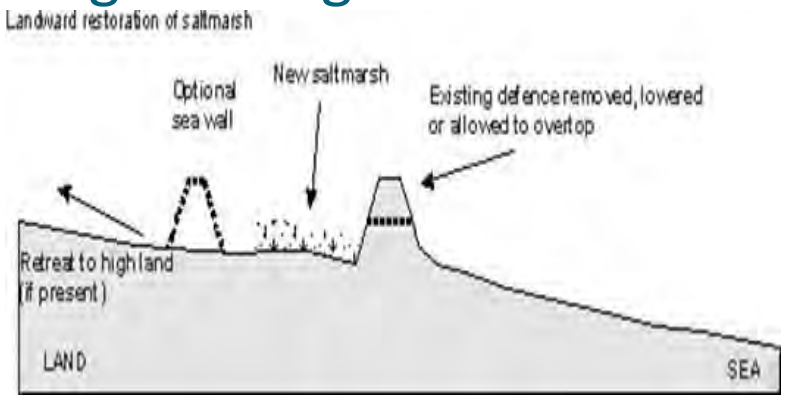
- CBA and climate change:
  - Mitigation
  - Adaptation
- We should treat adaptation and mitigation investments like other projects
- Adaption/mitigation investments are a cost
- But they mean we avoid impacts
- In other words they provide benefits

Definition of Project

- For a given cost how big are the benefits of an adaptation ?

- Let's look at managed realignment of coastal defences
- Suppose we are considering a project that has a life of 10 years

Managed realignment



Identification of project impacts

- Costs of moving sea defences
- Costs of managing land around existing defence
- Loss of some land and productive possibilities - e.g. loss of agricultural production

Identification of project impacts

- Benefits?
  - Reduction of damaging floods
  - Creation of new wildlife habitats
  - Recreational visits

- Decision making: are benefits >costs ?

Physical quantification of relevant impacts

- Investment costs –e.g. labour & materials
- Costs of foregone agricultural production
- Land purchase or simply the value of foregone crop revenues

Physical quantification of relevant impacts

- Benefits:
- Biodiversity ?
- Fish catch (quantity * price)
- Fewer flooding episodes (avoided cost)
- Recreational visits? (quantity of visits * value)

Which impacts are economically relevant?

- Translate the prices and quantities into values that can be entered into a spreadsheet as a cost or benefit

- E.g. annual increased fish catch
- Before 600 tonnes * $40/tonne = $24000
- After 750 * 40 = 30000
- Benefit = 30000 – 24000 = 6000

How to deal with values which occur through time?

- The time value of money - we prefer goodies now rather than later
- Discounting - provides a means to collapse different flows to their present value equivalent for comparison.
- The discount rate - Indicates how much more a society values a $1 today compared with a #1 next year.
- Opportunity Costs, i.e. the sacrifice made for not investing in another project.
- The net present value – the discounted value of chash flows from a project minus the project cost

Discounting

- Why Discounting?
- Ramsey equation:
  - $r = \rho + \eta \cdot g$
  - ρ – Time preference ; η – coefficient related to utility; and g – growth rates .
- 0.1 - 2.5%
- Declining discount rates

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Net Present Value

Year	Cash flows
Year 0	$- C_0$
Year 1	$C_1 \times \frac{1}{(1+r)^1}$
Year 2	$C_2 \times \frac{1}{(1+r)^2}$
Year 3	$C_3 \times \frac{1}{(1+r)^3}$
Year 4	$C_4 \times \frac{1}{(1+r)^4}$
Year …	….
Year n	$C_n \times \frac{1}{(1+r)^n}$

$$\sum \quad NPV = \sum_{n=1}^{N} \frac{C_n}{(1+r)^n} - C_0$$

Sensitivity Analysis

- Apply to all projects with quantified benefits and costs
- Involves recalculating project results for different values of major variables and combinations of variables.
- Developing "what if" scenarios
- In this way, the CBA becomes more robust concerning any challenges to its original assumptions.

Economic Assessment of climate change impacts in the protected areas between Drini-Mati River Deltas

A task performed within the project ”Identification and Implementation of Adaptation Response Measures in the Drini - Mati River Deltas” – A project fundetby the GEF and implemented by the Ministry of Environment and the UNDP Climate Change Program in Albania

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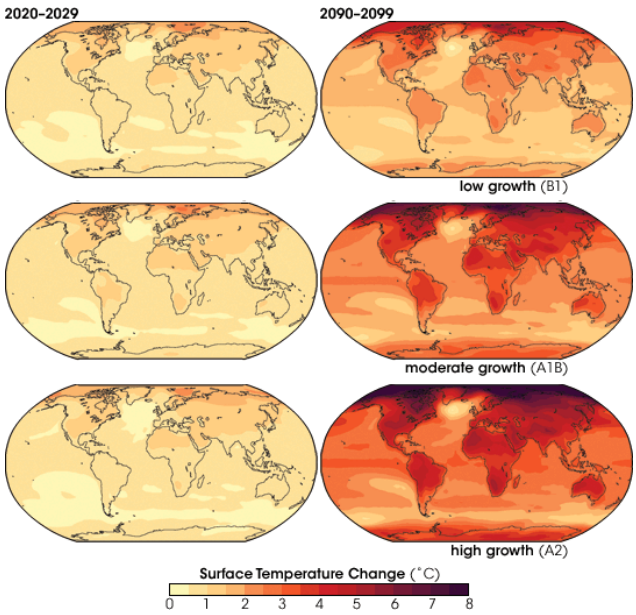
Projections of future changes in climate

Projected warming in 21st century expected to be

greatest over land and at most high northern latitudes

and least over the Southern ocean and parts of the North Atlantic Ocean



Climate change impacts

- Increase of weather disasters
- Public water supply and drinking water
- Biodiversity loss
- Agricultural production
- Forestry yield
- Energy for heating and cooling
- Tourism and recreation
- Health

Background information on the project and the protected area

- The Drini and Mati River Deltas (DMRD) are 2 of 3 deltas found on the northern Adriatic coast of Albania, which harbour significant biodiversity values.
- The DMRD has been identified as a region of critical vulnerability to climate change and variability.
- Climate change scenarios for Albania have predicted an increase in sea surface temperature and sea level rise of up to 61 cm.
- Serious stress on marine and littoral biodiversity as well as livelihoods of local communities.

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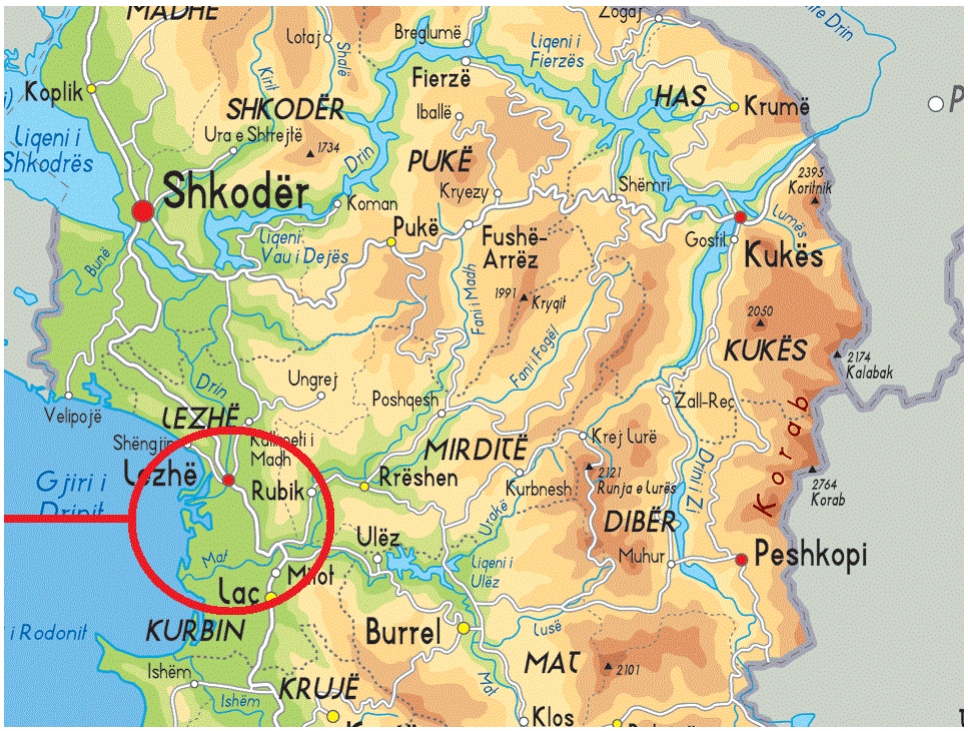

Communes within the project area

Climate impacts in the project area

- Biodiversity
- Agriculture
- Tourism
- Fishing
- Human settlements
- Ecosystem carbon

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Parameters	Unit	2030	2050	2080	2100
Annual temperature rise	°C	1.2 (0.8-1.3)	1.8 (1.3-2.4)	2.8 (2.1-4.1)	3.2 (2.3-5.0)
Number of days with temperatures ≥ 35°C	Days	4-5	6-7	8-9	10-11
Number of days with heat wave	Days	60	80	95	120
Precipitation decrease	%	3.9 (2.6-5.4)	8.1 (5.5-11)	12.9 (8.4-21)	15.5 (9-26)
Hazardous precipitation	Days	1-2	2-3	3-4	4-5
Sea level rise - Average scenario - Maximum scenario	cm	8 (5–14)	15 (7-28) 16 (9-29)	28 (12-53) 35 (15-62)	38 (15-72) 49 (21-91)
Coastline erosion for maximum scenario of sea level rise	Ha	520	1450	2860	5350

Impacts of sea level rise and coastal erosion		2050		2100	
		av. min	av. max	av. min	av.max
Net loss of wetland area	km^2	0.14	0.58	0.41	1.04
People actually flooded	1000/year	0.019	0.040	0.006	0.007
Coastal floodplain area	km^2	56.14	59.20	57.19	65.95
Coastal floodplain population	thousands	4.14	4.33	3.99	4.61
Total wetland area	km^2	4.5	4.06	4.22	3.60
Coastal forest area	km^2	1.14	1.01	1.12	0.91
Low unvegetated wetlands area	km^2	3.37	3.05	3.10	2.69

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Projection of coastal line in 2030

Source: Ndini, Mucaj 2010

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Projection of coastal line in 2050

Source: Ndini, Mucaj 2010

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Projection of coastal line in 2080

Source: Ndini, Mucaj 2010

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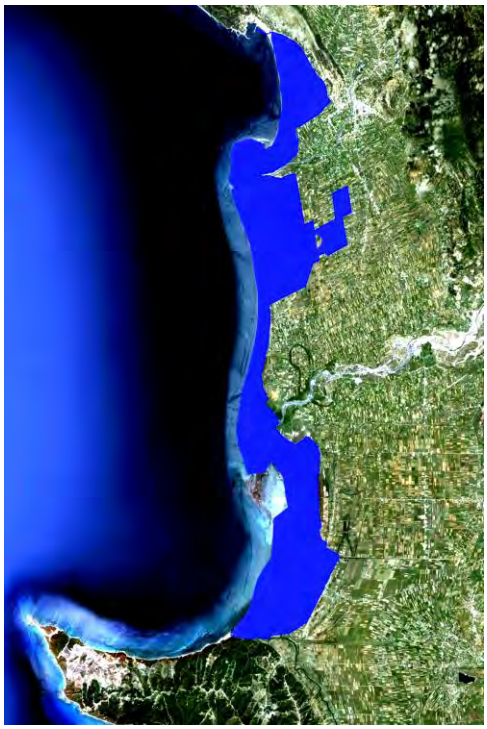
Projection of sea level rise in 2100



Source: Ndini, Mucaj 2010

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Valuation of damages from climate change

"Do nothing" Scenario:

- Damage from flooding event
- Damages from the loss in Agricultural production
- Damages from the decrease of coastal recreation
- Damages from loss in Biodiversity
- Damages from the decrease of fishing yields

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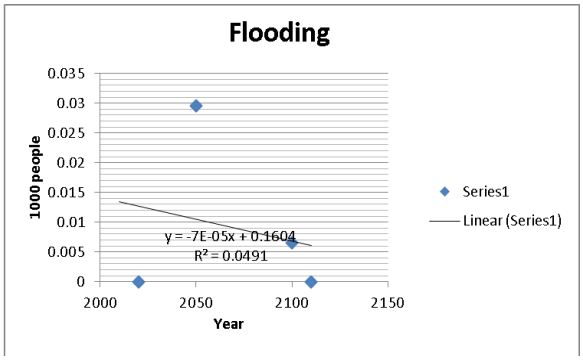
Flooding events

- Benefit transfer technique
- A damage value of Euro 26,301 per household in Albania (derived from a similar study of Meyer and Messner, 2005)
- 5% discount rate applied over 40 years



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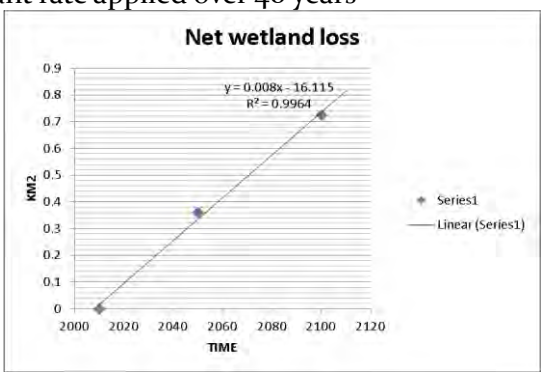
Wetland loss

Wetland values (biodiversity)

- Avoided predicted loss of area multiplied by a WTP - derived from an international meta analysis of wetland value studies – value of saltmarshes/year = 5734 Euro.
- The value include a national and international dimension of value, since these wetlands are internationally significant.
- 5% discount rate applied over 40 years



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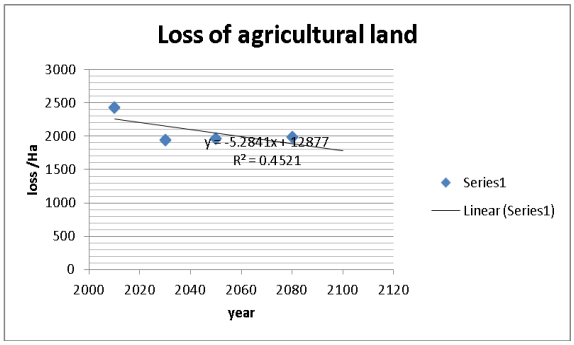
Loss of agricultural land

- Using the market values for crop yield derived from data on the yield and value of alternative field crops.
- We use wheat and salad crops to illustrate a high and low value (i.e. price) range for the damage cost.
- 5% discount rate and a 40 year horizon



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Tourism demand and the value of beach recreation

- Avoided lost visits – using the zonal travel cost method
- Shengjini beach receives 12,800- 40000 visitor days per year and attracts visitors from nearby areas, as well as visitors from Kosovo and FYROM.
- The beach will be partially destructed by 2080 in "do nothing" scenario.
- Data inputs for the ZTCM:
  - The number of visits that an individual or family makes to a touristic area during a year
  - The cost of travel to the area, including: the monetary cost of the trip and the cost of time spent in the area
- Outcome: deriving a demand curve for visits to the area

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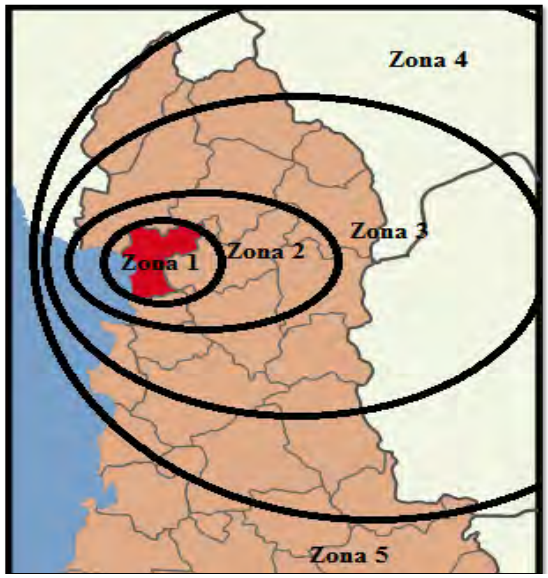
Assumptions



Daily and weekly visits to Shengjini Beach

Starting point: 26400 visits/year

Annex 1: Summary of daily and weekly visits to Shengjini Beach

Areas	Description of the area	Total number of daily visits	Percentage of tourists coming from each area for daily visits	Number of daily visits from each area	Total number of weekly visits	Percentage of tourists coming from each area for weekly visits	Number of weekly visits from each area
Area 1	Villages and towns in the district of Lezha	13200	33.3%	4400[4]	0	0	0
Area 2	Kurbini, Miredita, Puka		33.3%	4400	13200	10%	1320
Area 3	Kukës, Tiranë		33.3%	4400		40%	5280
Area 4	Dibër, Kosovë, Maqedoni	0	0	0		50%	6600
Area 5	Beyond the above listed areas	0	0	0	0	0	0
Total		0	100%	13200	0	100%	13200

Source: Calculation of the Author

Calculation of the visitors report

Annex 2: Calculation of the visitors report

	Total number of daily visits	Number of weekly visits converted in daily visits (weekly visits *8 days)	Total daily visits	Population from each area	Visitors report (Visits/inhabitants)*1000
Area 1	4400	0	4400	77184	57.0066335
Area 2	4400	10560	14960	105968	141.1746942
Area 3	4400	42240	46640	763050	61.1231243
Area 4	0	52800	52800	3909000	13.50729087
Area 5	0	0	0		0

Source: Calculation of the Author

Annex 3: Total cost of travel to the area

Area	Average round trip distance from Shengjini (km) (1)	Direct cost of travel (2)	Average time of travel (min) (3)	Time of weekly travel distributed per day 4)	Average daily time spent in the area (min) (5)	Total time (6) = (4+5)	Average/minimal e wage (7)	Cost of time spent traveling (8) = (7)*(6)	Total daily cost per visit (9) = (2+8)
1	0	0	0	0	480	480.0	3.8	1824.0	1824.0
2	100	2500	96	3.2	480	483.2	3.8	1836.0	4336.0
3	168	4200	132	10.2	480	490.2	3.8	1862.7	6062.7
4	428	10700	378	54	480	534.0	5.35	2856.9	13556.9

Notes:

(1) The average distance is calculated from the center of the area for areas that are within Albania, and from the average distance of some of the main cities of Kosovo (Pristina, Prizren, Peja) and Macedonia (Gostivar, Tetovo, Skopje)

(2) Direct cost of travel is calculated based on technical information on the average consumption in a standard vehicle: the average consumption for vehicles with smaller motorized power than 80-110 Kw is 9 liters per 100 km. The average price of fuel used for the trip is taken 200 lek / liter (including depreciation). The value of consumption per km calculated in this way results 25lek / km, which is considered a low value, considering that similar studies us a value of 0.3 Euro / km. The lower value is used to include in the average of all cases, even for those visitors traveling in groups or for those traveling by public transport.

(4) The weekly travel time spread over days represents the conversion and distribution of time spent on the trip shown in column (3) in each of the days within week because the weekly trips include one round trip in the area and not daily traveling. Calculation of converted time is accomplished by considering the percentage of weekly visits compared to total visits.

(5) The time spent in the area represents the time of one working day converted in minutes, so (8 hours*60 min), time which is actually spent on holiday, reflecting the opportunity cost of labor.

(6) The average salary is derived from the data of the Statistical Institutes in all three countries: Kosovo, Macedonia and Albania in 2013.

Source: Calculation of the Author

Demand curve for visits in the area

VR = 107.229 – 0.006*TC

Annex 4. Details on coordinates of demand function

Entry fee	0	6500	7000	8000	9000	10000	11000	12000	13000	14000
Number of visitors	26400	24054	21215	15538	9861	4184	2179	1128	665	202

Source: Calculation of the Author

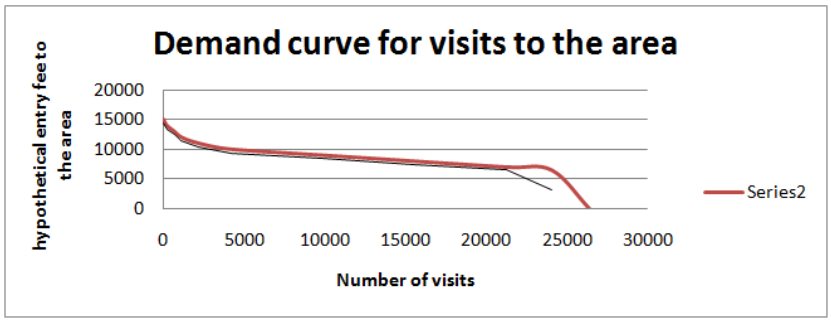
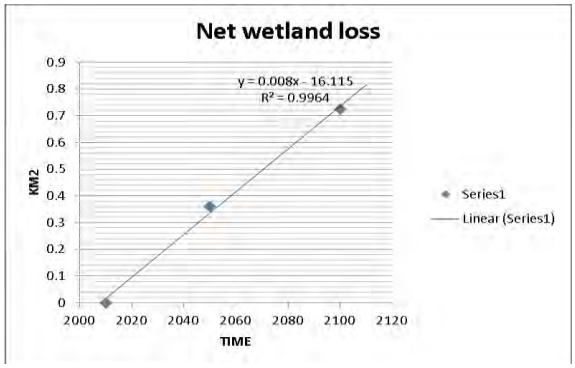


Figure 2: Demand curve for visits to the area

Source: Author

Fishing

- Using the market data for calculation of avoided lost yield multiplied by prevailing market prices for key species – average price 500 ALL (aprox. 5 $)
- We draw a link between wetland area (km²) and the current volume of fish harvest.
- 5% discount rate and a 40 year horizon



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Summary of Impacts

Value category	Estimated NPV (million Euro)
Wetland loss WTP	0.7
Flood damages	1.7-1.9
Agricultural land loss Approximated by wheat (low value) and salad crops (high)	0.05-0.9
Forest carbon	0.00015
Coastal beach recreation	1.6
Fishery loss	9
Total	12.3-15.07

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