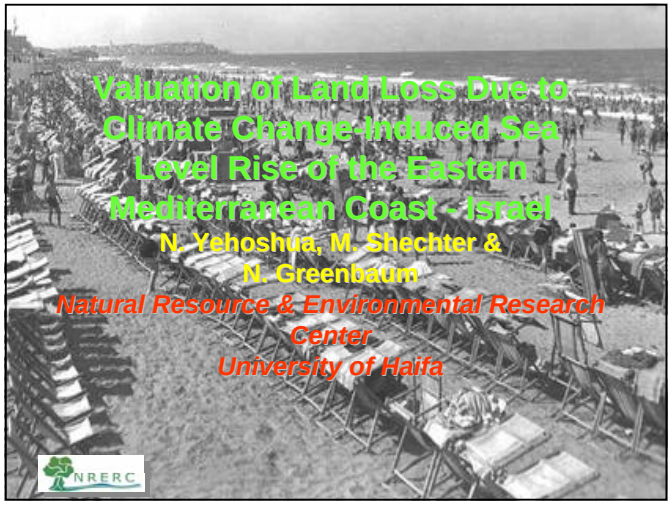


The assessment of the impacts of sea level rise is a prospective, interdisciplinary and complex

GHG emission scenarios

↓

GHG concentration scenarios

↓

Oceanic & atmospheric Temperature change scenarios

↓

Sea level Rise scenarios

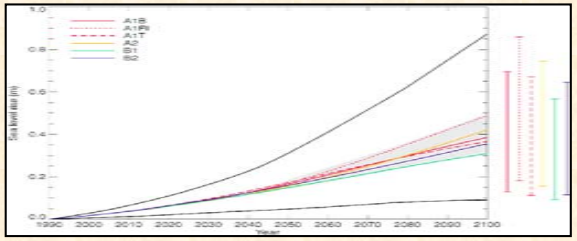
↓

Local SLR scenarios

NRERC

Sea level Rise: recent assessments

- Sea level rise is one of the most troubling effects related to future climate changes
- IPCC (2001) predicts a SLR of about 0.5 meter up to the end of the century, according to different scenarios.



NRERC

Major Impacts

- Erosion & inundation: Two primary mechanisms that induce land loss due to SLR
- Seawater intrusion into fresh groundwater
- Rising risks of storm floods
- Encroachment of tidal waters into estuaries and river systems
- Destruction of coastal ecosystems & Coastal biodiversity

This study will focus on the first impact (land loss)

NRERC

Research Objective

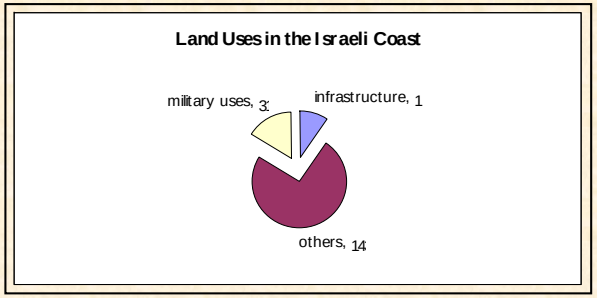
- To assess the major impact of sea level rise: land loss due to permanent inundation and erosion focusing on the Israeli Mediterranean coast.
- To investigate the loss of economic welfare due to the narrowing of beach & coastal lands in recreational uses.
- Underlying assumptions:
  - 100 cm SLR by around 2060
  - No adaptation measures

An Overview of Israel's Mediterranean Coast

Physical characteristics:

- Total length -196 km
- No substantial-size islands
- The coast is part of the littoral sedimentary cell of the Nile R.
- Typical coast profile:
  - Gravel cliffs in the east
  - Downhill to the cliff - relatively narrow sandy strip of variable width

Land uses in the Israeli Coast



The Coastline as a Public Recreational Resource

- High demand:
  - Suitable climate and water temperature
  - Lack of other water recreation sites
  - Accessibility to majority of population centers
- Limited supply:
  - Relatively short coast (straight, no islands)
  - Major parts are occupied by military & infrastructure
  - Relatively narrow sandy strip (gravel cliffs)

→ Excess demand for recreational uses

Methodological scheme

Determine magnitude & location of land loss

↓

Characterize ordinal rating of value of costal lands

↓

Estimate a monetized value (using benefit-transfer)

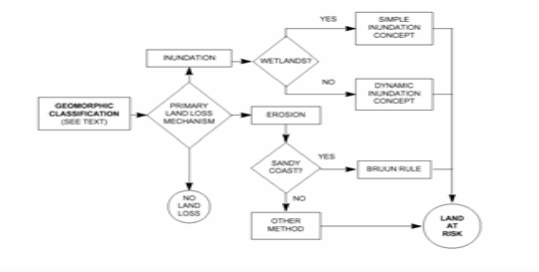
↓

Assess land losses due to SLR

Estimating land loss:
How much land is lost and where?

- Two primary mechanisms of land loss:
  - Erosion- physical removal of sediments- basically measured according to Bruun rule (1962)
  - Inundation- simple inundation
- The appropriate mechanism was selected according to the geomorphologic characteristics of the coast

Estimating land loss (2):
How much land is lost and where?



Source: *Klein, 1999*

Estimating land loss (3):
How much land is lost and where?

- Data sources:
  - GIS based maps (covering only 30% of the coast length)
  - Detailed topographic maps (1:10,000) available for the entire coast
  - Detailed map of Haifa bay, where a substantial land loss was suspected (estuary)
- The various sources were used to calibrate the results

Estimating land loss (4): How much land is lost and where?

The Israeli coast was divided into 9 sections, each was associated with the appropriate land loss mechanism: erosion or inundation

The classification was based on:

- Lythology
  - Beach resistance and type
- Morphology
  - Coast formation

Area characterization

- The main objective: determine the value (*ecological, social, and other*) of the shoreline
- To this end, the coastal strip was divided into 87 cells
- The relevant level was set according to two basic criteria - Accessibility and Social importance - determined by four parameters:
  - Proximity to population centers
  - Recreation attractiveness
  - Archeological & heritage sites
  - Accessibility

characterization

parameter	rating	characterization
Proximity to population centers	1 0 -1	High proximity medium proximity Low proximity
Access convenience	1 0 -1	High accessibility Medium accessibility Low accessibility
Recreation value importance	1 0 -1	High value Medium value Low value
Heritage & archeology importance	1 0 -1	High value Medium value Low value

- *Each cell received total rating according to these parameters*
- *The accumulated rating ranged between -4 to 4 (9 value categories)*

Assigning economic values to the ordinal ratings

- The vast majority of land area subject to SLR-induced losses is dedicated to publicly provided recreation and leisure activities
- The valuation of benefits is ordinarily based on non-market methods (TCM, CVM etc.)
- We employed existing estimates of non-market valuations of beach recreation, using a Benefit Transfer Method.

Assigning economic values to the ordinal ratings (2)

- Most of these estimates measured *WTP for coastal recreation per visitor per day*
- Transforming these estimates into land values:

$$Vs = \frac{N}{S} * WTP$$

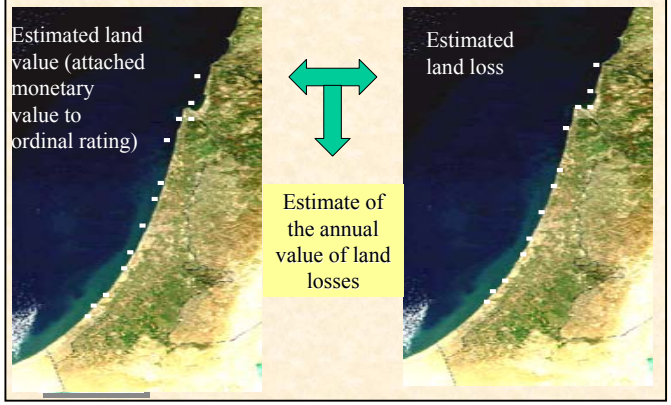
Vs = value of a unit of land area
N = number of visits per annum
S = total area of the shoreline according to the statutory definition (a strip of 100m from water line)
WTP = willingness to pay per visit

Assigning economic values to the ordinal ratings (3)

Ordinal rating of the beach cell	Attached value according to "transferred" estimates Per m^2 (Euro per annum) in that beach cell
4	35.71
3	24.02
2	10.36
1	6.87
0	4.73
-1	3.93
-2	2.65
-3	1.85
-4	0.79

Range of estimates transformed into m^2 value

Estimating future impact of SLR



Total Damage Estimates

$$TD = \sum_{1}^{t} \frac{\frac{t}{60} * X}{(1+\alpha)^t} + \frac{\frac{X}{\alpha}}{(1+\alpha)^{60}}$$

t= 1....60

TD = total capitalized monetary value of future land loss

X = the loss per year at SLR of 1m

α = time discounting rate

t = years from the present (2000)

Discussion

- ***Physical*** **impacts per 1m SLR:**
  - Total estimated land loss expected: 8.7 km^2
  - Average coastal retreat: 51m
  - The total land loss indicates that the Israeli coast is **relatively insensitive** to the phenomena, however:
  - Major parts of the coastal strip (where the coastal cliffs are close to the water line) may disappear

Discussion (2)

The damage to the coastal cliff induced by SLR

- The coastal cliff collapse/retreat is substantial and may cause land loss (resulting in further collapse) by itself, along with capital and real-estate loss
- This particular (and important) impact was not quantified in this study because the cliff is *already* retreating at a very high rate (24 cm per year!) as result of several additional reasons, and there is a scientific dispute over the relative contribution of SLR to this phenomenon.

Economic Assessments

- The estimated *annual* damage of land loss is about € 55 mil.
- The total capitalized damage is relatively sensitive to the level of the discounting factor and the number of years to 1m SLR

Total capitalized damage(€ mil.)

Years to full potential	Discount rate		
	1%	3%	6%
30	4,286	1,103	400
60	3,732	780	234
100	3,140	535	145

Discussion

- The results indicate that the annual value of the coastal strip, serving as a public resource for recreation, could reach **€ 6.4 mil per km^2**
- In comparison, the annual value of an average km^2 resulting from the sometimes-used "*National product per area*" method equals **€ 3.7 mil.**

Some Conclusions

- The sensitivity of the Israeli Mediterranean Coast is relatively low (regarding future land losses due to SLR)
- However, the ***value*** of the future land lost is relatively high, considering its major use as open space in a semi-arid, highly densely populated region with few water-based summer recreational alternatives
- Land loss is only one of the impacts induced by SLR (itself being only one among CC-induced impacts in this region)

Thank you !!