Flood risk reduction using vegetated foreshores

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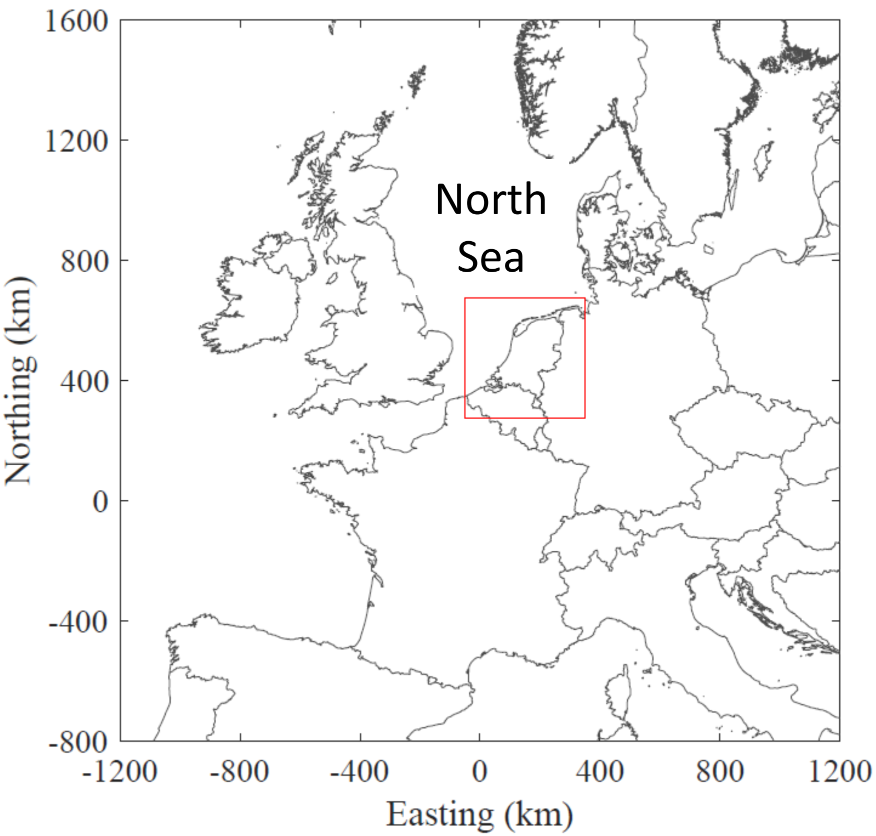
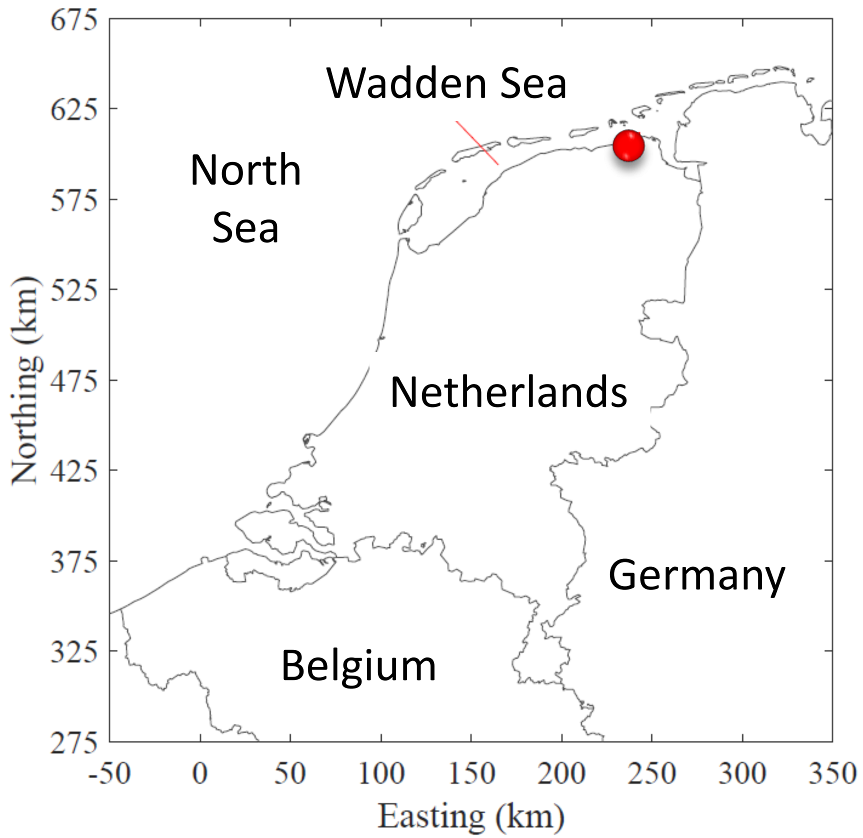
Vegetated foreshores

Vegetated foreshores

Study site


1600
1200
800
400
0
-400
-800
-1200
-800
-400
0
400
800
1200
North
Sea
Northing (km)
Easting (km)

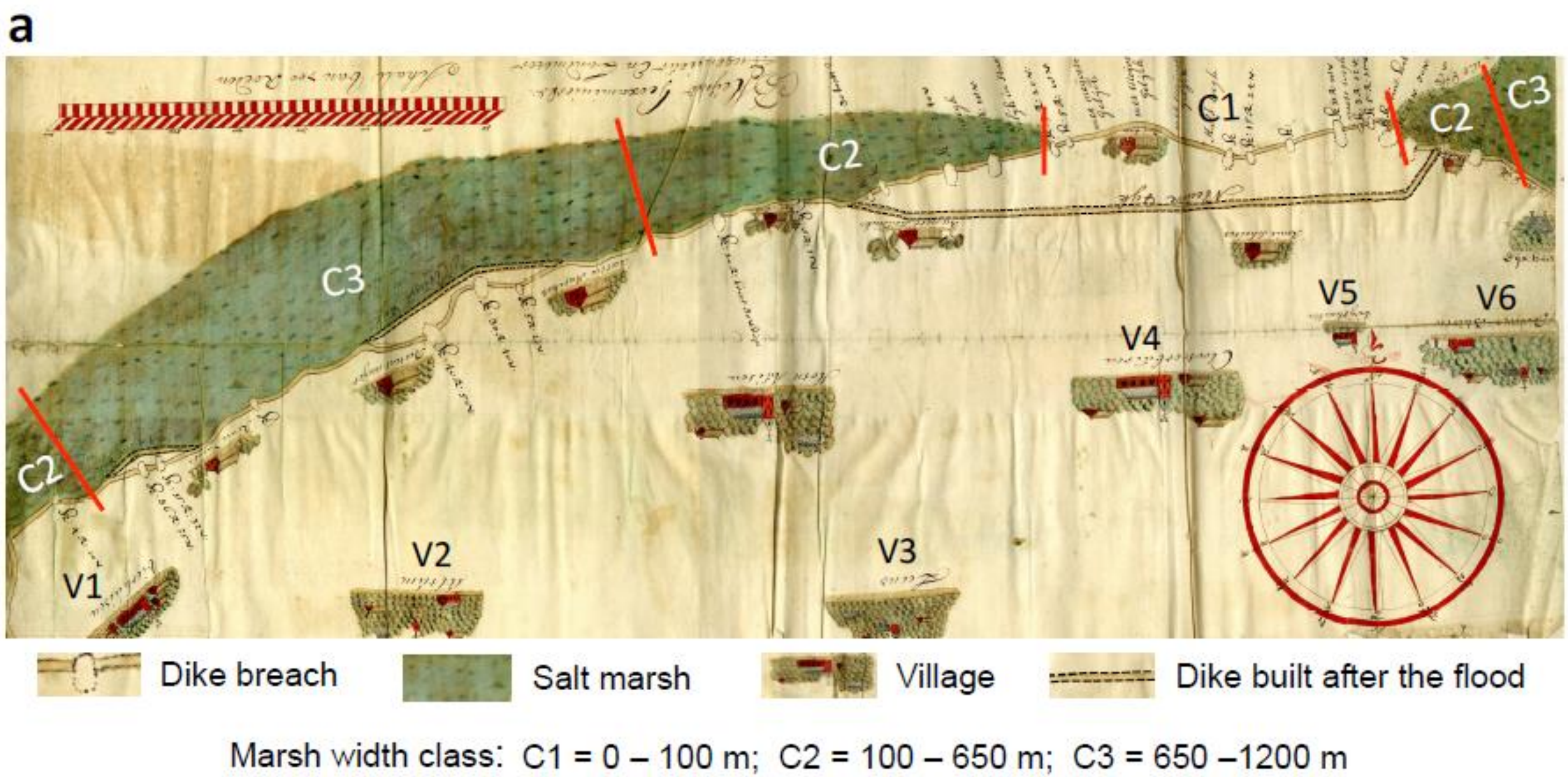

675
625
575
525
475
425
375
325
275
-50
0
50
100
150
200
250
300
350
Wadden Sea
North
Sea
Netherlands
Germany
Belgium
Northing (km)
Easting (km)

Contents

1. Evidence for wave load reduction
2. Failure probability of a dike with foreshore
3. Cost effectiveness

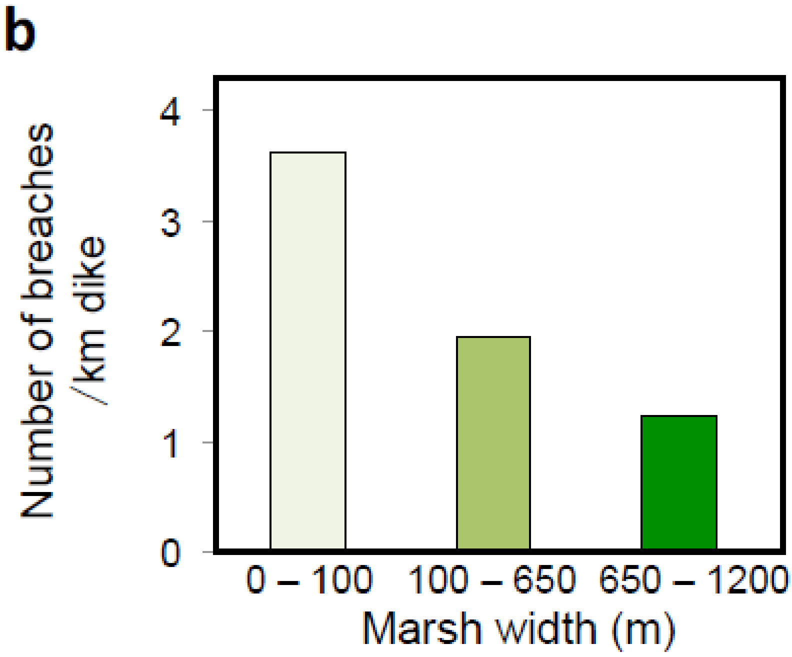
Christmas Flood 1717

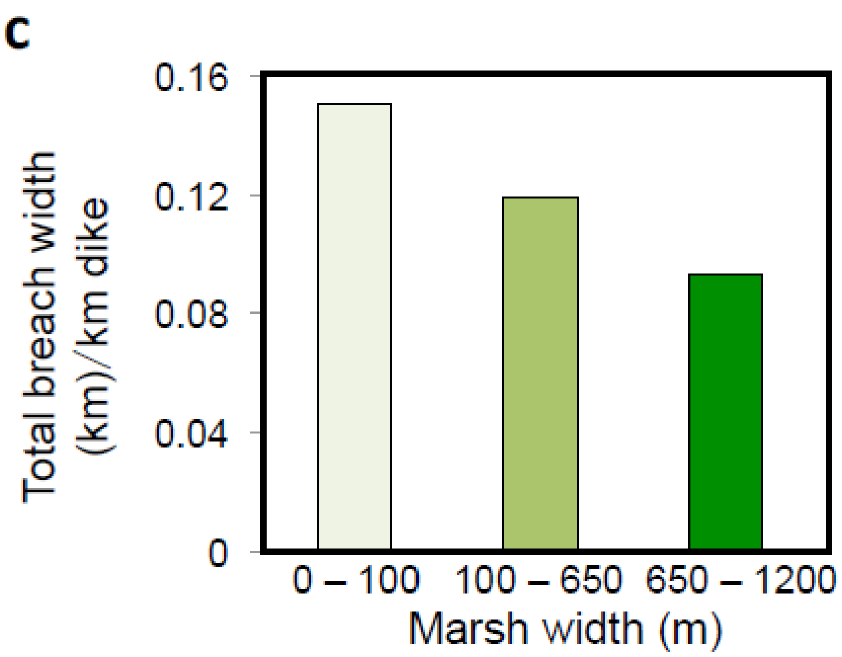
Christmas Flood 1717



Zhu et al. (2018) *in prep.*

Christmas Flood 1717

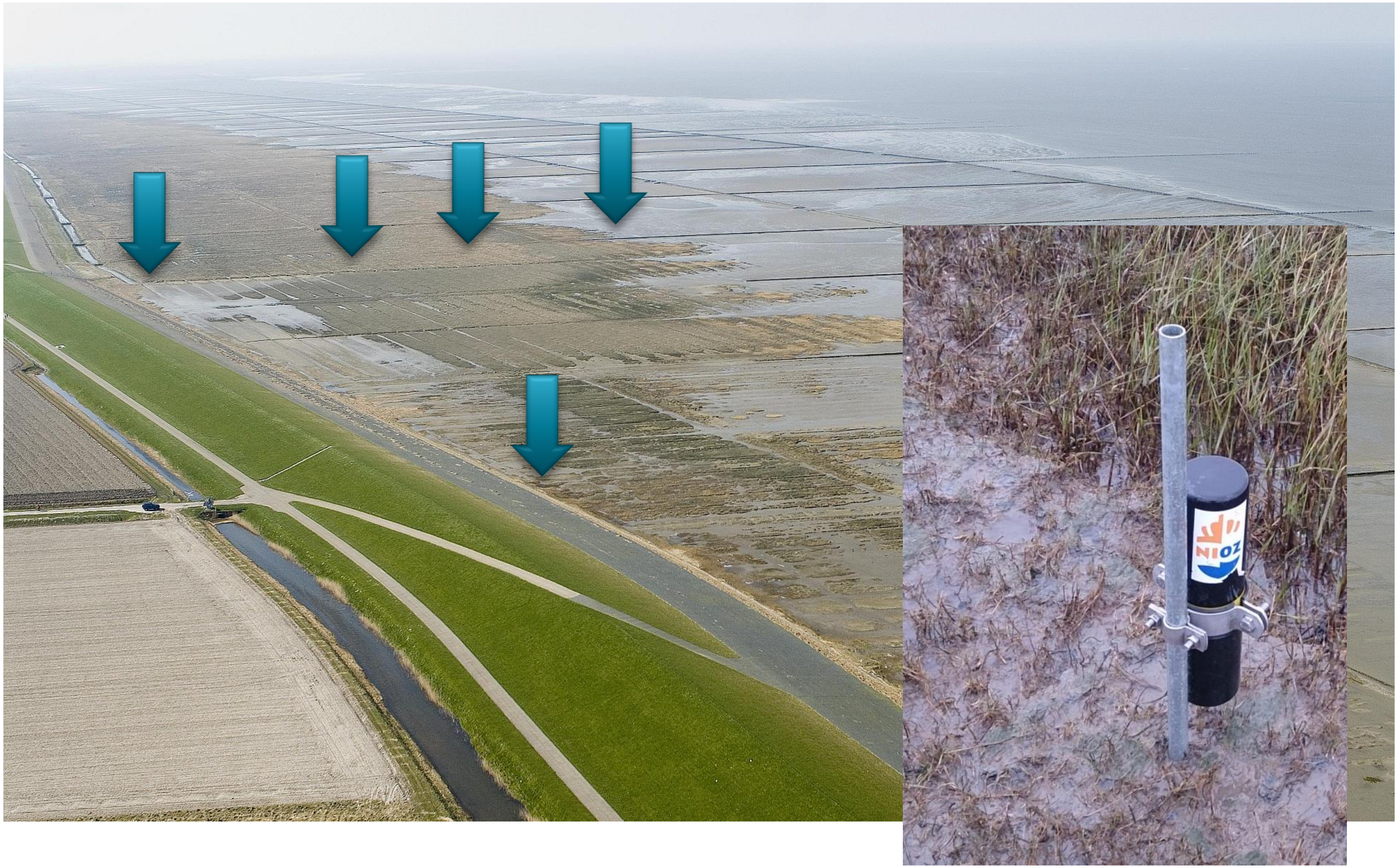




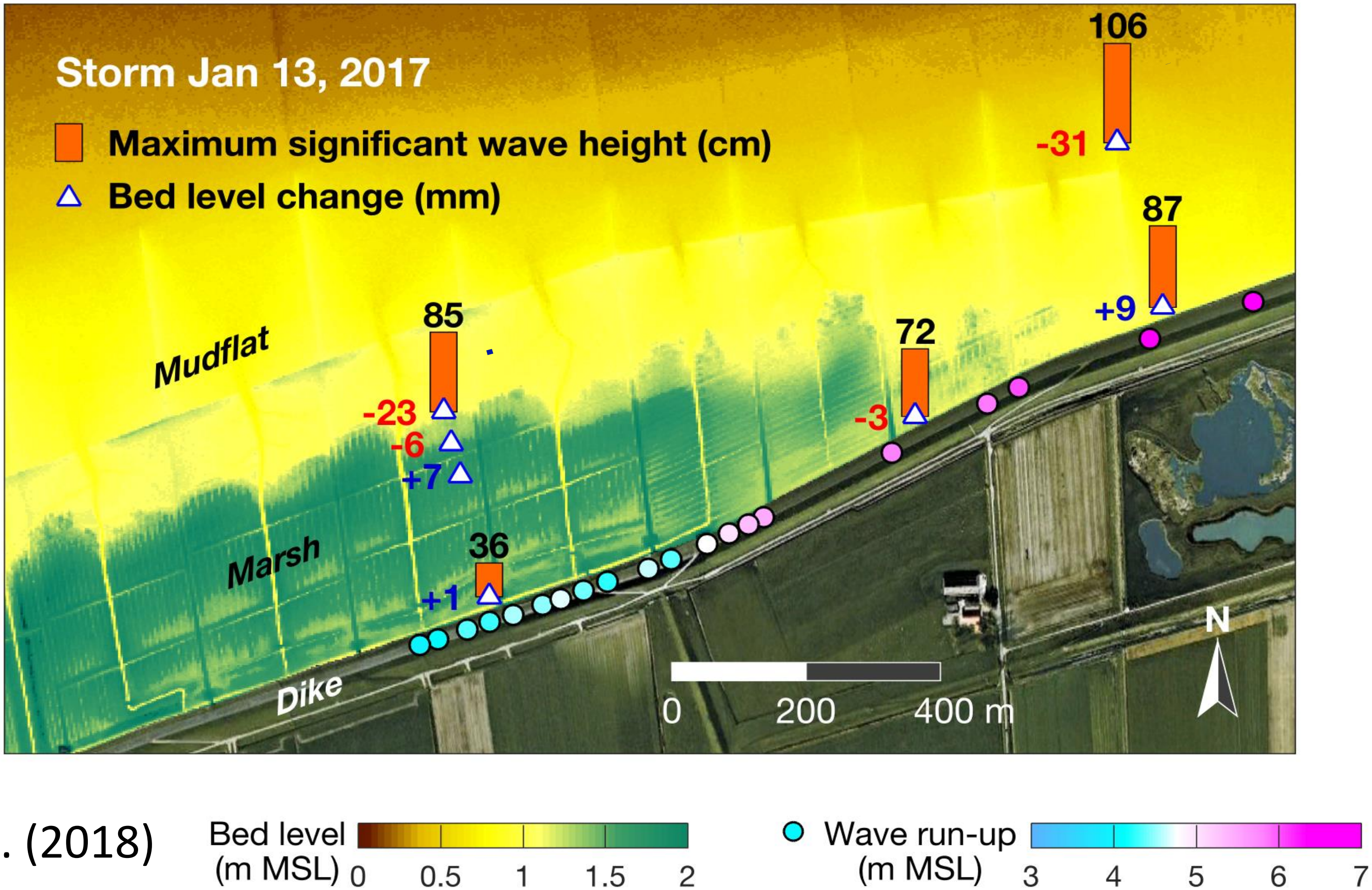
Zhu et al. (2018) *in prep.*

Wave measurements

Wave measurements

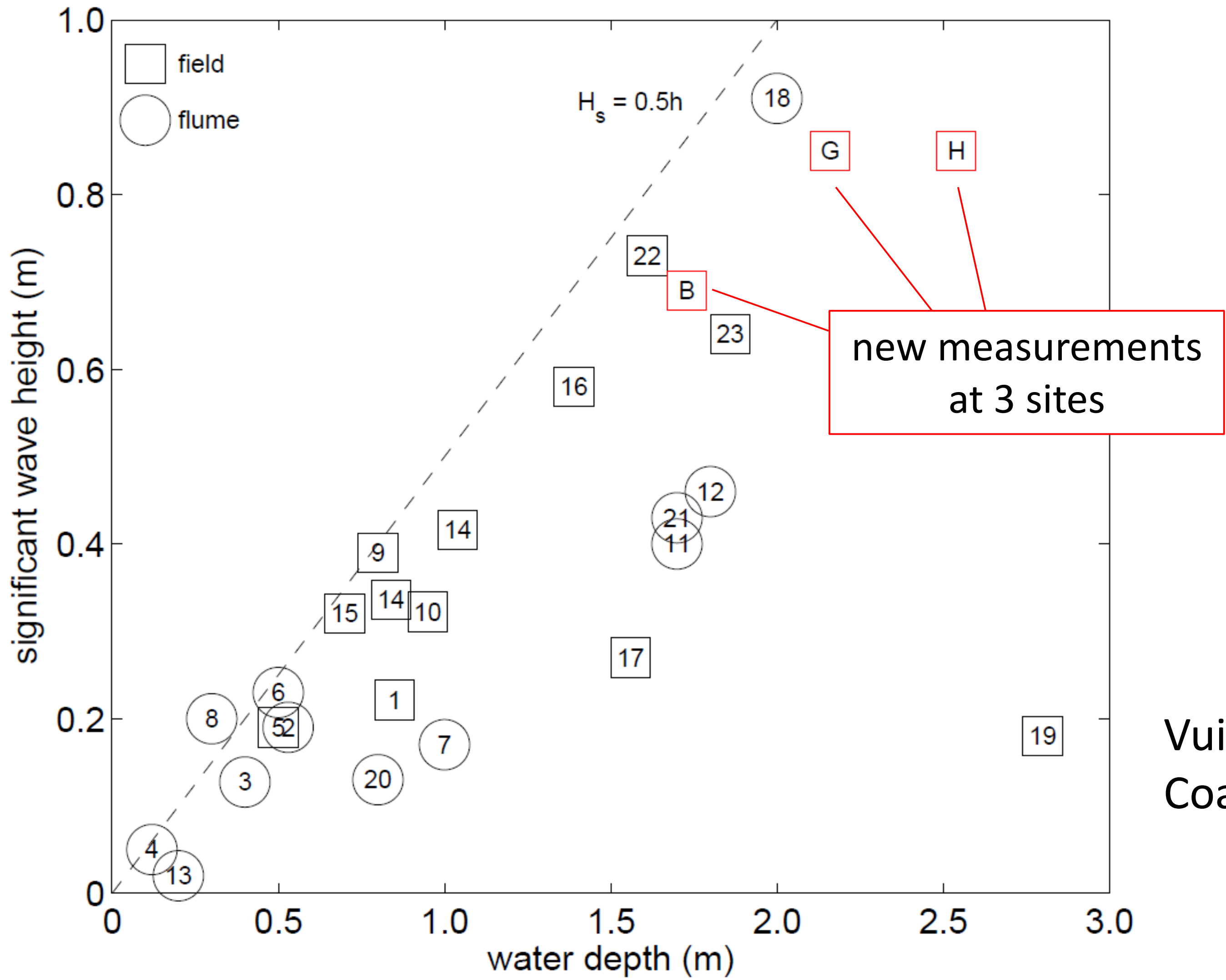


Wave measurements



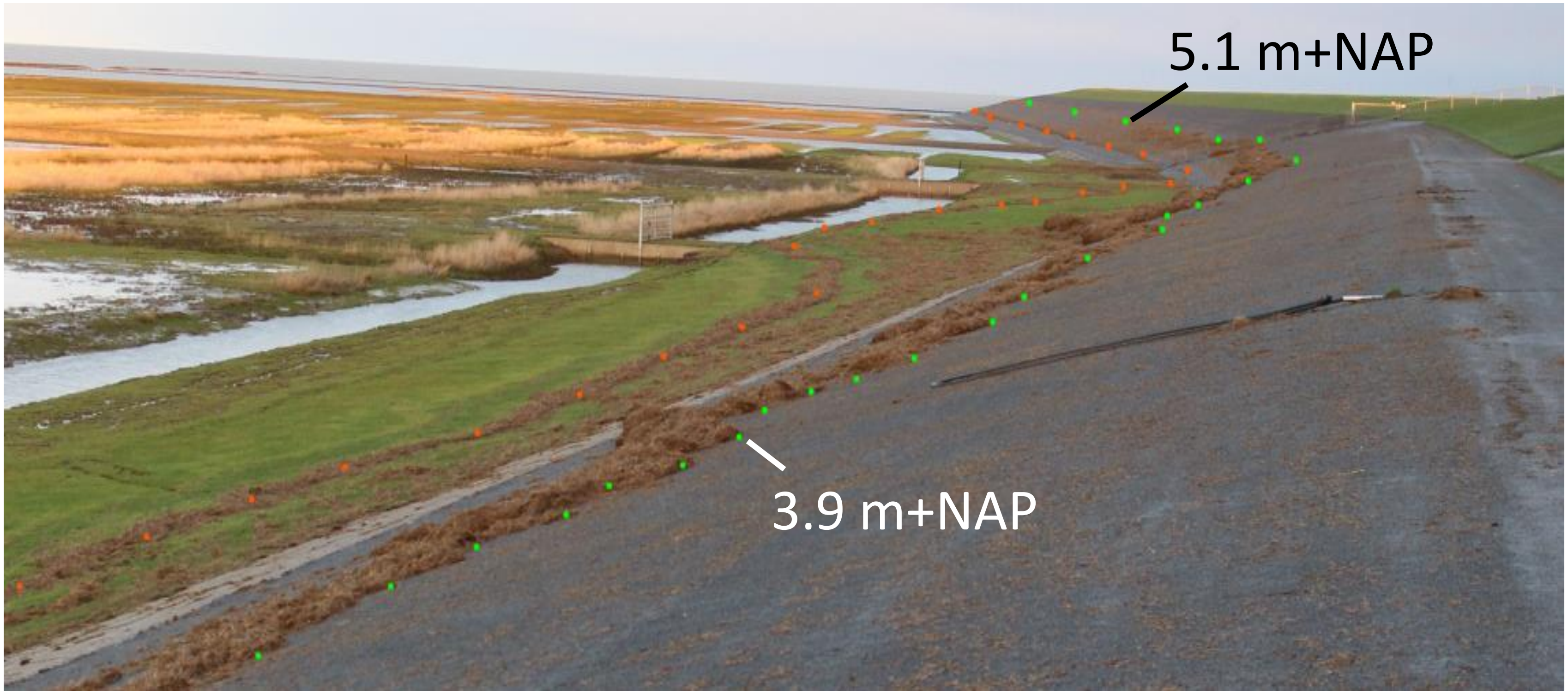
Zhu et al. (2018) in prep.

Wave measurements

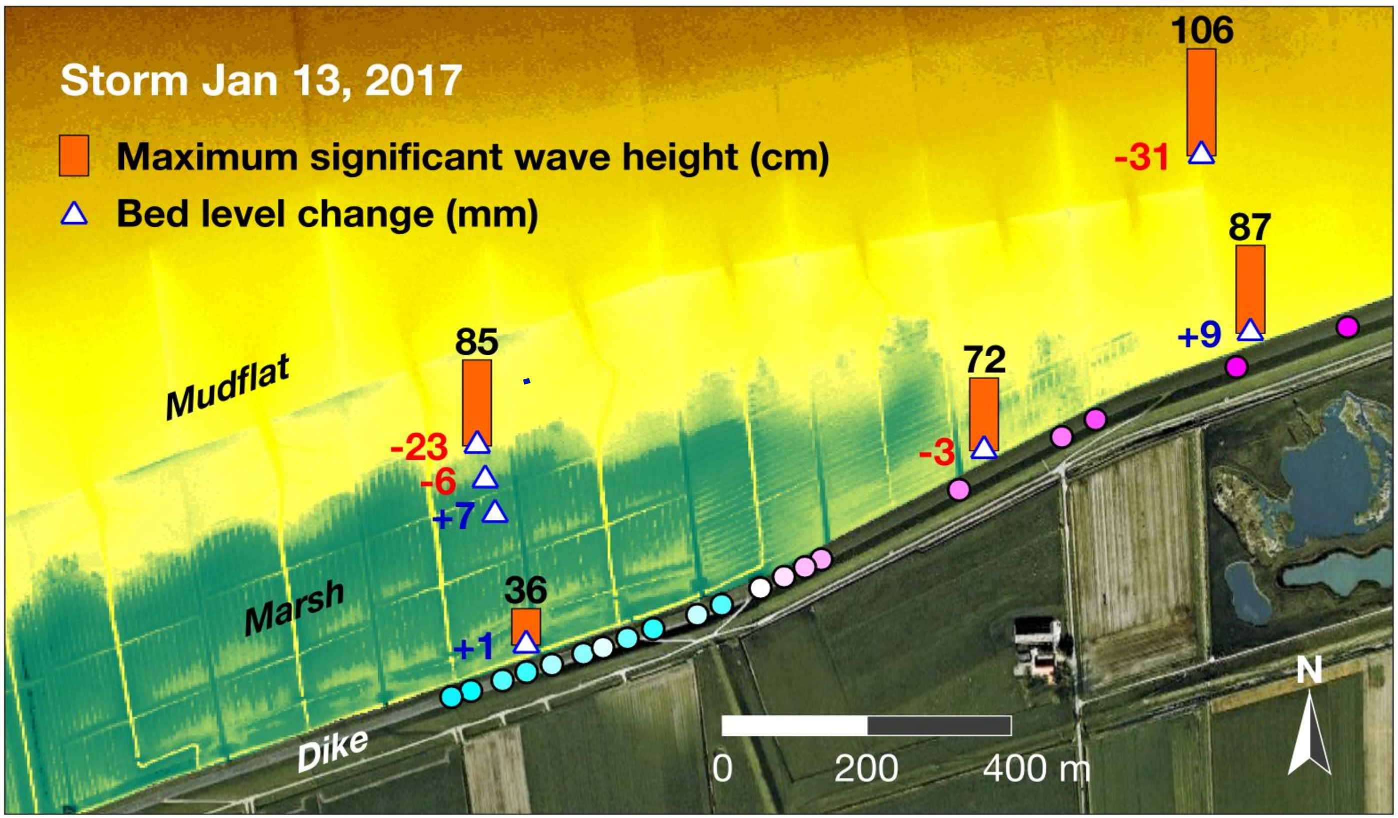


Vuik et al. (2016)
Coastal Eng.

Wave run-up

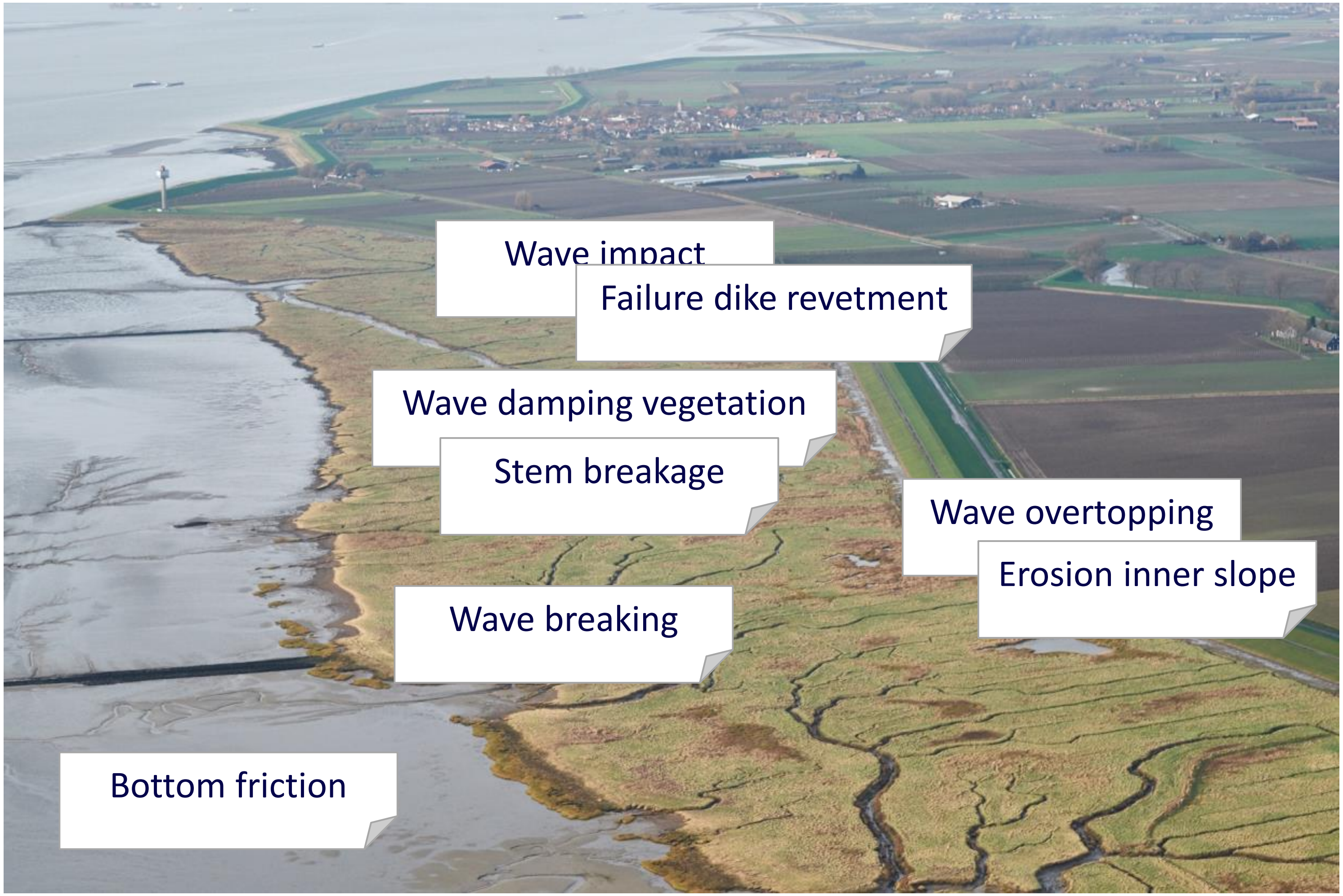


Wave run-up

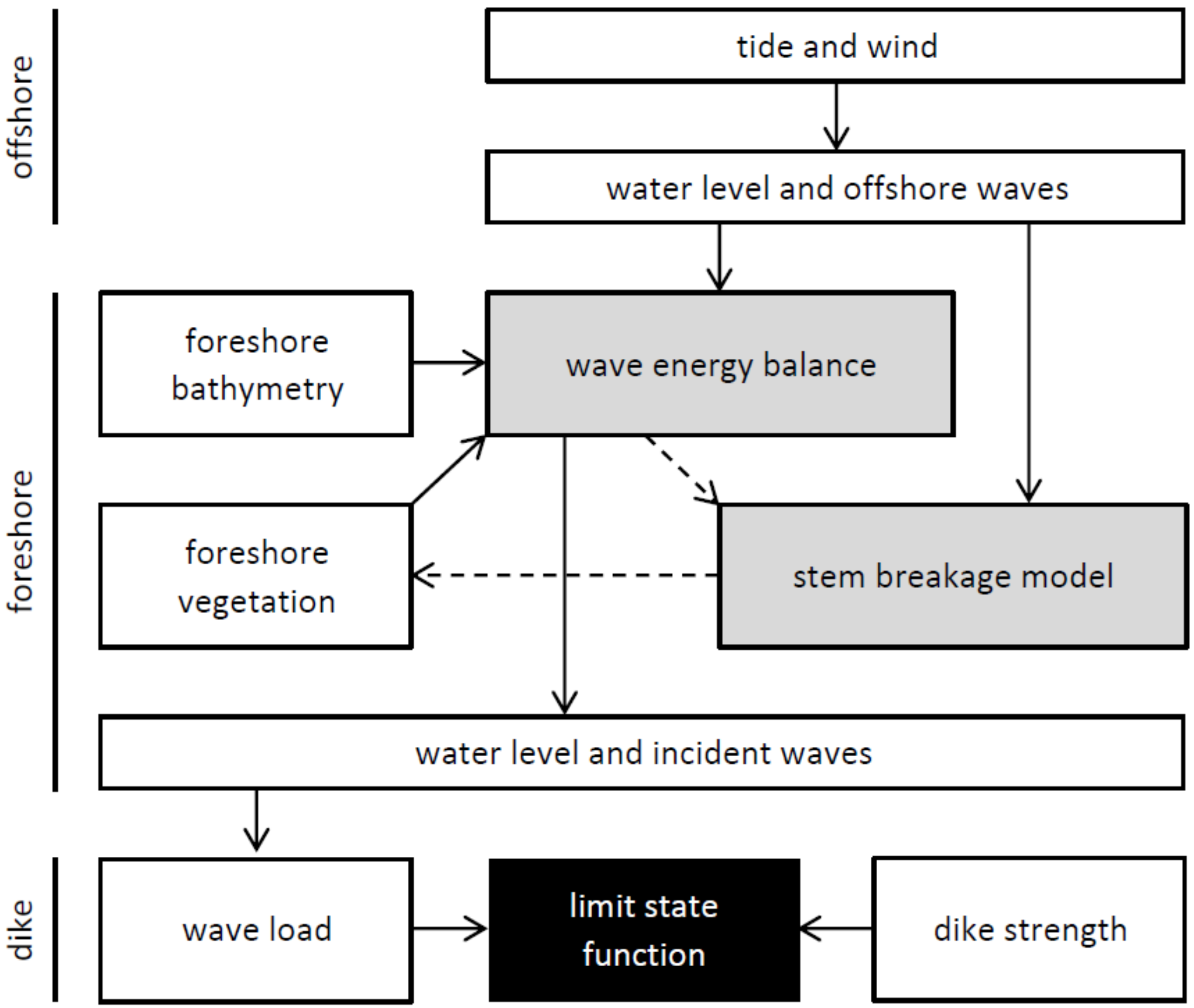


Zhu et al. (2018) in prep.

Physical processes



Failure probability calculation



Limit State Functions

Wave overtopping

EurOtop (2016) vs. tolerable discharge

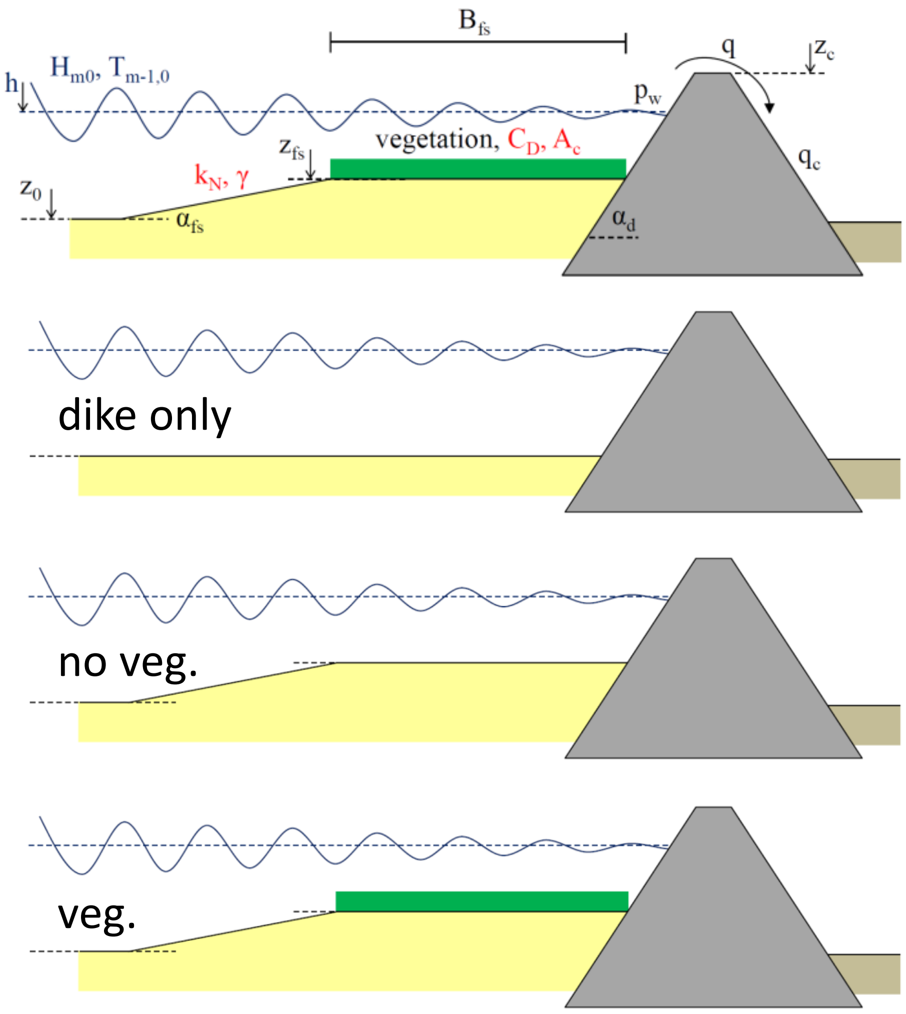
Asphalt (fatigue)

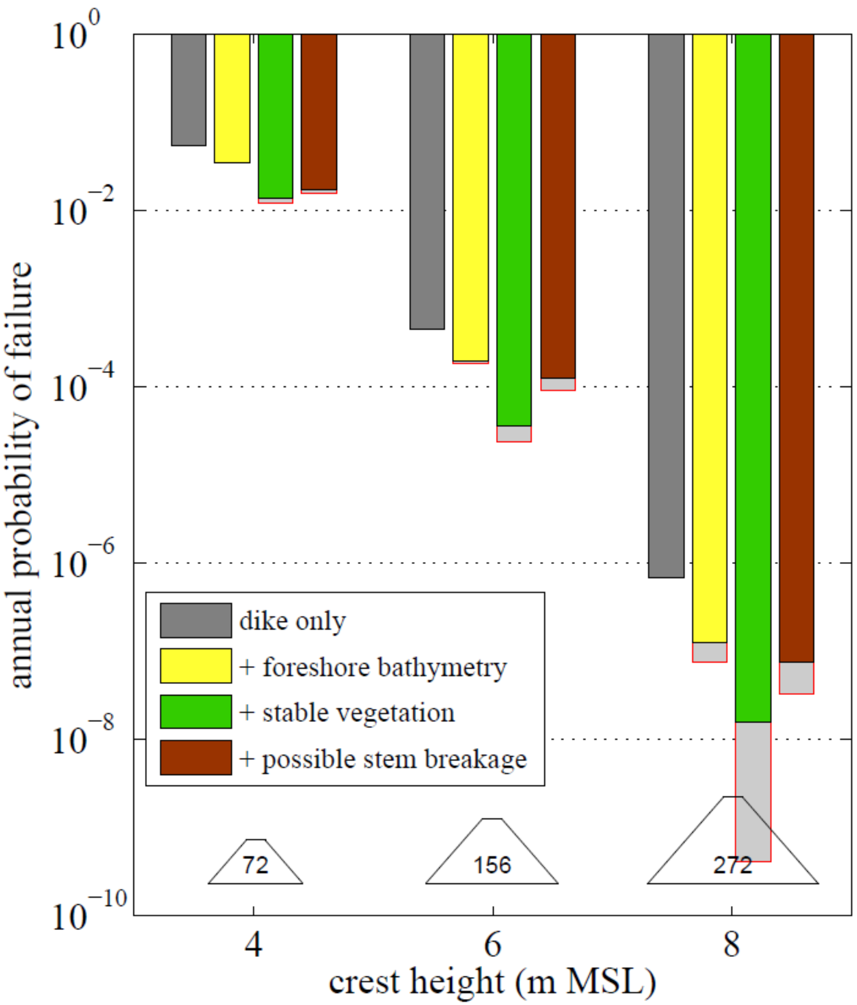
Actual vs. tolerable number of waves

Grass (erosion)

Storm duration vs. 1/(erosion rate)

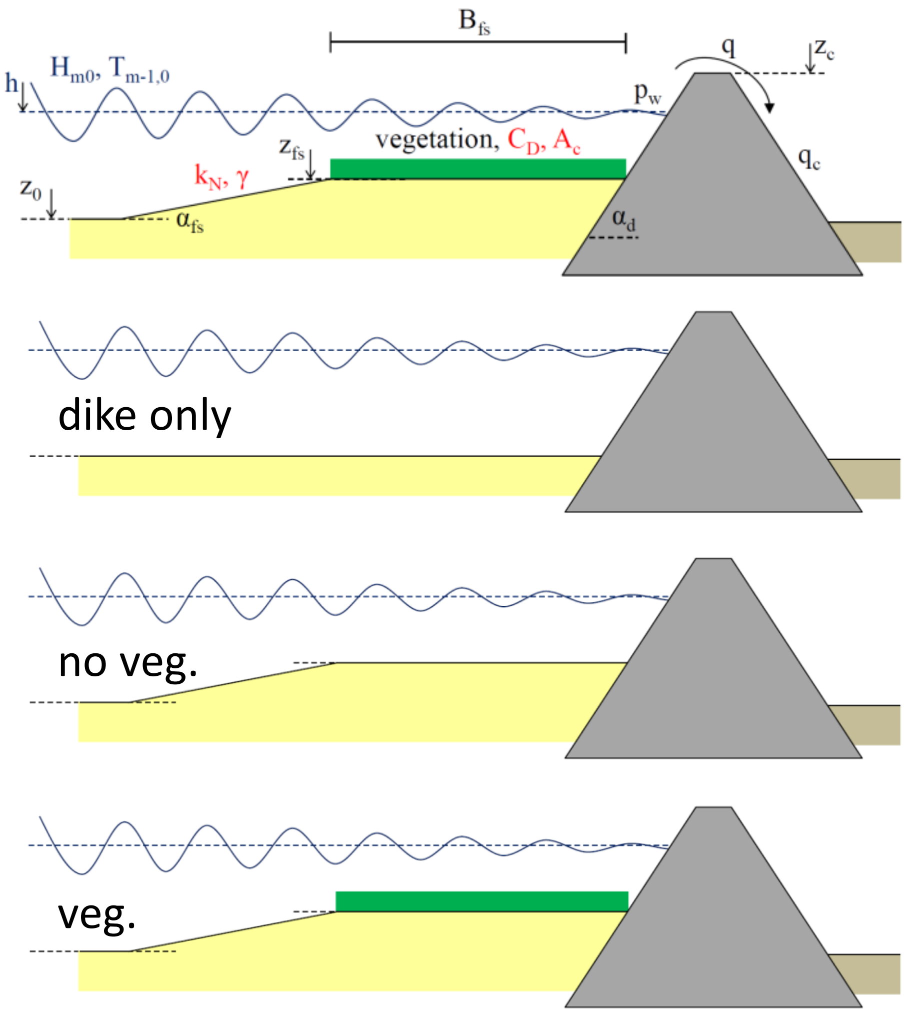
Probability of failure

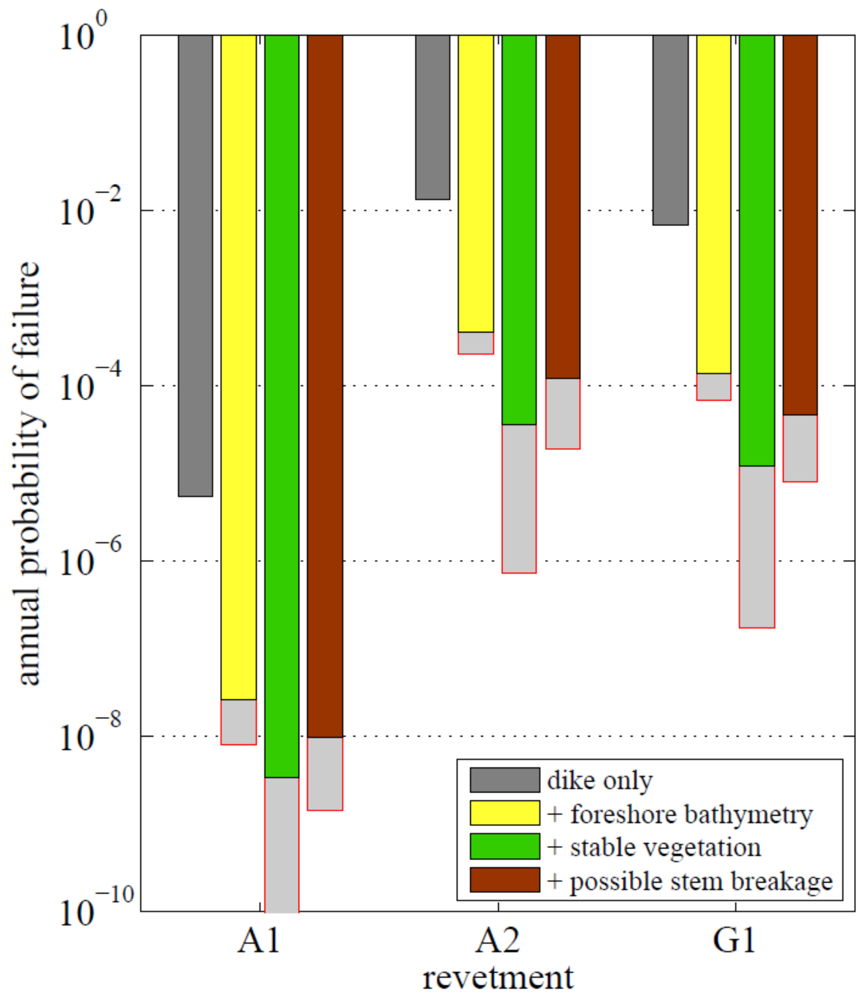




Vuik et al. (2018) Coastal Eng.

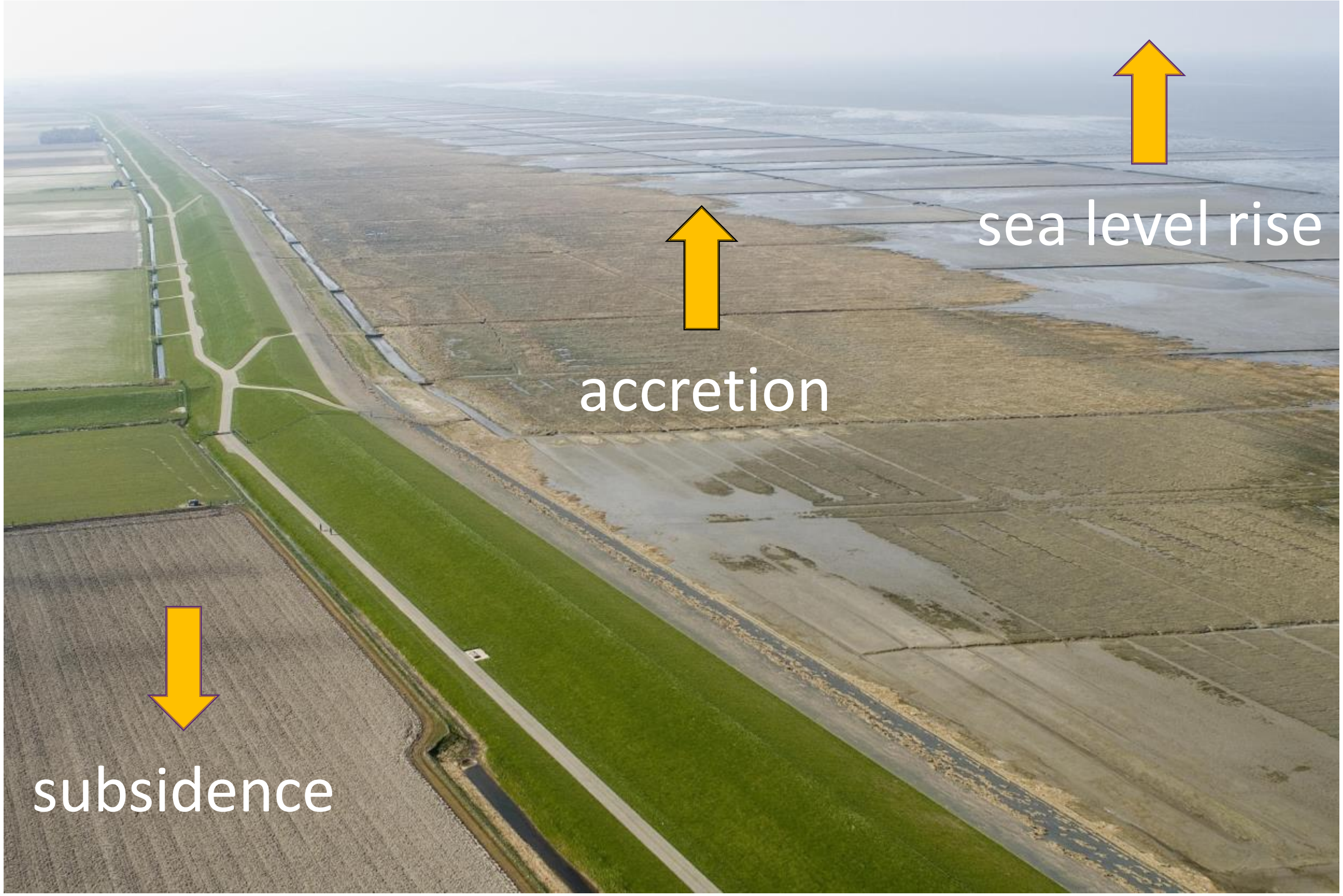
Probability of failure



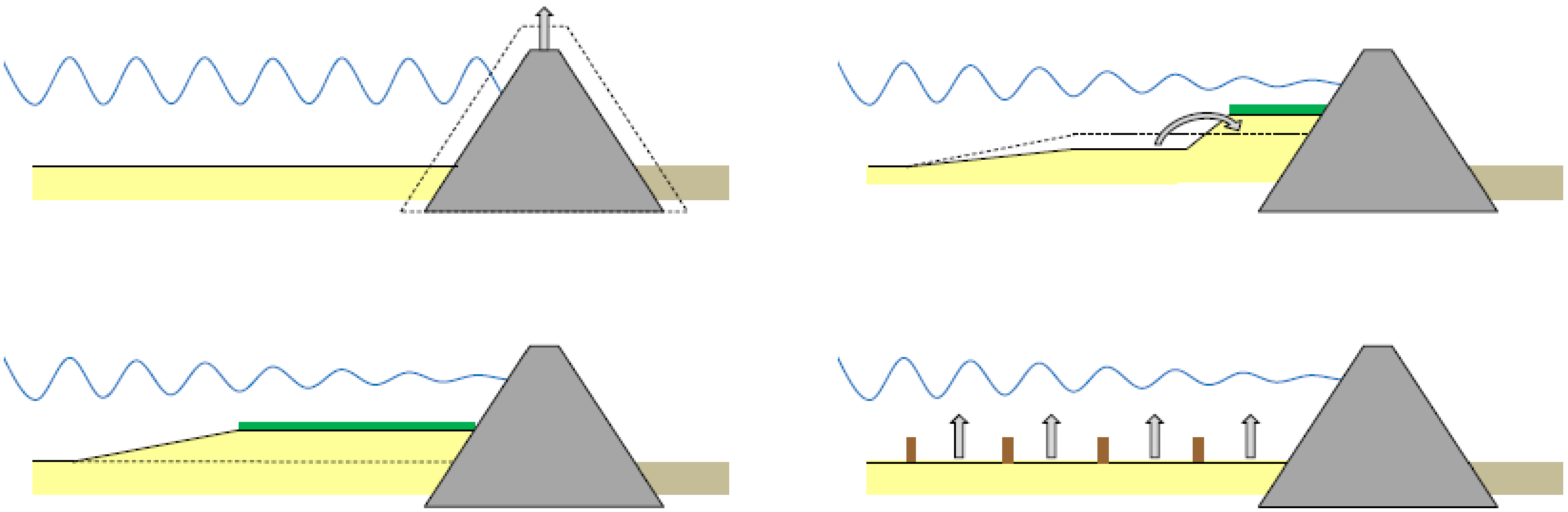


Vuik et al. (2018) Coastal Eng.

Long-term cost effectiveness



Design alternatives



(0. do nothing)

1. dike heightening
2. salt marsh construction
3. foreshore with high zone
4. brushwood dams

Cost effectiveness

Total Costs = Investments + Expected Damage

Cost effectiveness

Total Costs = Investments + Expected Damage = $I + P_f D$

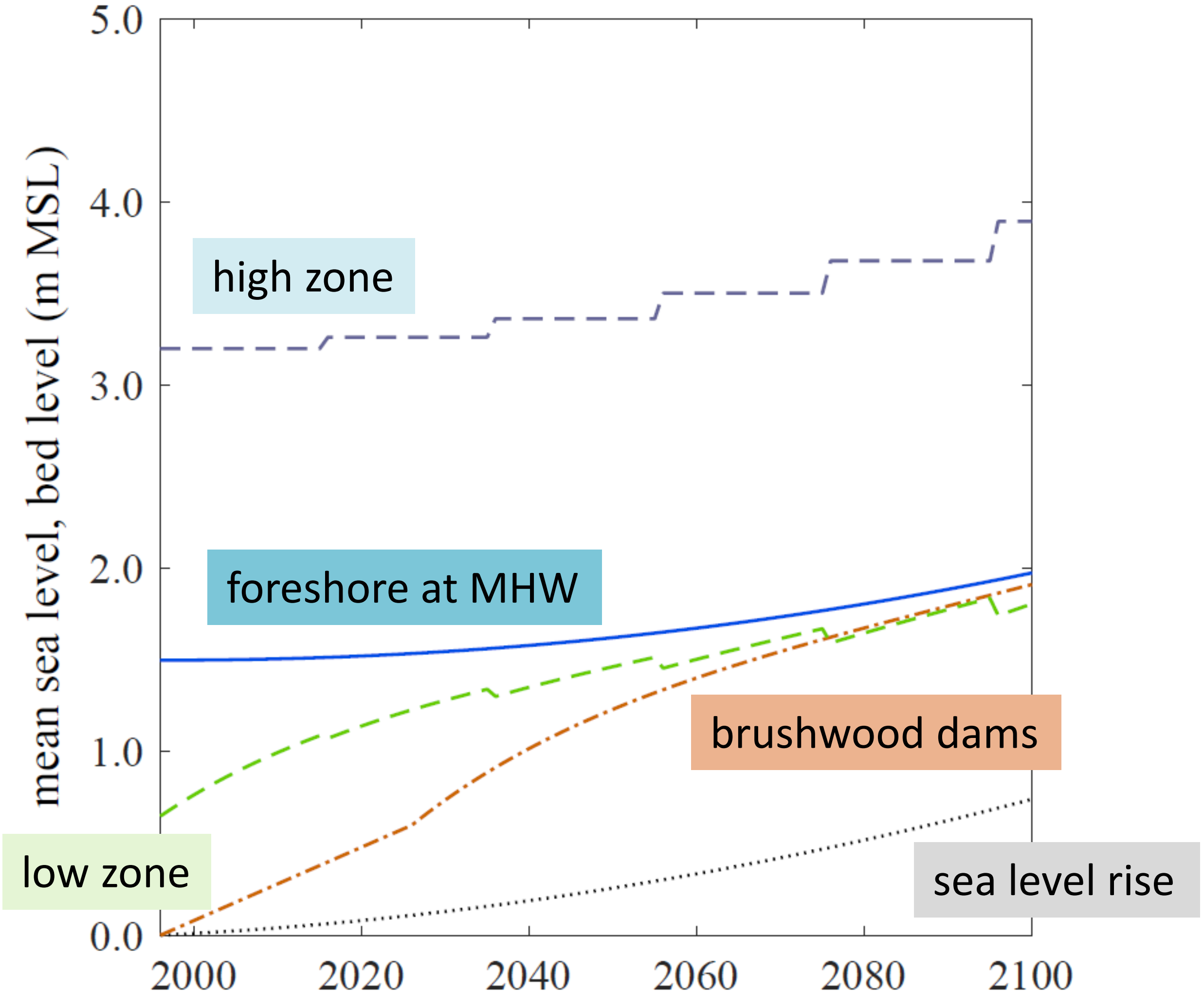
- Investments (I):
  - Dike heightening by 1 m:
    5.4-14.9 M€/km
  - Dredging & nourisment:
    2.4-7.0 €/m^3
  - Earthmoving:
    4.6-15.4 €/m^3
  - Brushwood dams:
    22 €/m^1

Cost effectiveness

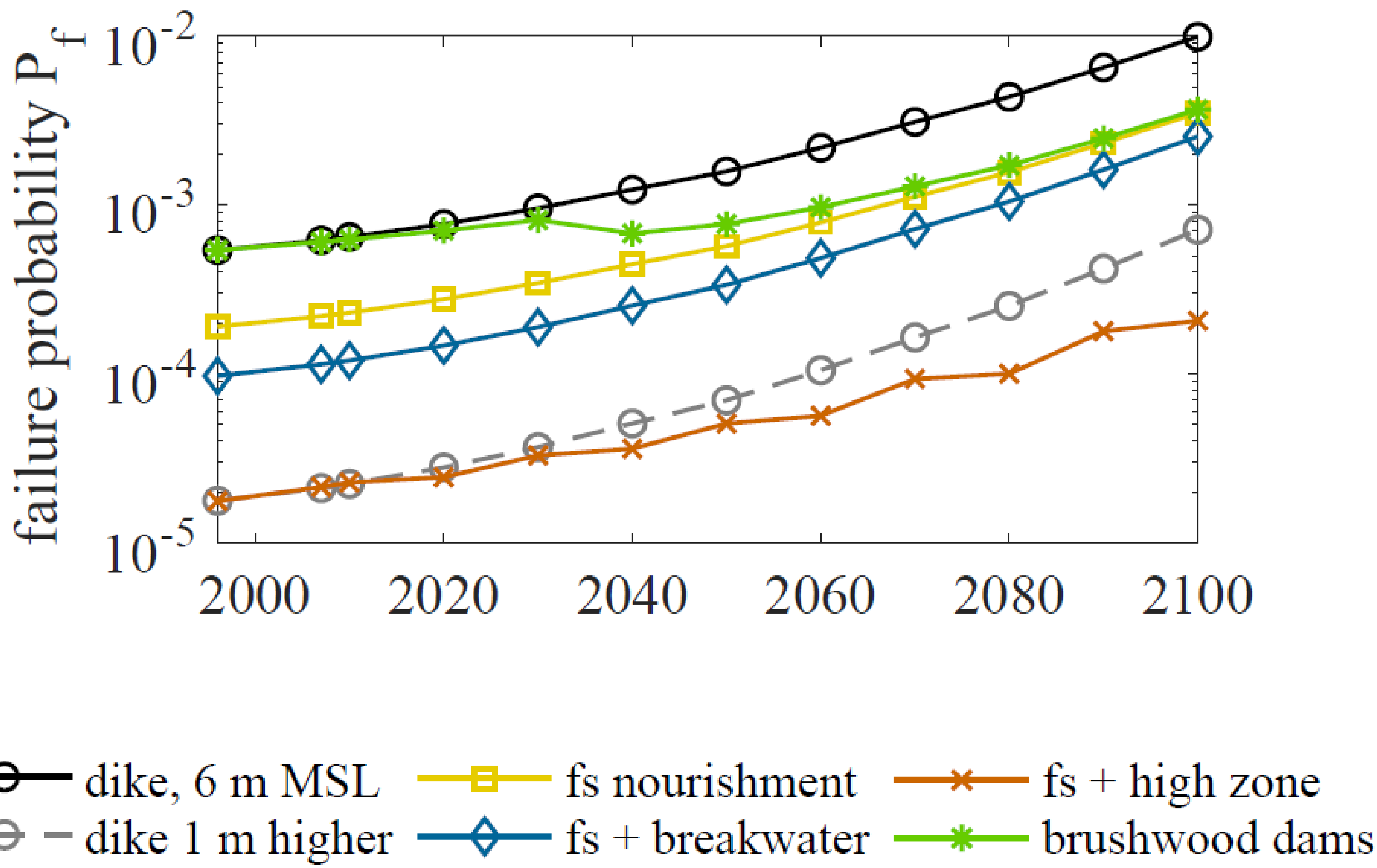
Total Costs = Investments + Expected Damage = $I + P_f D$

- Expected damage = $P_f D$
- Failure probability P_f in time, affected by:
  - Sea level rise: IPCC RCP8.5
  - Foreshore dynamics
- Damage: determines attractiveness of investments

Foreshore elevation



Failure probability in time



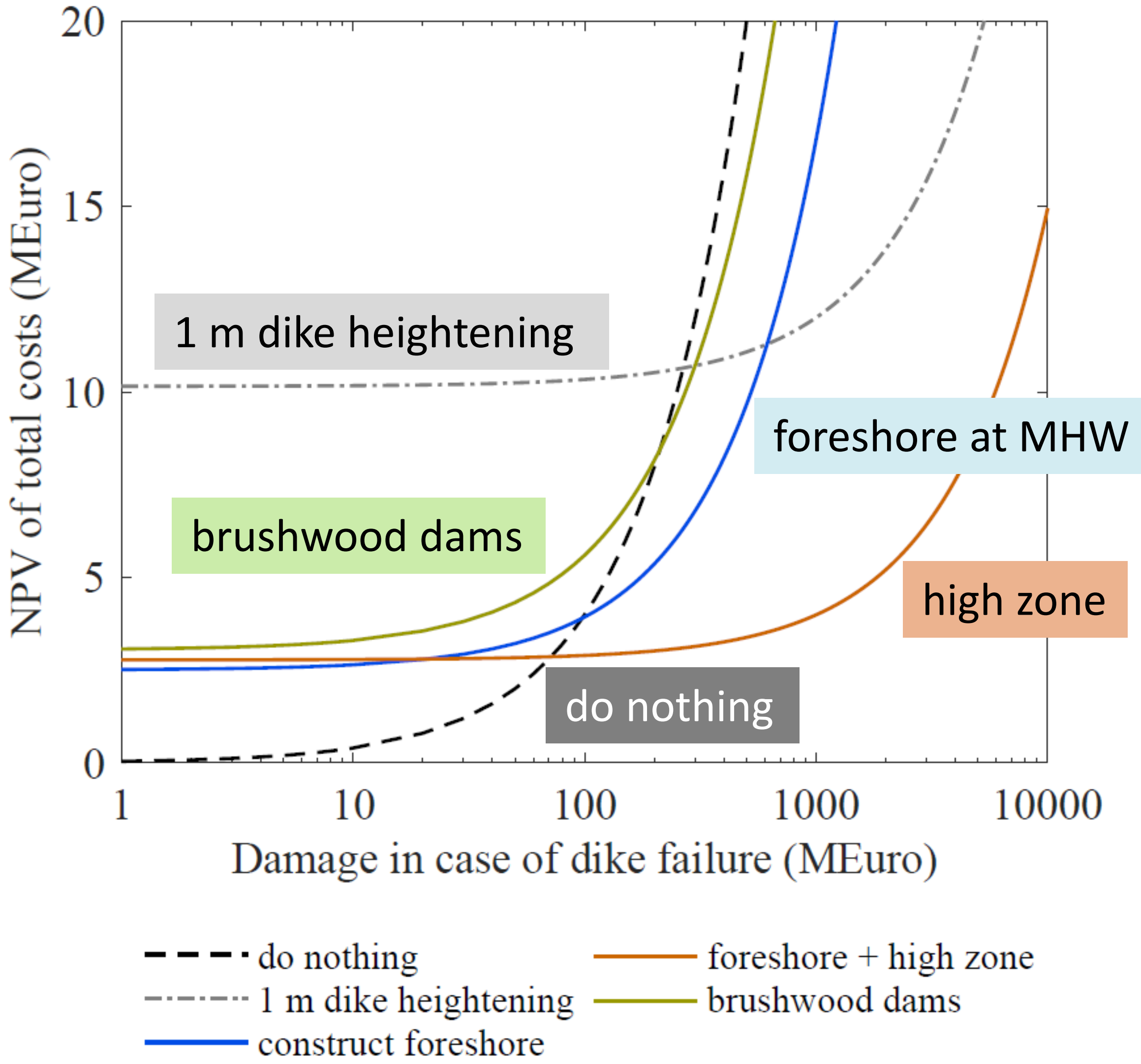
Cost effectiveness

Total Costs = Investments + Expected Damage

Sum over time (1996-2100, from IPCC) of Net Present Value of Total Costs: $\Sigma(I+P_f D)$

Economically most attractive alternative: minimum NPV of Total Costs: $\min\{\Sigma(I+P_f D)\}$

Cost effectiveness



Conclusions

- Foreshores reduce wave height, wave run-up and dike failure probabilities
- Natural foreshores are limited in effectiveness by their maximum elevation around MHW
- Using natural foreshores can be economically attractive when dike heightening is too expensive
- Artificial foreshores can be more cost-effective than dike heightening

Thanks to

Boskalis
Dredging & Marine Experts
HKV
LIJN IN WATER
stowa
NWO
Van Oord
Marine ingenuity
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WNF
Deltares
Enabling Delta Life
EcoShape
building with nature
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Rijkswaterstaat
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It Fryske Gea
staatsbosbeheer

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