

# Results update of the LSA Fehmarn case study



*Luís Costa & Damian Arikas*



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DEVELOPMENT  
FUND



Ministry of Environmental  
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Republic of Latvia



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County Administrative  
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Environmental  
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Municipality



Holbæk  
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Göteborg Region  
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Local Authorities



TALLINN UNIVERSITY

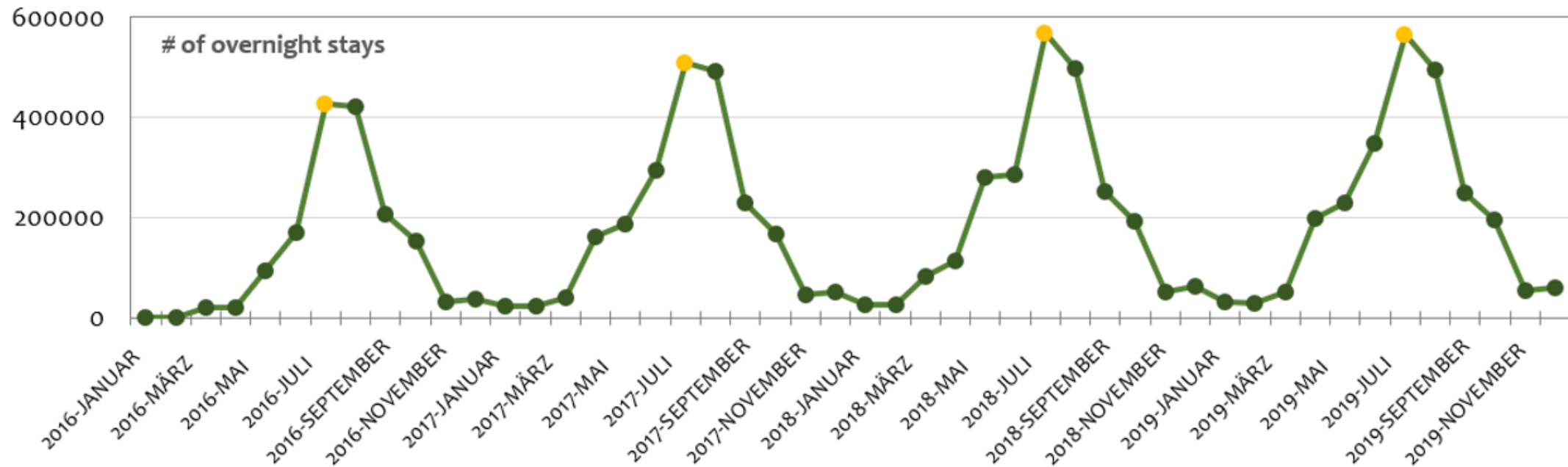
**Land-Sea-Act**



# Overview

- Context
- Mapping of blue economy activities
- Mapping of coastal conflicts
- Conceptualization of the surfer's island App and data
- Climate impact and potential adaptation measures
- Summary of results

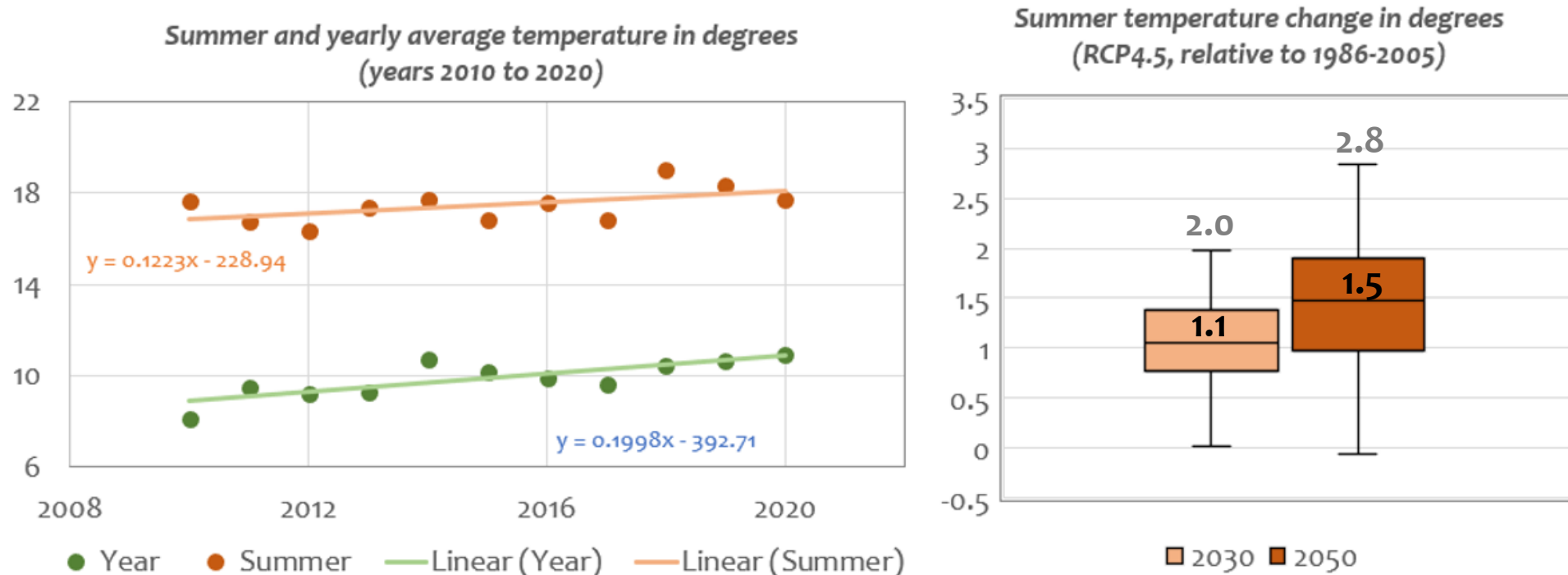
# Context – Visitors



Monthly variation in the number of overnight stays in Fehmarn between 2016 and 2020. Month of July highlighted in yellow. (Source [BEF](#) using data of the [Fehmarn's tourism office](#))

- Yearly number of overnight stays grew 12% from 2.2 to 2.5 million (2017-2019).
- Average overnight stay length decreased from 6.3 to 5.8 nights (2016-2019).

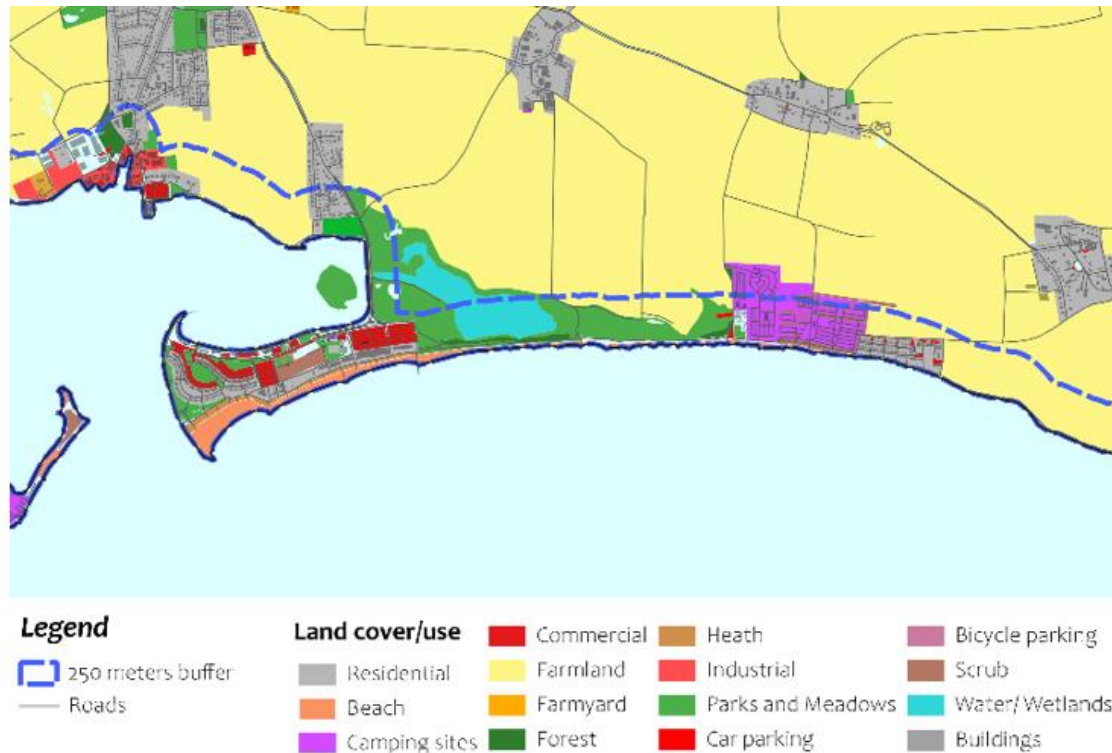
# Context – Climate



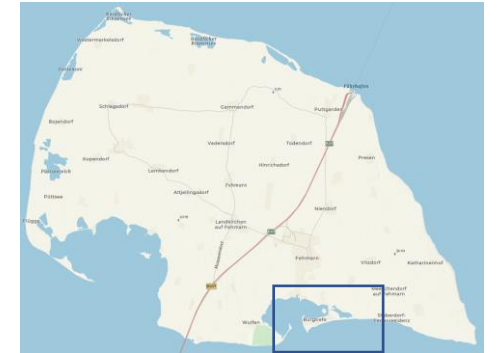
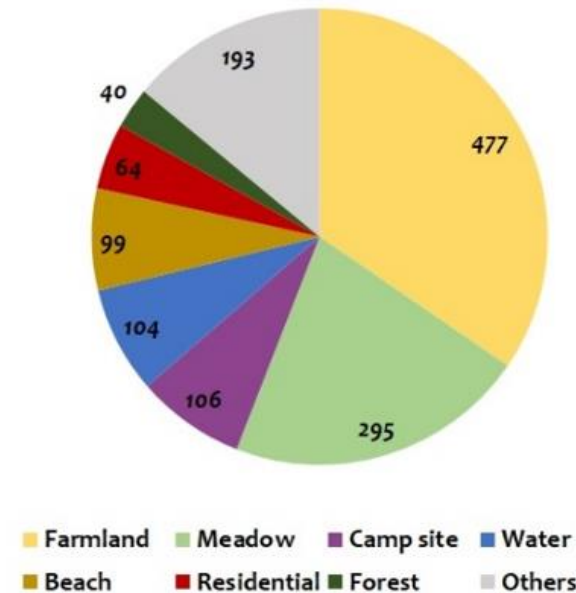
*Yearly and summer average temperatures (left). Projected changes in average summer temperatures(right)  
(Source: [BEF](#) based on data from KNMI [Climate Change Atlas](#))*

- Average annual/summer temperature increased 0.19 and 0.12 deg/yr respectively (2010-2020).
- Median summer temperatures projected for RCP4.5 using 43 models (ref 86-05\*).

# Context – Land cover & use



Example of land cover/use acquisition near Burg and the delimitation of the coastal zone (left). Distribution of coastal land cover/use over Fehmarn's coastline (right) (Source: BEF).



- Majority of coastal land (< 250m shoreline) dedicated to agriculture activity (34.5%).
- Campsites uses about 106ha of costal land approx. = to total beach area (99ha).

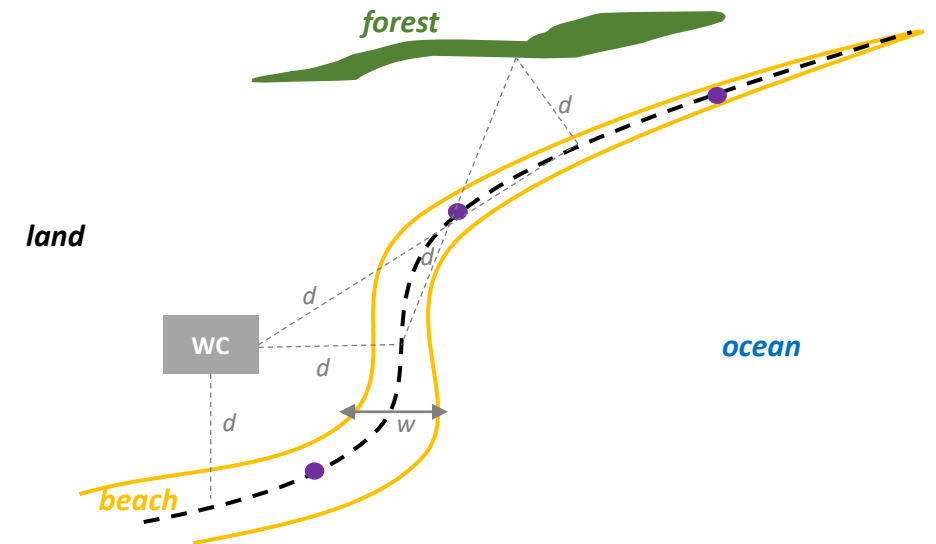


# Mapping of blue economy activities

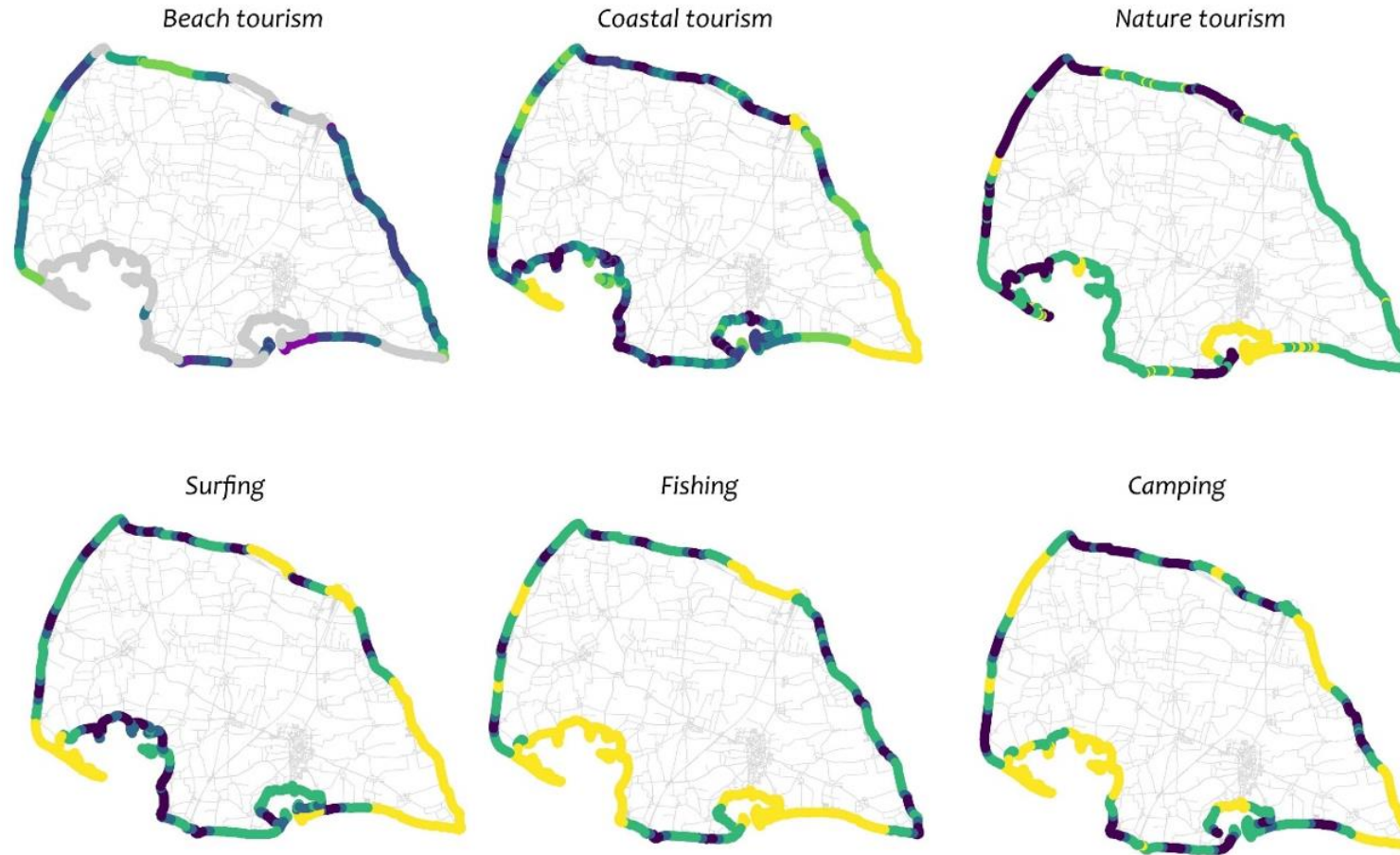
- The distribution of blue economy is dependent on attractiveness of a coastal location.

*Data proxies and rationale to estimate the attractiveness of a coastal location by blue economy activity. All indicators are calculated in meters (m) unless otherwise stated.*

Activity	Indicator	Rationale
Beach tourism (swimming, walking on the beach, sunbathing).	<ul style="list-style-type: none"> <li>Beach width - wide</li> <li>Proximity to carparking</li> <li>Proximity to toilet</li> <li>Proximity to bus stop</li> </ul>	The wider the beach the more attractive it is for a larger number of users. The existence of a carpark and toilet facilities increase the convenience of the location and hence its attractiveness.
Coastal tourism (Biking, walking, eating, hotel).	<ul style="list-style-type: none"> <li>Proximity to dike</li> <li>Proximity to footpaths</li> <li>Proximity to amenities or infrastructure such as benches, restaurants, cafes, etc...</li> </ul>	At Fehmarn the top of the dikes is bike-ridable and a popular activity. The existence of footpaths eases the accessibility of the coast for tourists and so does the presence of amenities such as restaurants.
Nature tourism	<ul style="list-style-type: none"> <li>Proximity to natural reserves</li> <li>Proximity to forest</li> <li>Beach width - narrow</li> </ul>	The existence of nature reserves or areas with close to natural vegetation increase the potential of such areas being used for nature tourism such as bird watching. Narrower beaches provide more close-to-natural features that are more attractive to tourists sensitive to nature.
Surfing	<ul style="list-style-type: none"> <li>Proximity to surf spots</li> <li>Proximity to car parking</li> </ul>	The existence of adequate parking conditions is determinant in the attractiveness of a give surf spot.
Fishing	<ul style="list-style-type: none"> <li>Proximity to fishing spots</li> </ul>	Proximity of the coastline to the fish stop enhances its attractiveness.
Camping	<ul style="list-style-type: none"> <li>Proximity to campsites</li> </ul>	Presence of the camp parks enhances the attractiveness of the coastline to the activity of camping.



# Mapping of blue economy activities

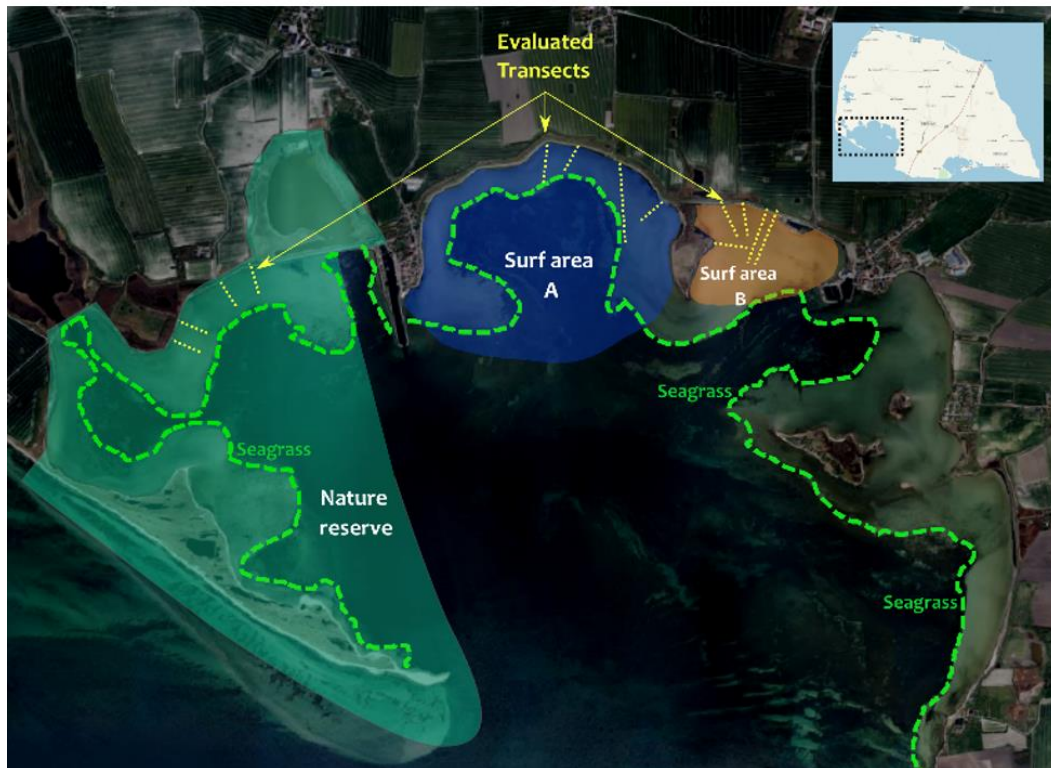


Estimated attractiveness of a coastal segment to a blue economy activity (Source: BEF own calculations) **[map legend still missing]**

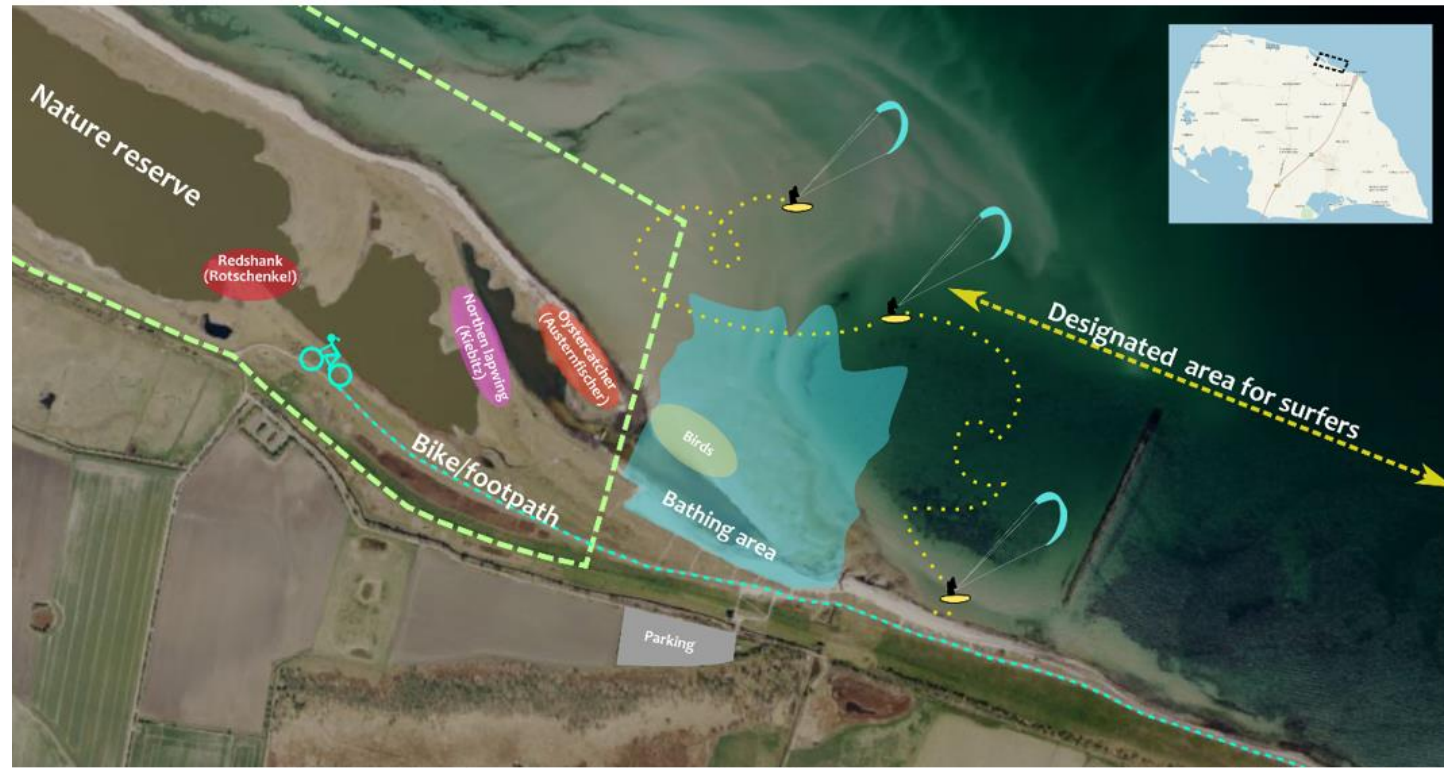
# Mapping of coastal conflicts

In the context of Marine Spatial Planning (MSP) spatial conflicts exist when:

- a) the direct competition over a limited space or
- b) one coastal activity negatively impacts another



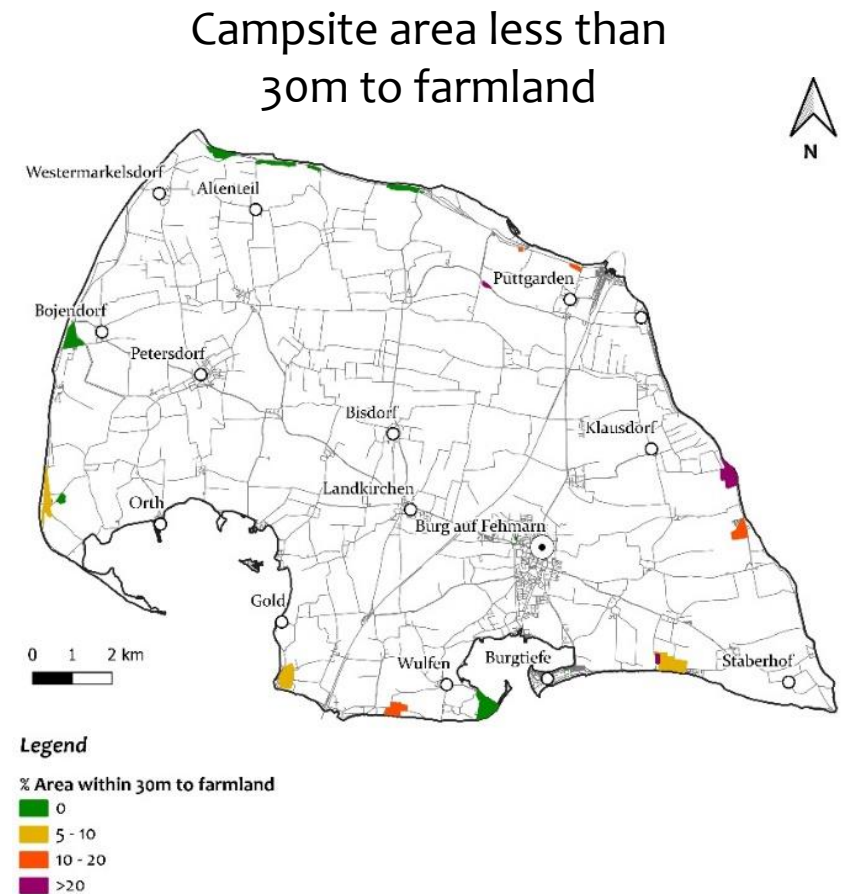
Transects in surf areas and nature reserve investigated for the coverage of macrophytes (Source: BEF)



Depiction of the spatial overlap of several coastal and blue economy activities at Grüner Brink (Source: BEF in communication with Strandpate)



# Mapping of coastal conflicts



Closeness of farmland to campsites and conversion of land cover/use (Source. BEF)

# Conceptualization of the surfer's island App (SIA)

Core principle: incentivise the use of parking spaces at surf spots according to the spot's sustainable capacity.



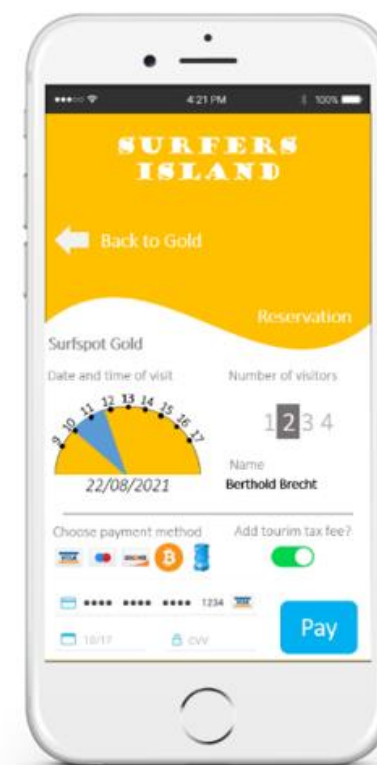
Overview



Availability map

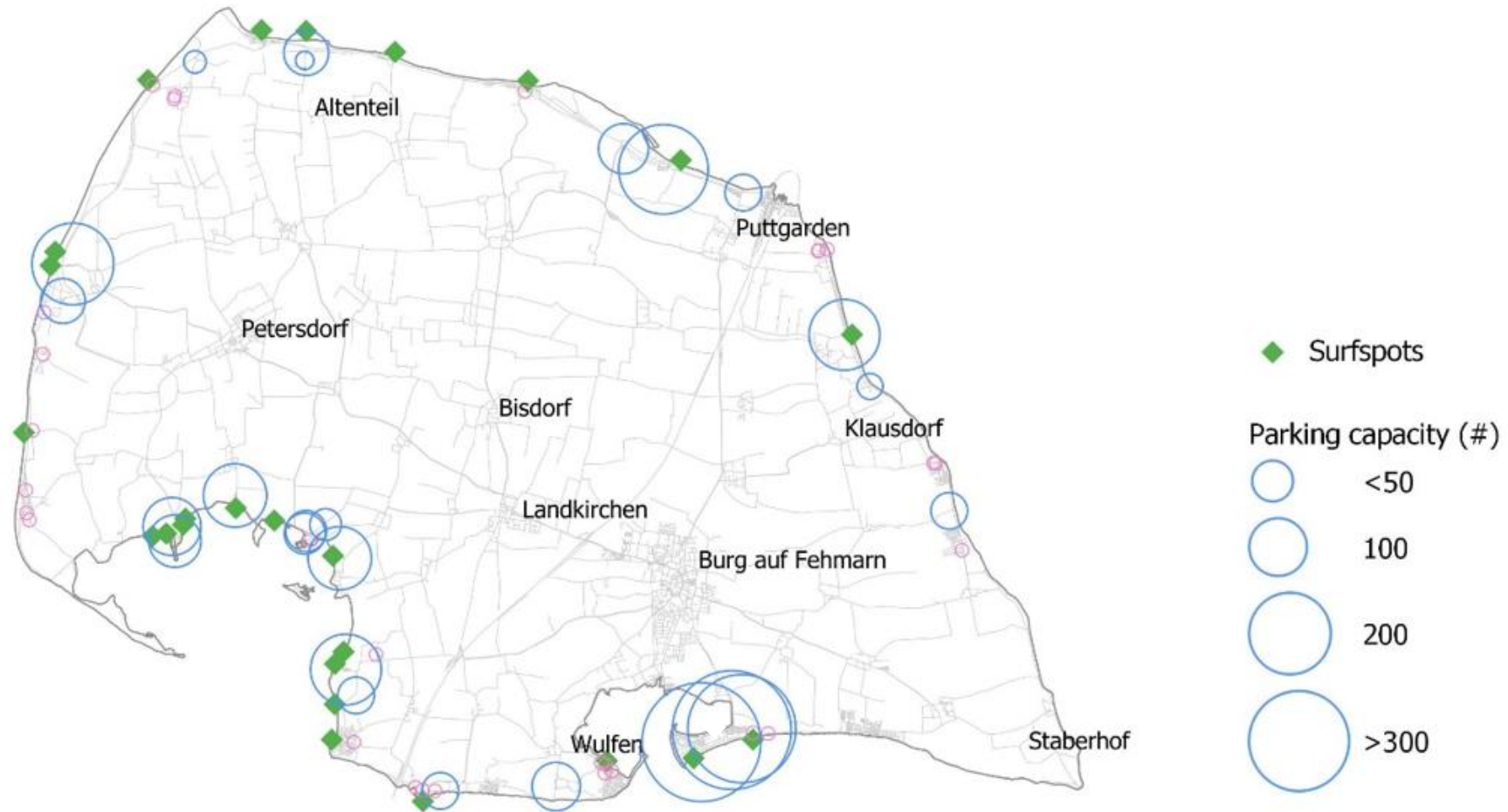


Detail map/parking



Payment

# Parking capacity data for SIA



Compilation of available public parking capacity nearby surfspots. (Source: [BEF](#) using data from [Fehmarn's Parkraumkonzept und Parkleitsystem](#))



# Parking capacity data for SIA

- ***Hard to define the “sustainable capacity”*** of each surf spot. (function of current number of visitors, free parking places, ecological considerations).
- SIA is thought with surfers in mind but ***probably would make more sense to have a general “parking App”*** (categorizing visitors as surfers and non-surfers).
- ***SIA will require additional physical structures*** (e.g., QR code readers) to effectively control the flows.
- ***Only one element of the management strategy*** (physical demarcation of the hotspots, guiding structure to channel surfers entering the water and avoid dispersion).



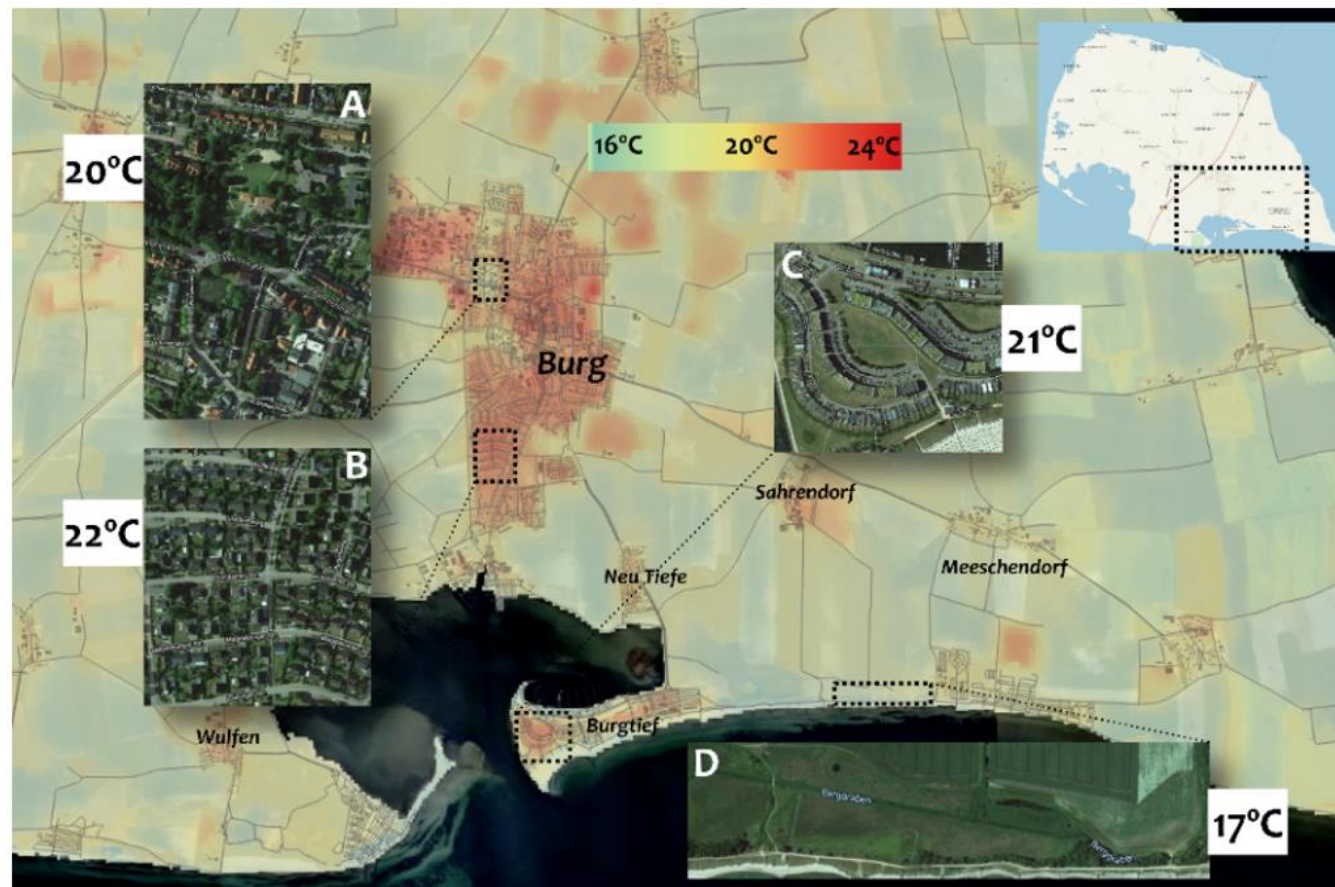
# Climate change adaptation

- Initiate the discussion for an adaptation plan for the island.
- Quantify relevant climate change impacts (water supply, coastal flooding, heat).
- Propose some adaptation options.



# Climate change adaptation - Heat



Summer 2020 day-time temperature map (based on LandSat8 data)



Average 2020 summer day-time temperatures at Fehmarn with focus on different configurations of urban fabric at Burg and Burgtief (Source: BEF)

## Adaptation measures targeting urban heat

Measures of urban greenery, cooling potential and dependency on extra factors, adapted from [Wong et al, 2021](#).

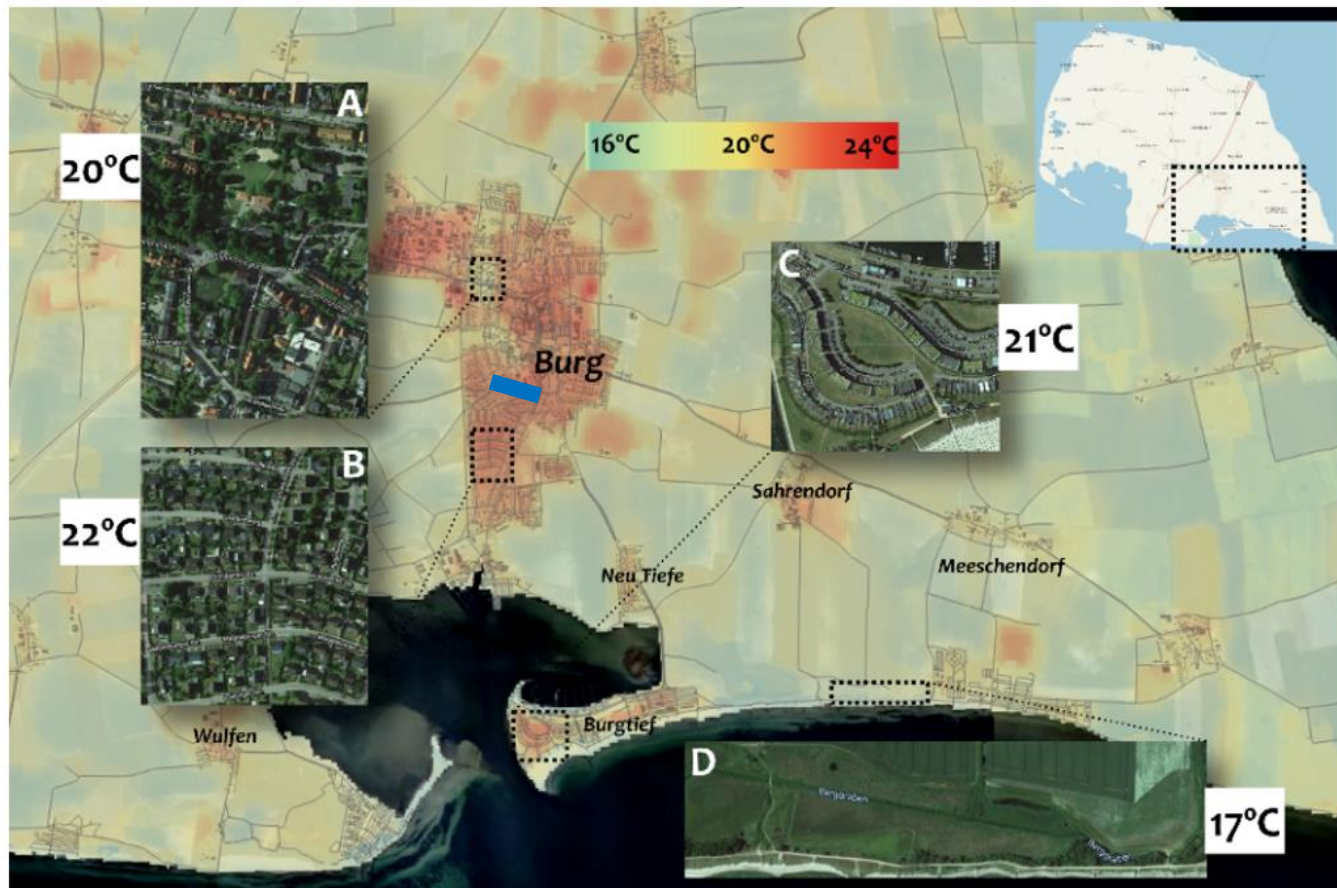
Measure	Temperature reduction range	Depending on:
<b>Green parks</b>  (Park Gleisdreieck, Berlin)	2 to 4 degrees	<b>Distance to the park</b> Typically, cooling effect takes place <50m from the park.  <b>Park size</b> Larger parks tend to have a more pronounced cooling effect. In temperate cities optimal size between 0.5 ha and 0.69 ha.  <b>Park shape</b> Cooling effect more pronounced in regular shaped circular or polygonal parks.
<b>Green roofs</b>  (Green roof in Stuttgart)	1.5 to 4.1 degrees	<b>Climate</b> temperature reduction is most effective in sunny weather, becoming less potent during cloudy or rainy periods.  <b>System</b> Intensive rooftop systems (soil depths >250 mm and able to hold large shrubs) exhibit greater heat absorption and reduced temperature fluctuations.

Reduce “sealed surface” area.

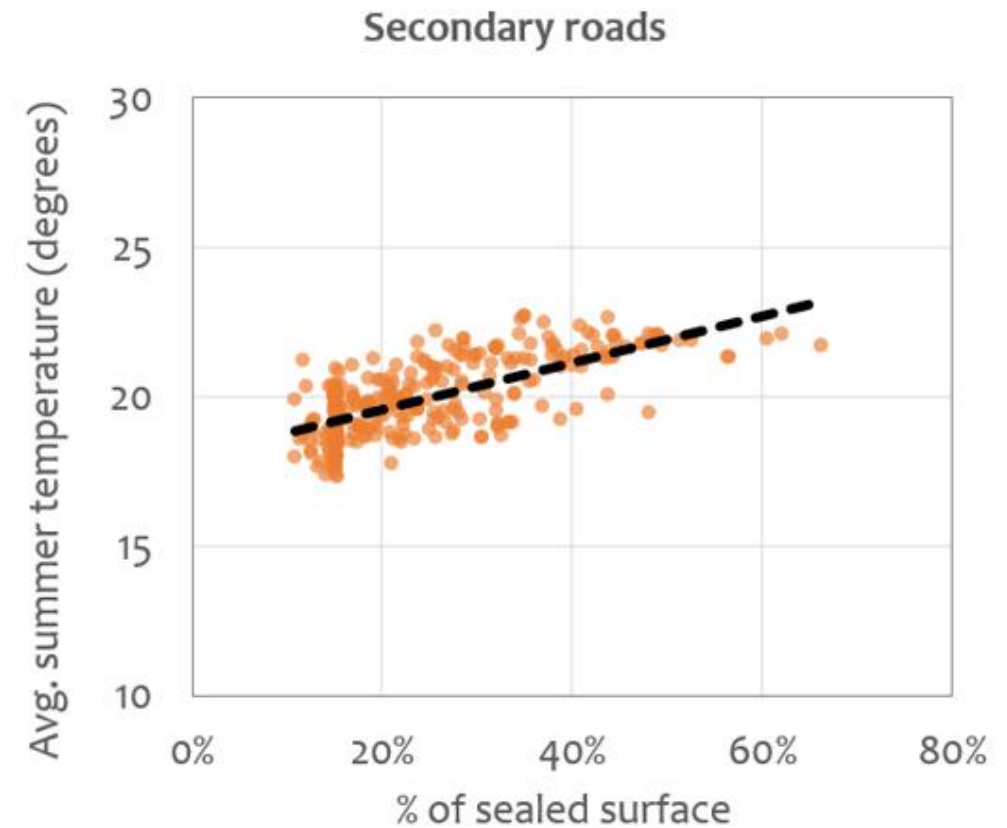


# Climate change adaptation - Heat

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Average 2020 summer day-time temperatures at Fehmarn with focus on different configurations of urban fabric at Burg and Burgtief (Source: BEF)

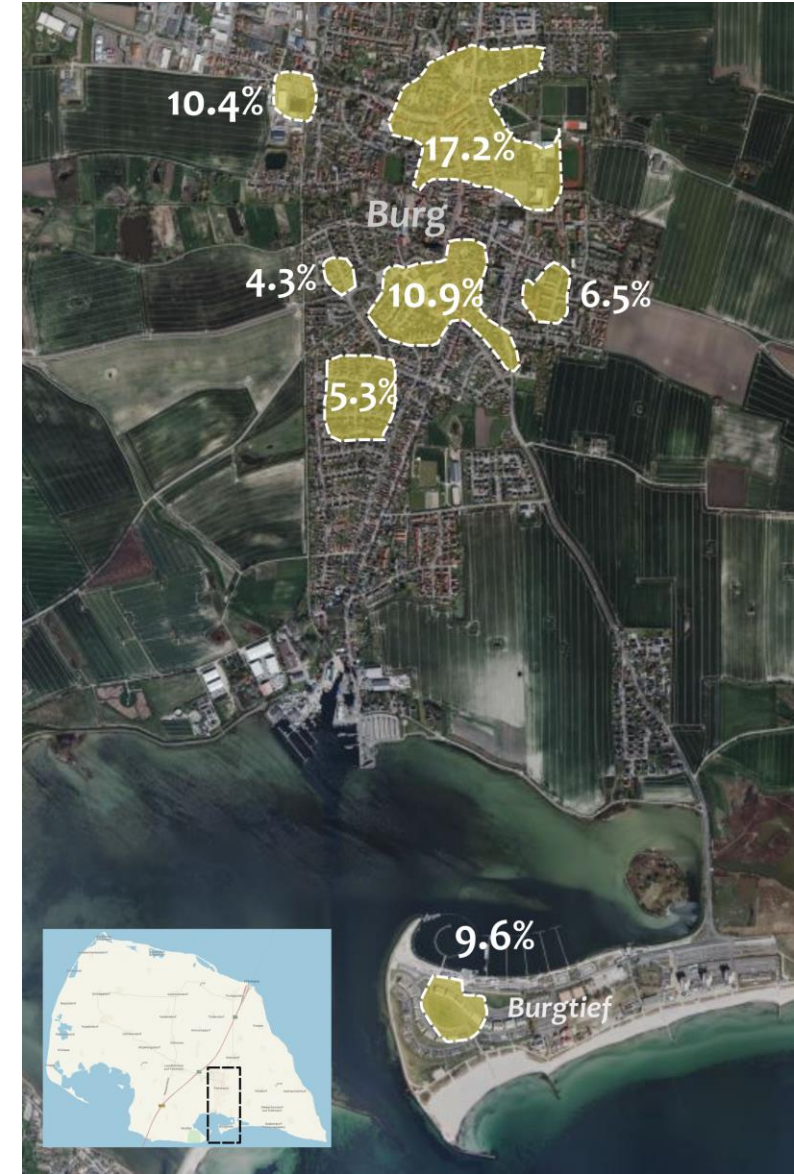


# Climate change adaptation - Heat

## Example:

Fehmarn decides to adapt *locations with average summer temperatures above 21 degrees* so that next summer *these are lowered to 20 degrees*.

Fehmarn then hires BEF to determine how *much additional green space needs to be put in place?*





# Climate change adaptation – Water supply

- Fehmarn receives on average 1.4 million m<sup>3</sup> of water annually (2016-2020).
- Yearly supply increased moderately by 0.65%, supply in the summer months increased about 8.4%.
- Warmer summers are likely to pose additional stress to Fehmarn's water supply system.
- **But how much more stress?**

## FEHMARNSCHE TAGEBLATT

Amthliches Veröffentlichungs-Organ der Stadt Fehmarn und des Kreises Ostholstein

Jahrgang 163, Nr. 174

Sonntag/Sonntag, 28./29. Juli 2018

Einzelpreis 1,20 €



### Auf Fehmarn wird Trinkwasser knapp

Verbandsvorsteher Werner Ehlers ruft Bürger auf, Wasser zu sparen / Wasserspeicher leeren sich langsam

#### SPRUCH ZUM TAGE

Sparsamkeit in allen Dingen ist die vernünftige Handlung eines rechtsdenkenden Menschen.

Immanuel Kant

#### KNUST-WETTER

Tag	29°
Nacht	18°
Ostsee	24°

Es ist sonnig und schwülwarm, sodass sich nachmittags und abends Gewitter bilden können. Die Temperaturen klettern wieder auf 29 Grad, nachts geht es runter auf 18 Grad. Der Wind weht aus östlicher Richtung. Morgen geht es unverändert mit Sonnenschein weiter.

→ Menschen und Medien

#### GUTEN MORGEN, LIEBE LESER

Wildes Campen in der freien Natur kann teuer werden. Wie die Plattform campanda.de im Rahmen einer Untersuchung herausgefunden hat, können – je nach Bundesland – bis zu 10000 Euro Strafe fällig werden, wenn in einem Landschafts- oder Naturschutzgebiet wild gezeltet wird. Die höchsten Bußgelder verhängt Schleswig-Holstein. Aber auch in anderen Bundesländern kann es teuer werden. In Niedersachsen und Mecklenburg-Vorpommern sind bis zu 5000 Euro fällig, in Bayern und Hamburg bis zu 2500 Euro. Auch im Ausland werden teilweise empfindliche Strafen erhoben. Eine Ausnahme bilden hinein

FEHMARN • Das Thermometer knackt seit Tagen permanent die 30-Grad-Marke, die Ostsee ist mit 25 Grad so warm wie nie zuvor und ein grundlegender Wetterumschwung ist nicht in Sicht. Und Fehmarn ist ausgebucht. Das schlägt sich auch auf den Trinkwasserverbrauch nieder. Dieser ist in den letzten Tagen rasant angestiegen, sodass der Wasserbeschaffungsverband Fehmarn (WBV) Alarm schlägt und Einheimische wie Urlauber dazu aufruft, Wasser zu sparen, denn derzeit wird mehr verbraucht, als vom Festland zugeführt werden kann.

Noch vor einer Woche hatten sich Verbandsvorsteher Werner Ehlers und Wassermeister Ulrich Prange gegenüber dem FT ganz entspannt gegeben und einen möglichen Engpass bei der Trinkwasserversorgung nahezu ausgeschlossen (wir berichteten). Nun sieht die Lage nicht mehr so rosig aus. „Wir können den Abfall in den Speichern nicht mehr auffangen“, so Werner Ehlers gestern gegenüber dem FT. Am Donnerstag seien innerhalb von 24 Stunden etwas

mehr als 7000 m<sup>3</sup> Wasser verbraucht worden, berichtet Ehlers, rund 800 m<sup>3</sup> mehr als noch vor einer Woche. „Und auch da war die Insel voll“, verweist Ehlers auf die angespannte Situation. Der WBV Fehmarn ordert täglich 6000 m<sup>3</sup> Wasser vom Zweckverband Ostholstein (275 m<sup>3</sup>/std), speist diese ins Netz ein oder befüllt damit die insgesamt rund 6000 m<sup>3</sup> fassenden Wasserspeicher in Struckkamp und Sahrendorf. Theoretisch kann der WBV 299 m<sup>3</sup>/std ordern, mehr ist mit den drei Versorgungsleitungen vom Festland technisch nicht möglich. „Doch die kommen hier gar nicht an“, macht Werner Ehlers



Werner Ehlers, Verbandsvorsteher des Wasserbeschaffungsverbandes Fehmarn. • Foto: FT-Archiv



Willkommene Abkühlung nach einem heißen Strandtag. Auch der kurze Sprung unter die Dusche trägt dazu bei, dass auf Fehmarn zurzeit mehr als 7000 Kubikmeter Trinkwasser täglich verbraucht werden. • Foto: dpa

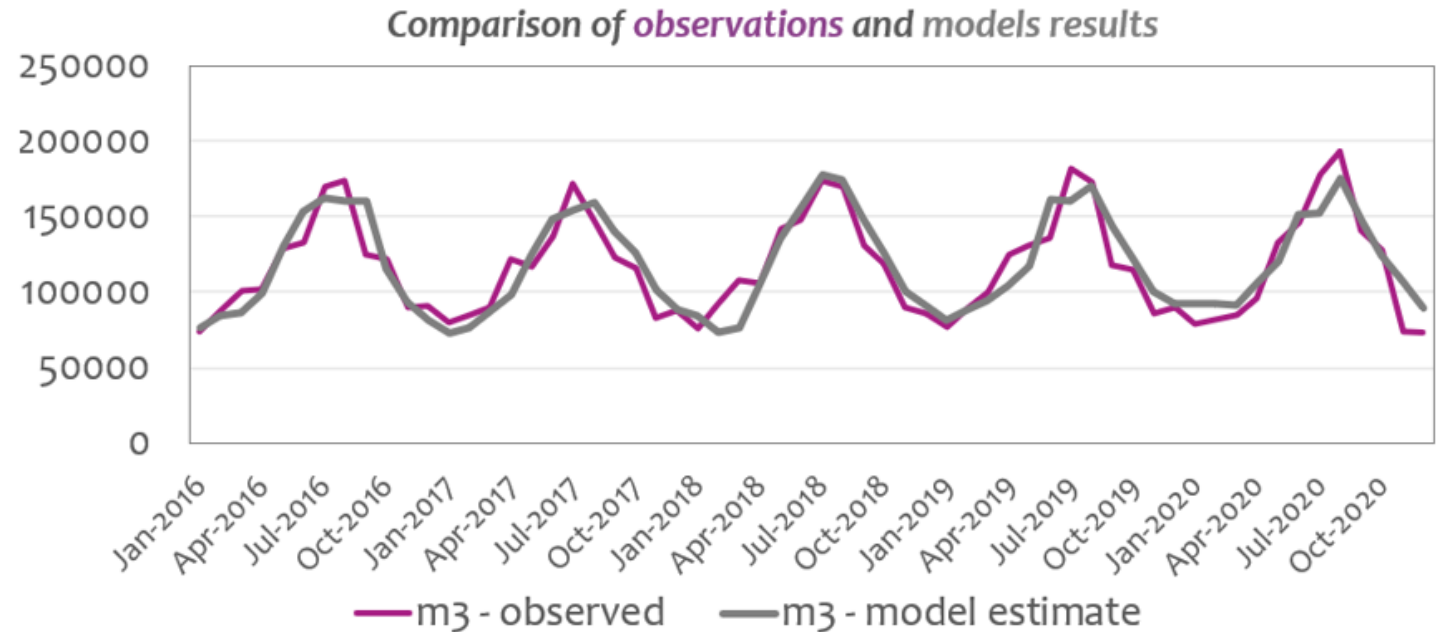
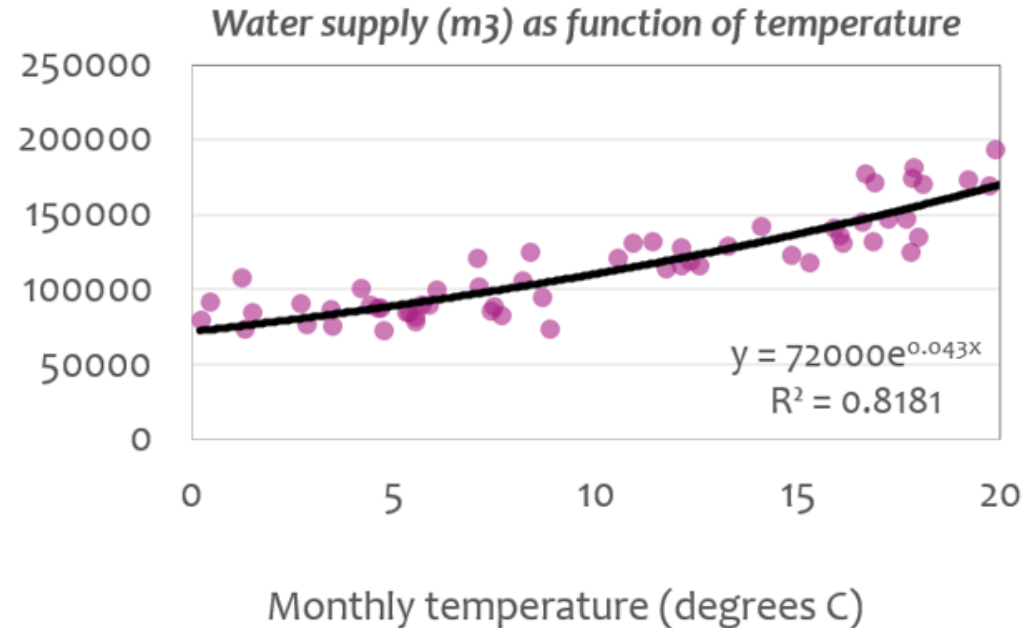
deutlich, dass es in der Praxis etwas anders aussieht. „Morgens geht es schon zwischen 6 und 7 Uhr los und abends bis 23 Uhr“, verdeutlicht Ehlers die angespannte Situation.

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#### Option: Zufuhrdrosselung zwischen 21 und 6 Uhr

Vor diesem Wochenende, an dem wiederum viele Tagessäfte erwartet werden, richtet der Verbandsvorsteher des WBV noch einmal den dringenden Appell an die Bevölkerung, sparsam mit dem kostbaren Gut Wasser umzugehen und „vielleicht einmal das dringendste Wasser gespart werden muss, damit Fehmarn nicht irgendwann auf dem Trockenen sitzt, was vor einer Woche noch die Vorstellungskraft von Werner Ehlers sprengte.“ h6

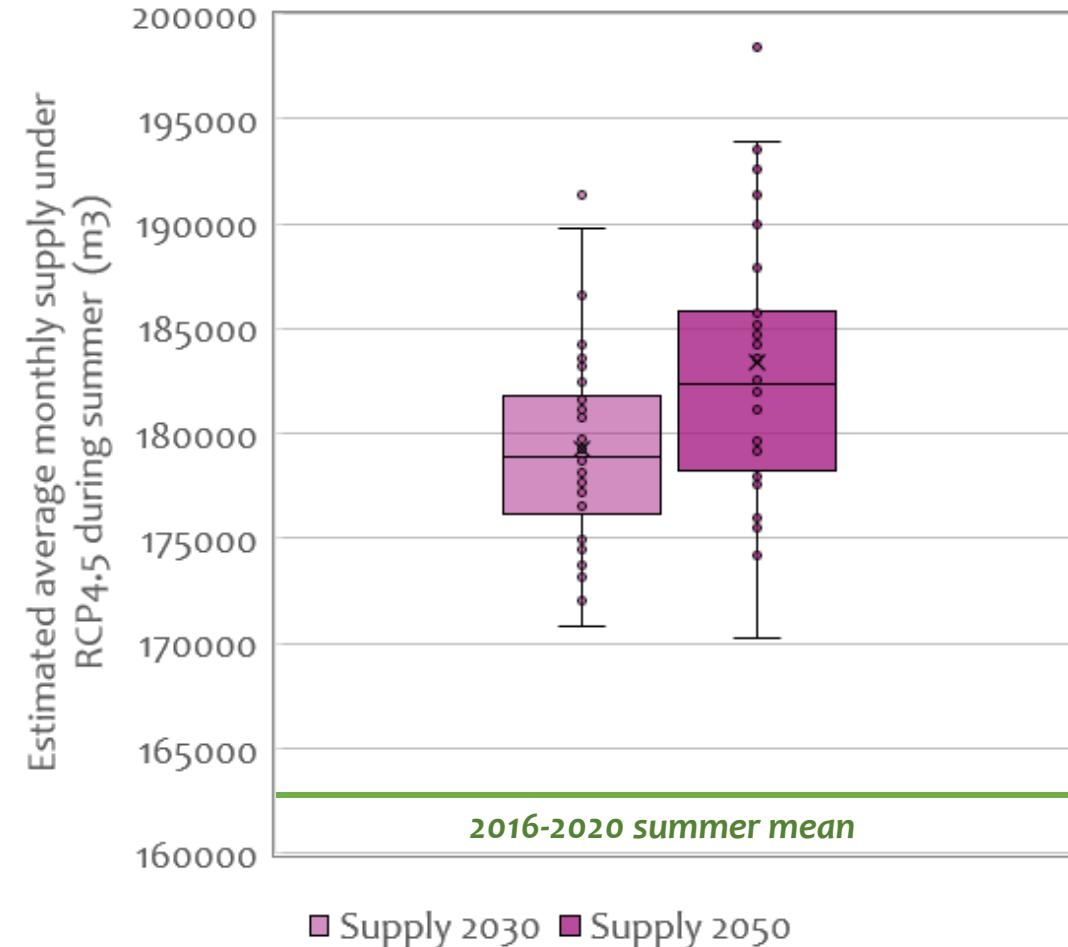
# Climate change adaptation – Water supply



*Water supply model and comparison of model outputs with observations (Source: [BEF](#))*

- Water supply and temperature positively and non-linearly correlated.
- Simple model (only temperature and independent variable) captures 82% of yearly variability.
- In summer months supply is underestimated by circa 9.2 (+10% recalibration).

# Climate change adaptation – Water supply



Summary results of the projected change in water supply to Fehmarn under RCP4.5 and absence of adaptation  
(Source: BEF)

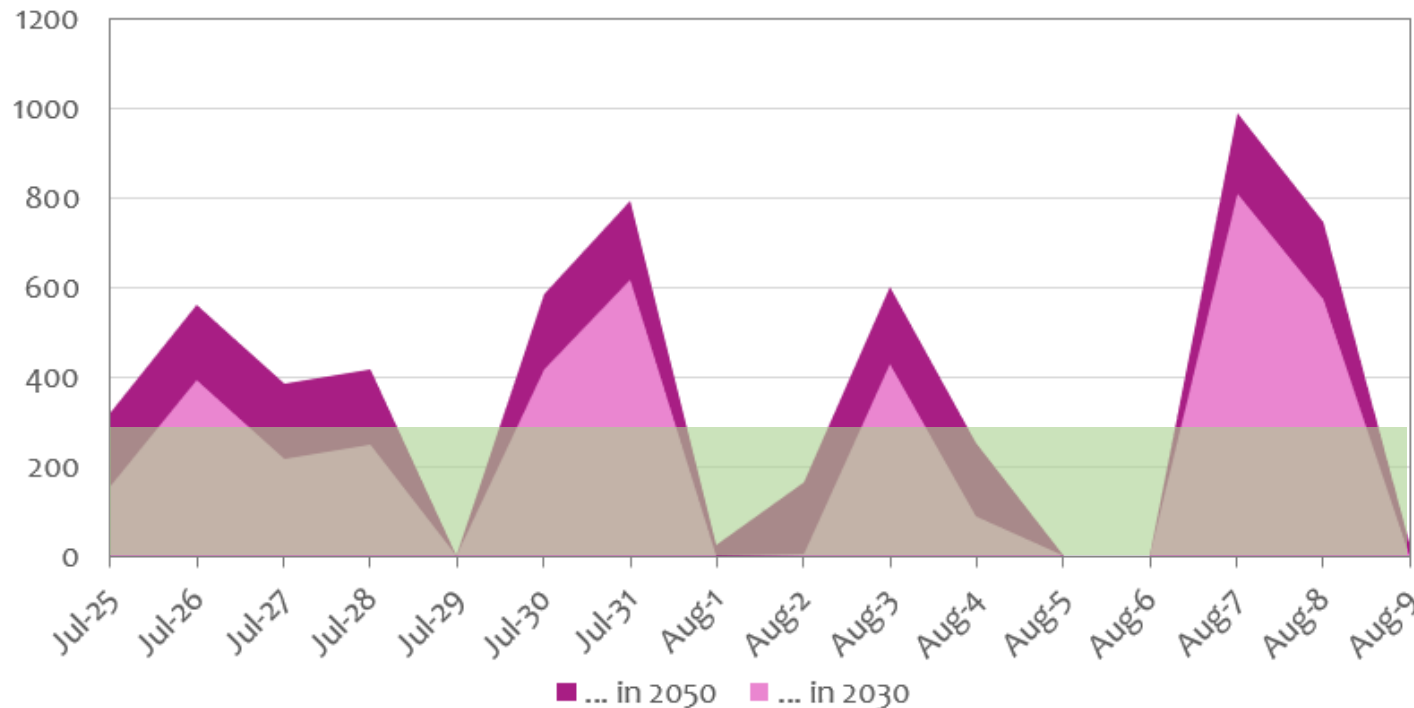
Reference summer supply (2016-2020 summer mean)	Projected summer supply (2025-2035 and 2045-2050 summer mean)	
	2030	2050
162 K m <sup>3</sup>	179 K m <sup>3</sup> (171 – 189)	183 K m <sup>3</sup> (170 – 194)
% Change	9.5%	11.5%

- Most of the additional water supply estimated is required by 2030 (short-term adaptation).
- Moderate climate change adds about 10% of water needs **on top** of those from an increase in tourists.
- But... real management takes place at daily scale!

# Climate change adaptation – Water supply

***What if, the summer of 2018 would happen in 2030 or 2050, what additional daily water volumes would Fehmarn require?***

Water needed (in m<sup>3</sup>) if the 2008 July/August stress event would take place...



Daily water consumption per household activity in Germany 2019 (Source: [Statista](#))

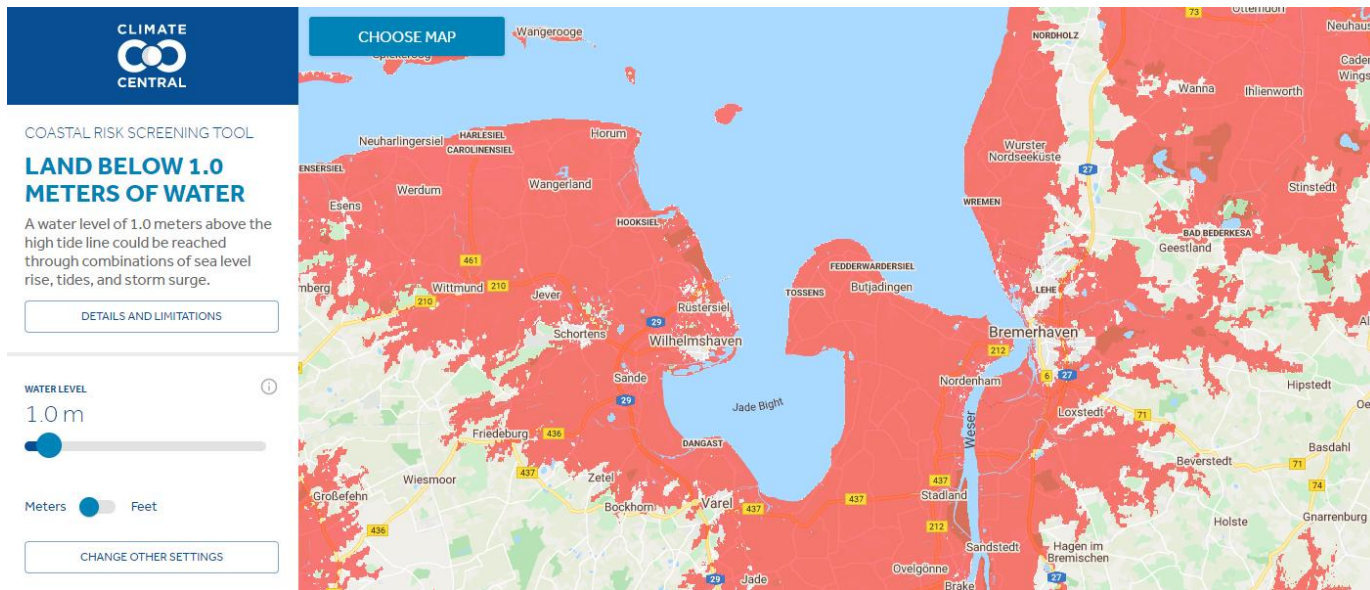
Activity	Water consumption (litres/day)
Bath/showering/hygiene	45
Toilet flush	34
Laundry	15
Dishwashing	8
Car washing/Garden	8

25% of the population has 1 less shower and skips 1 day of laundry



# Climate change adaptation - Coastal flooding

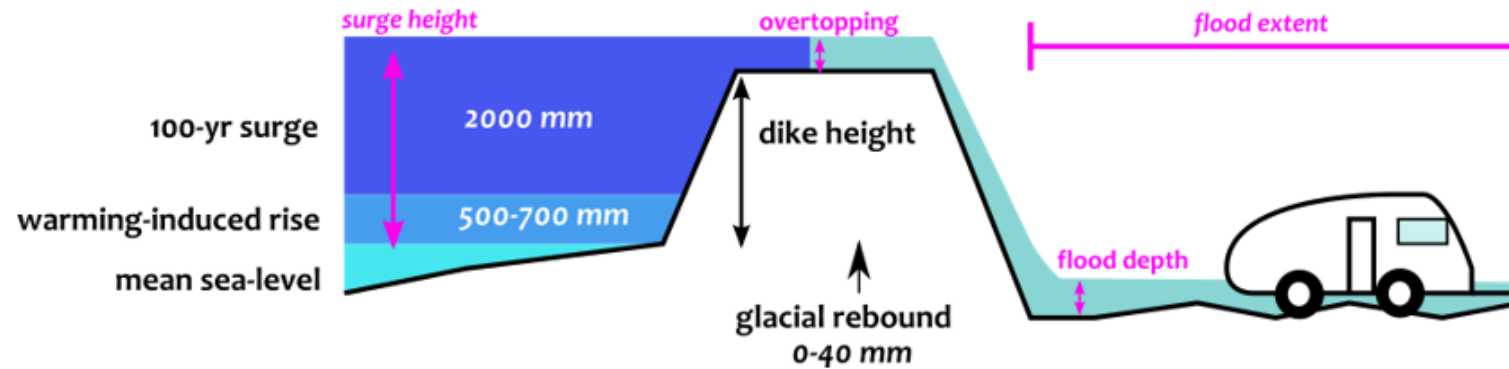
- ***Account for the effect of local dikes*** in flooding simulations from sea-level rise.



*Dike-height sampling (May 2021)*



# Climate change adaptation - Coastal flooding



*Illustration of the main contributing factors for coastal flooding in Fehmarn (Source: [BEF](#))*

Work in progress





# Climate change adaptation - Coastal flooding



*Illustration of the main contributing factors for coastal flooding in Fehmarn (Source: BEF)*

Work in progress



# Summary of results

- Blue economy activities along the coastline and (some) spatial conflicts mapped.
- Surfers App visualized and parking-capacity database created. Operational challenges raised.
- Three climate-related impacts quantified at relatively detailed spatial and temporal scale.
- First quantitative investigation of potential adaptation options for the island of Fehmarn.

Effect of vegetation in lowering urban heat estimated (urban planning).

About 10% additional water needs in the summer under moderate climate change (even in the absence of tourism growth).

Flood extents for different surge heights estimated with a simple but locally-representative flood model.



# We thank:

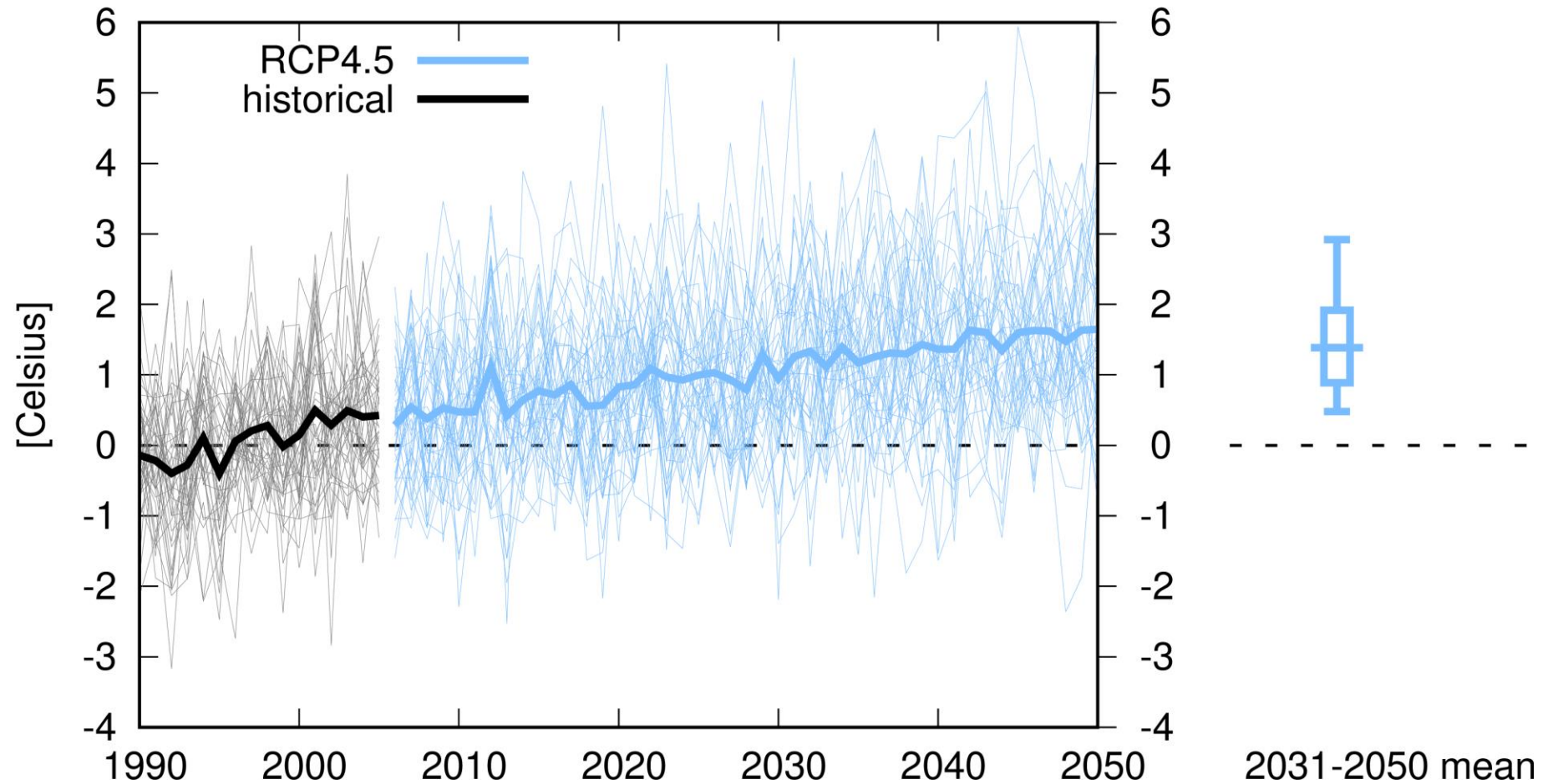
The city of Fehmarn  
Frau Beate Burow  
Tolles Wetter



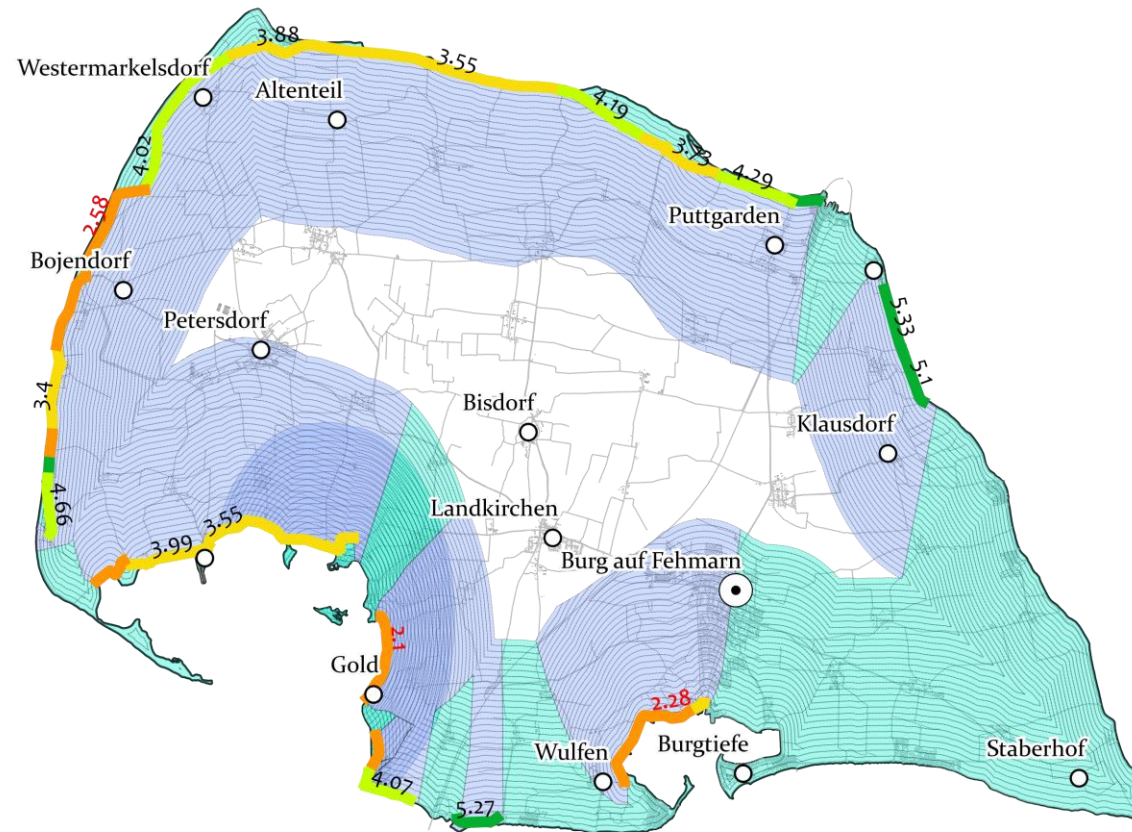
... and the Bürgerbus

# Climate model spread

Temperature change 54.467337N, 11.141473E Jun-Aug wrt 1986-2005 AR5 CMIP5 subset



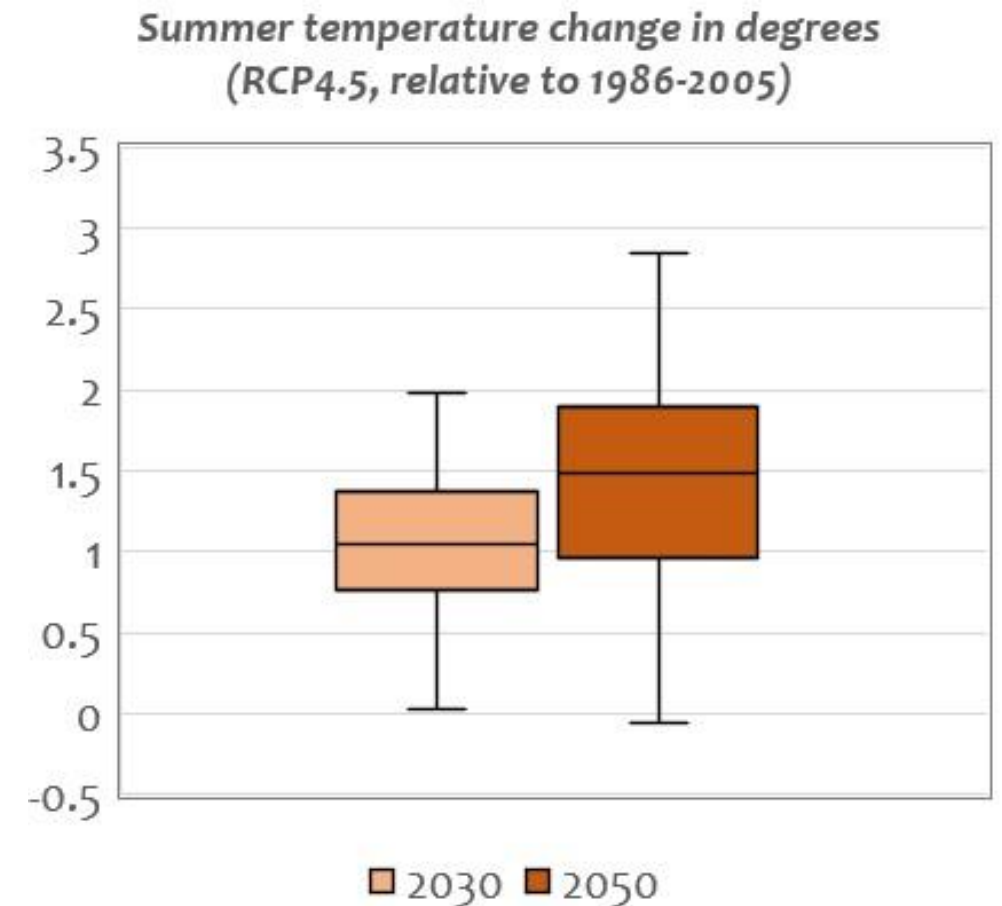
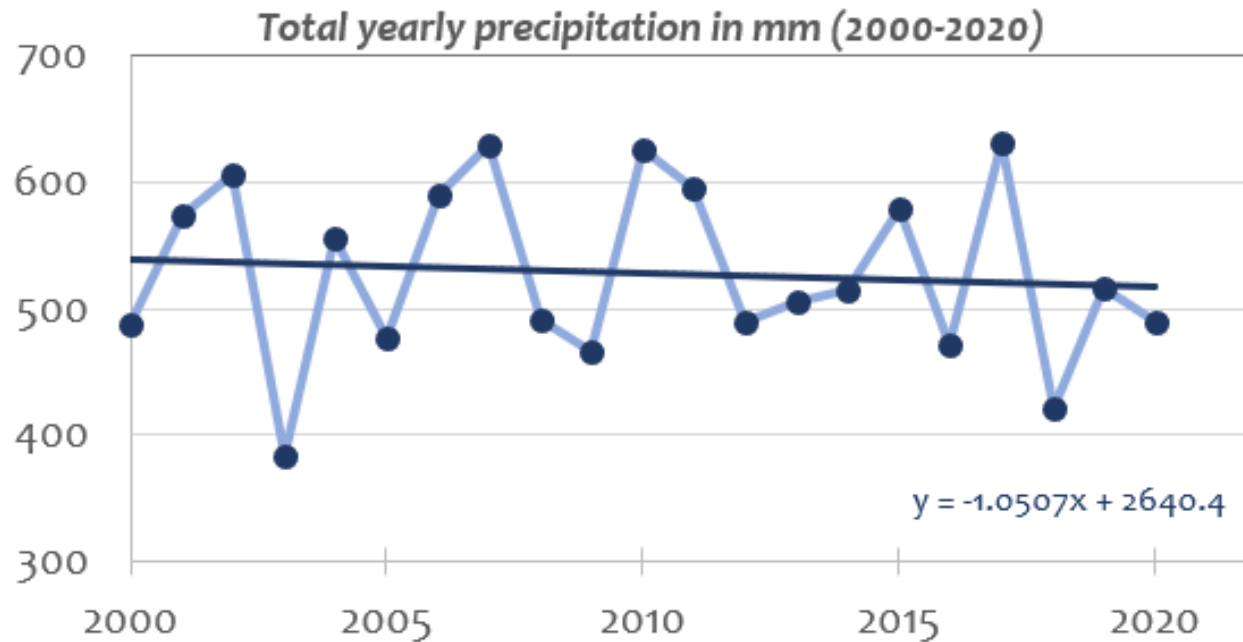
# Flood modeling domain and dike height



## Legend

Estimated dike height (m)	Model domains
< 3	Non protected
3 - 4	Dike protected
4 - 5	
> 5	

# Precipitation trend & temperature projection





# Daily water supply estimate

