

The National Problem of Coastal Erosion and the Strategic Approach of the Public Works Department

A two-part presentation

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Mr Christopher Gauci

Coastal SAGE Project – Stakeholders Meeting - 27th January 2021



Part One:

Overall Approach:

Research and Strategic Planning





Part Two:

Pilot Study:

Coastal Erosion
Risk Assessment
of Għar Lapsi

Mr Christopher Gauci

Part One:

Overall Approach: Research and Strategic Planning



Erosion of the Coast - Nature of the Problem



Response of the PWD – Research and Planning



Multi-dimensional Strategic Approach



Recent Initiatives



Overall Vision and Plan for the Future



Coastal-Climate Protection Strategy (C-COVER)



Preparing for the Task



Erosion of the Coast - Nature of the Problem

- Dynamics that make our coastline a **resource** are also a source of **hazard** and **risk** to our wellbeing
- Issues of **Risk** arise from a combination of:
 - Hazard** (natural/humanly induced processes.)
 - Exposure** (patterns of use, location and type of assets)
 - Vulnerability** (inherent characteristics of what is at risk)
- Coastal erosion problem is **not limited** to rocky shores and public safety. Deleterious effect on **sandy beaches** with **Severe Impact** on the tourism industry
- Other serious impacts (e.g. **coastal heritage**)

Geomorphology
and erosion:
create features
that give the coast
its character,
scenic beauty and
amenity value





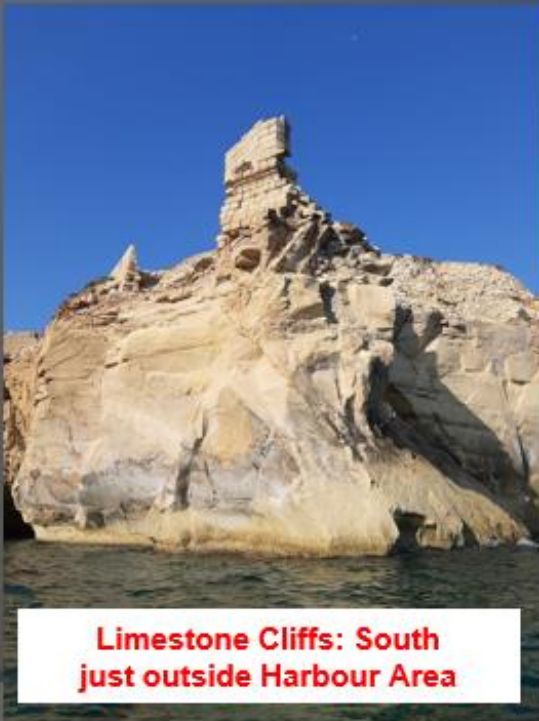
Rockfall warning sign: Gnejna



Cliff face below promenade: Marsaskala Bay (South)



Knights' Historic Fort: Ricasoli



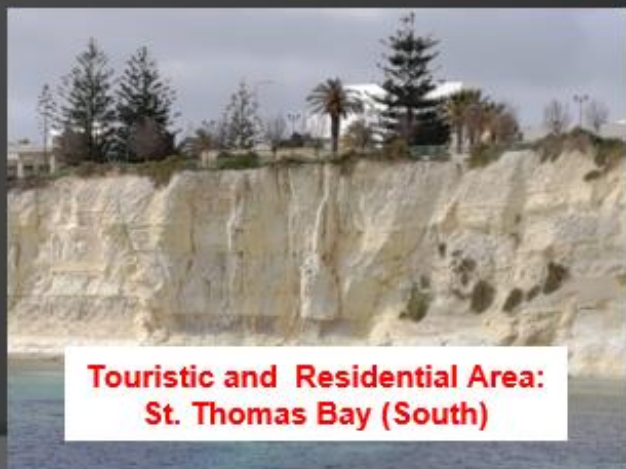
Limestone Cliffs: South just outside Harbour Area



Touristic and Residential Area: St. Paul's Bay (North)



Ghajn Tuffieha Bay



Touristic and Residential Area: St. Thomas Bay (South)



Gnejna Beach

Impacts on tourism



Balluta Bay after beach replenishment project



Balluta Bay eroded after heavy rainfall



Fomm ir-Rih before (left), during (middle), and after the rock fall (right)



Response of the PWD – Research and Planning

- Historically: reactive and piecemeal in approach
- Recently: proactive, scientific and integrative



Response of the PWD – Research and Planning

- Historically, through **‘Dangerous Structures Reporting’**
 - mostly reactive and piecemeal
 - solely demand-driven,
- **Shifting towards more:**
 - Comprehensive, structured and research-based
 - Proactive, scientific, integrative approach
- While also maintaining our **rapid response** to:
 - immediate, localized and specific needs

Dangerous Structures Reporting – historically: reactive and demand-driven by incidents

Situations where coastal erosion creates risks to public safety are not new to the Public Works Department



Footpath providing the only access from the parking area to the sandy beach – Paradise Bay, Cirkewwa



Popular bathing spot – Gnejna Bay

Profile outline and action framework to organise ICM initiatives to be undertaken by the WID-MTIP

Vision and Time-Line	Short term/immediate	Interim/ongoing	Long-term
Strategic and Tactical Matters	Develop strategy for ICM, phase, implement and review		Review and strengthen
	Preliminary coastal assessment To identify high risk areas and 'hot-spots' of imminent danger		
	Prepare plans for and prioritise RRI (Rapid Response Intervention) on identified hotspots	Direct action - RRI according to plan for identified hotspots	Review RRI execution and risk/change monitoring of sites
Political institutional platform	Assessment of prevailing policy/legislative frameworks	Develop and coordinate network of key actors and stakeholders	Amend legislation to strengthen and clarify roles
Cognitive-Knowledge basis	Identify gaps and plan for capacity development at this level	Review of existing information and identification of key sources	Data base on GIS Regular site monitoring and risk assessment Research and management model development
	Generic public awareness of coastal hazard risks	Case by case public information of specific hotspots and high-risk areas/zones	Enhanced public awareness and education on geohazards as well as specific risk zones
		Development of public involvement/crowd-sourcing systems, including apps for reporting and info updates on specific sites	
Resourcing for direct and indirect actions	Build capacity for assessment and monitoring of coastal areas and risk zones		Proactive and preventive interventions
	Build capacity for RRI (resources, network, procedures, HR, etc)	Direct action RRI on emergent cases (unidentified in preliminary or risk escalation in known cases)	Review risk assessment methodology and update site information Review RRI as above
integrate elements of <u>all of the above</u>	Identification and coordination of projects and initiatives for ICM under the MTIP, including but not limited to: <ul style="list-style-type: none"> • ENI CBC MED project / Other EU funded projects • Projects and initiatives from national funds, based on business plans and budget allocations 		

to mention just a few:

- Preliminary Hazard Zonation
- Campaigns of Site Assessments (2018, 2019, 2020, ...)
- Project planning (for the Strategy per se, and also for funding)

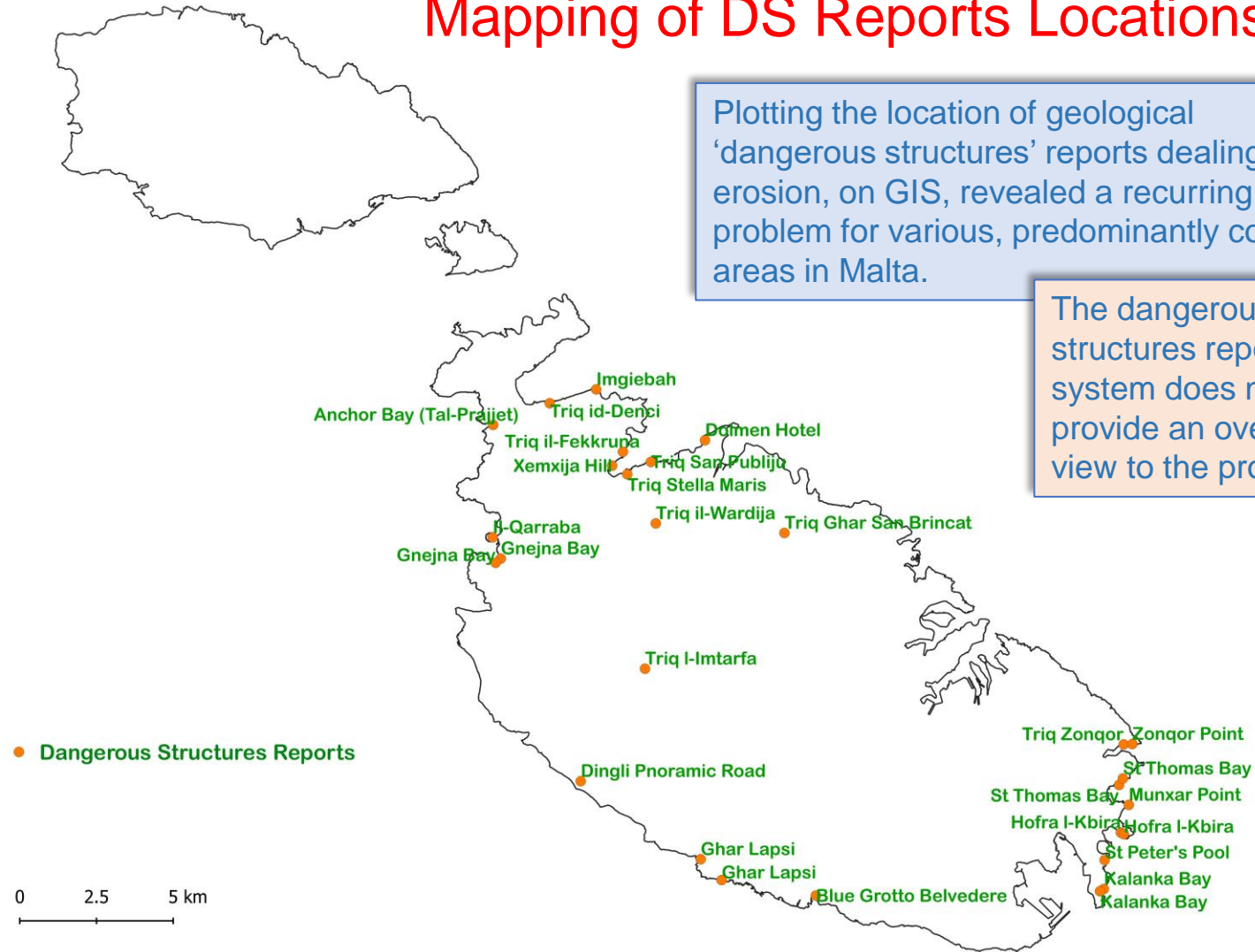
- Centralised Georeferenced Database
- Dangerous Structures Report Locations
- Continuous Research

Mapping of DS Reports Locations



Plotting the location of geological 'dangerous structures' reports dealing with erosion, on GIS, revealed a recurring problem for various, predominantly coastal areas in Malta.



The dangerous structures reporting system does not provide an overall view to the problem.

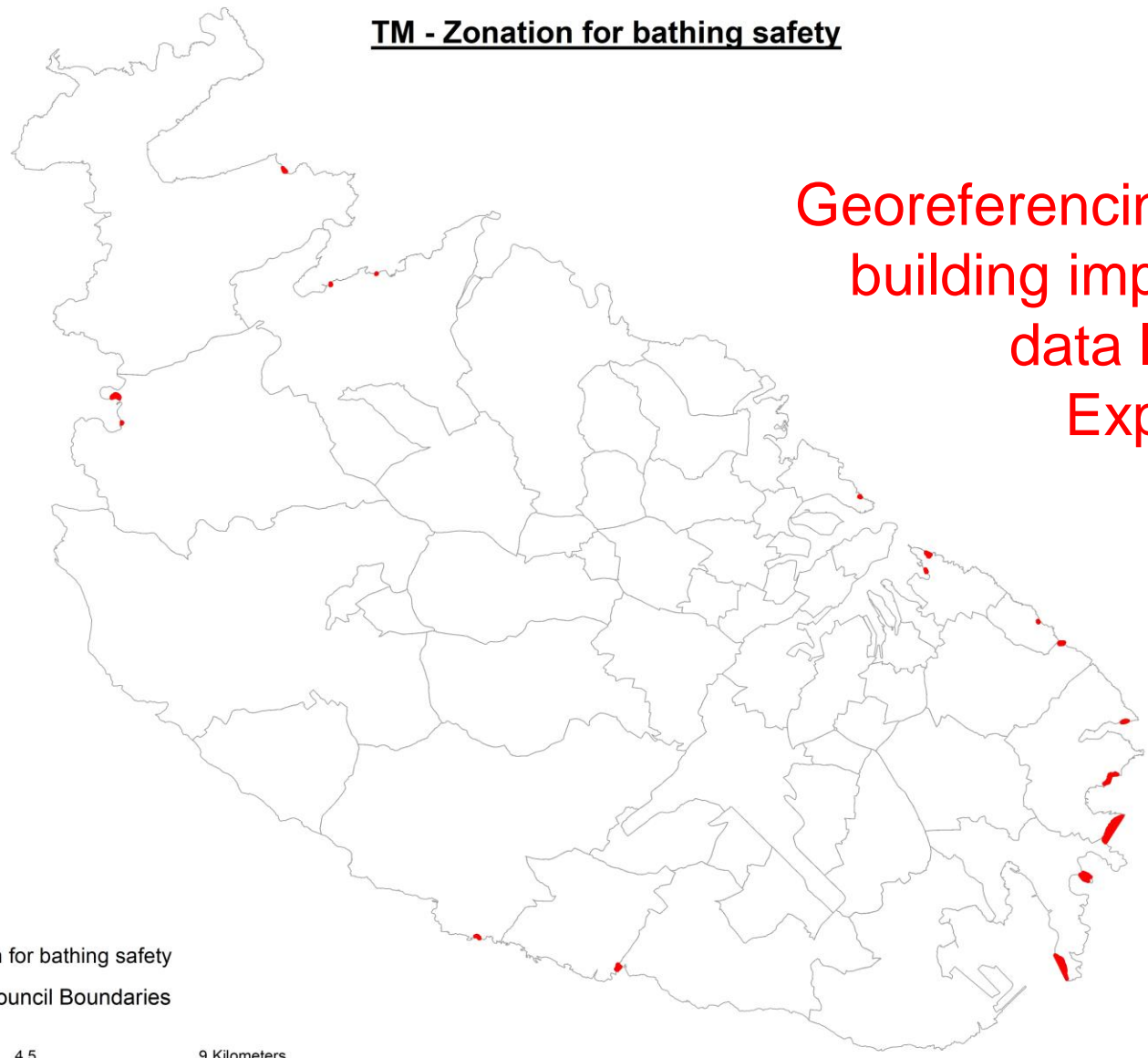


TM - Zonation for bathing safety



**Georeferencing and
building important
data layers:
Exposure**

-  Zonation for bathing safety
-  Local Council Boundaries



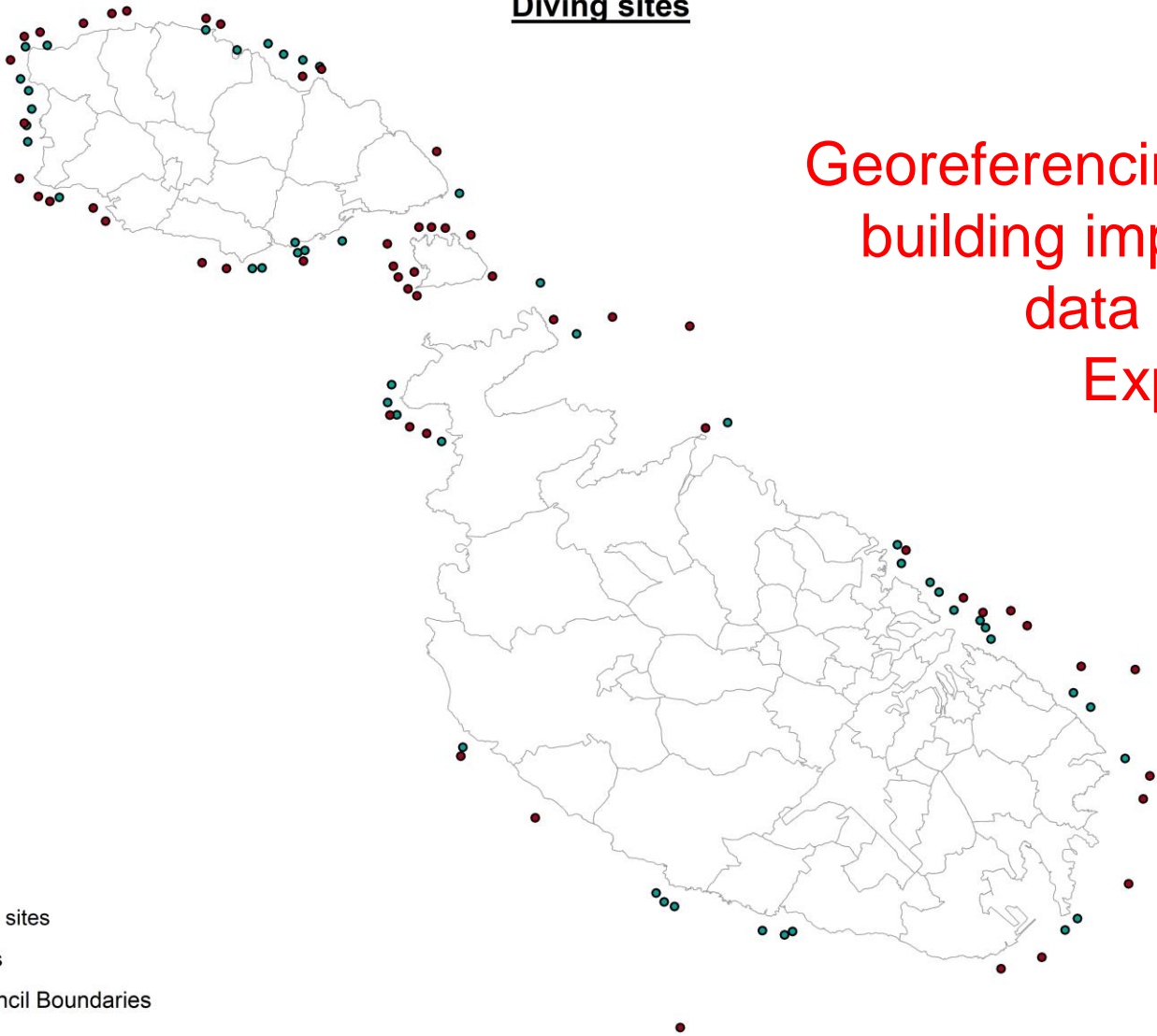
Diving sites



Georeferencing and
building important
data layers:
Exposure

- Boat diving sites
- Diving sites
- Local Council Boundaries

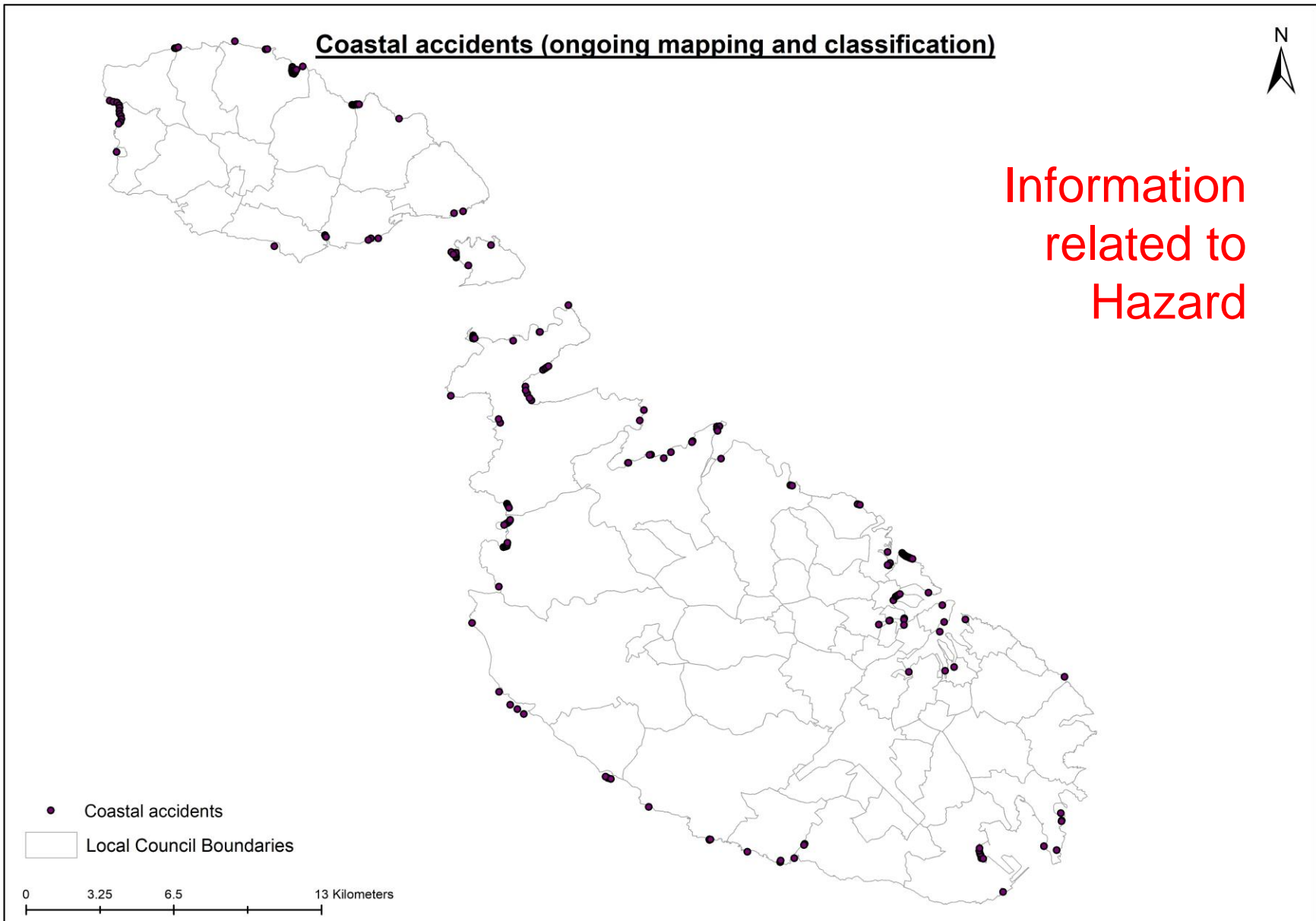
0 3.75 7.5 15 Kilometers



Coastal accidents (ongoing mapping and classification)



Information
related to
Hazard



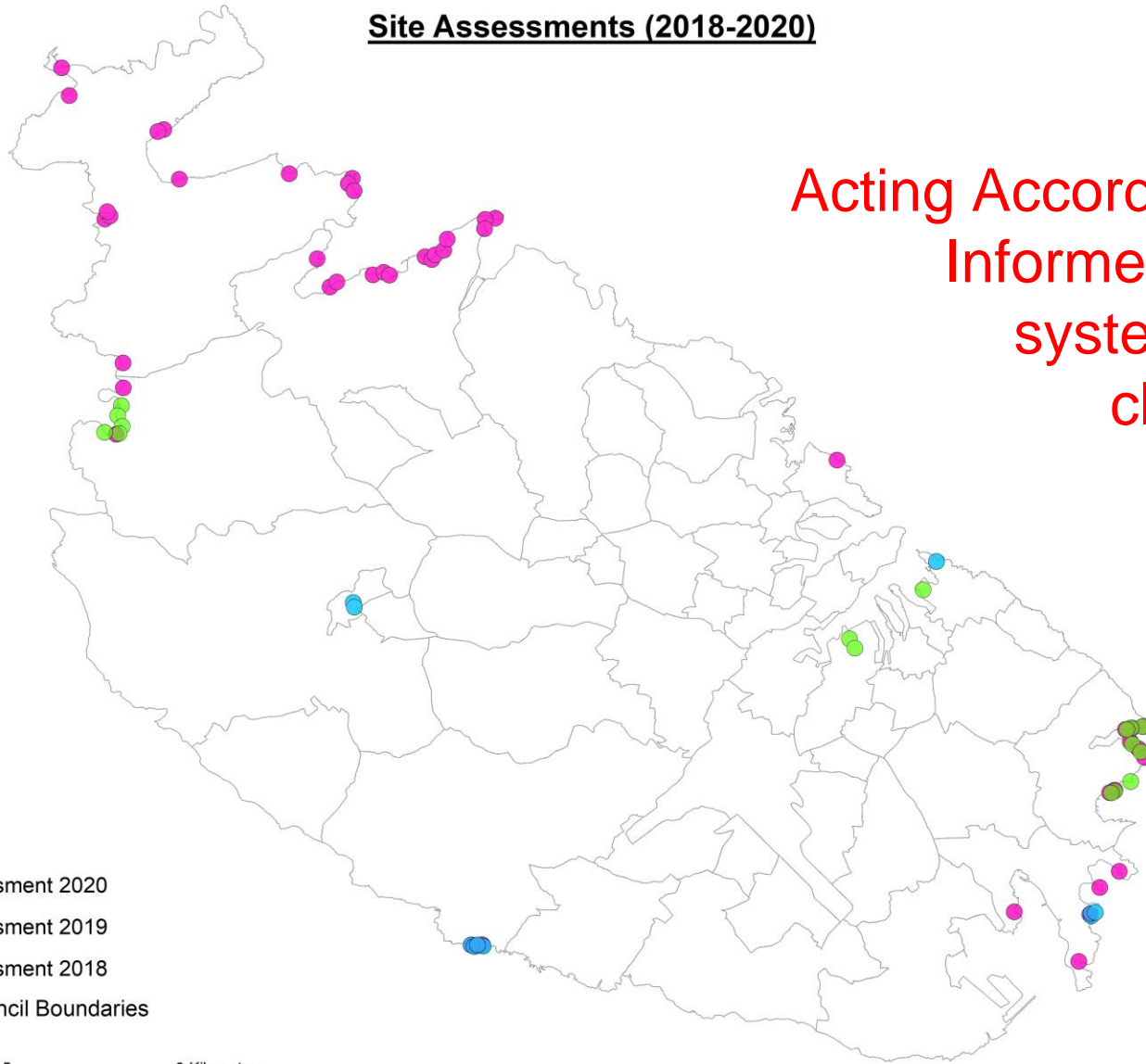
Site Assessments (2018-2020)



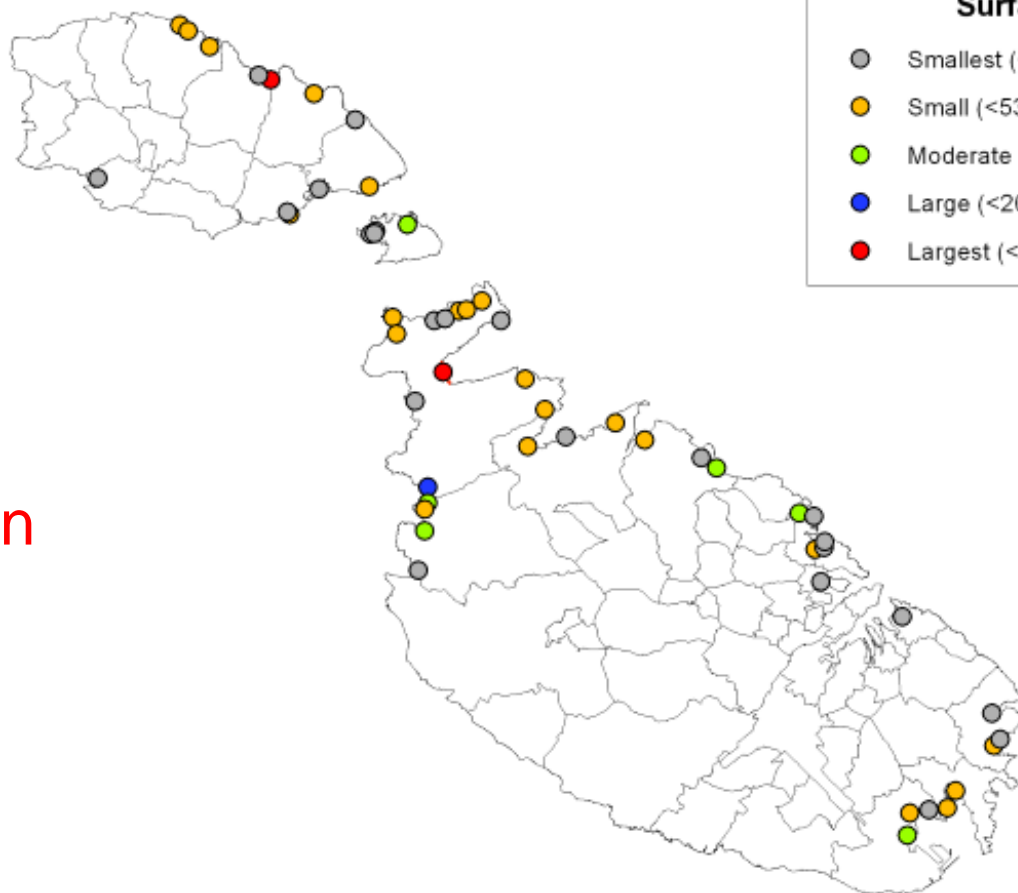
Acting Accordingly:
Informed and
systematic
checks

- Site assessment 2020
- Site assessment 2019
- Site assessment 2018
- Local Council Boundaries

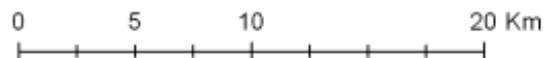
0 2.25 4.5 9 Kilometers



Sandy Beaches (Surface Area)



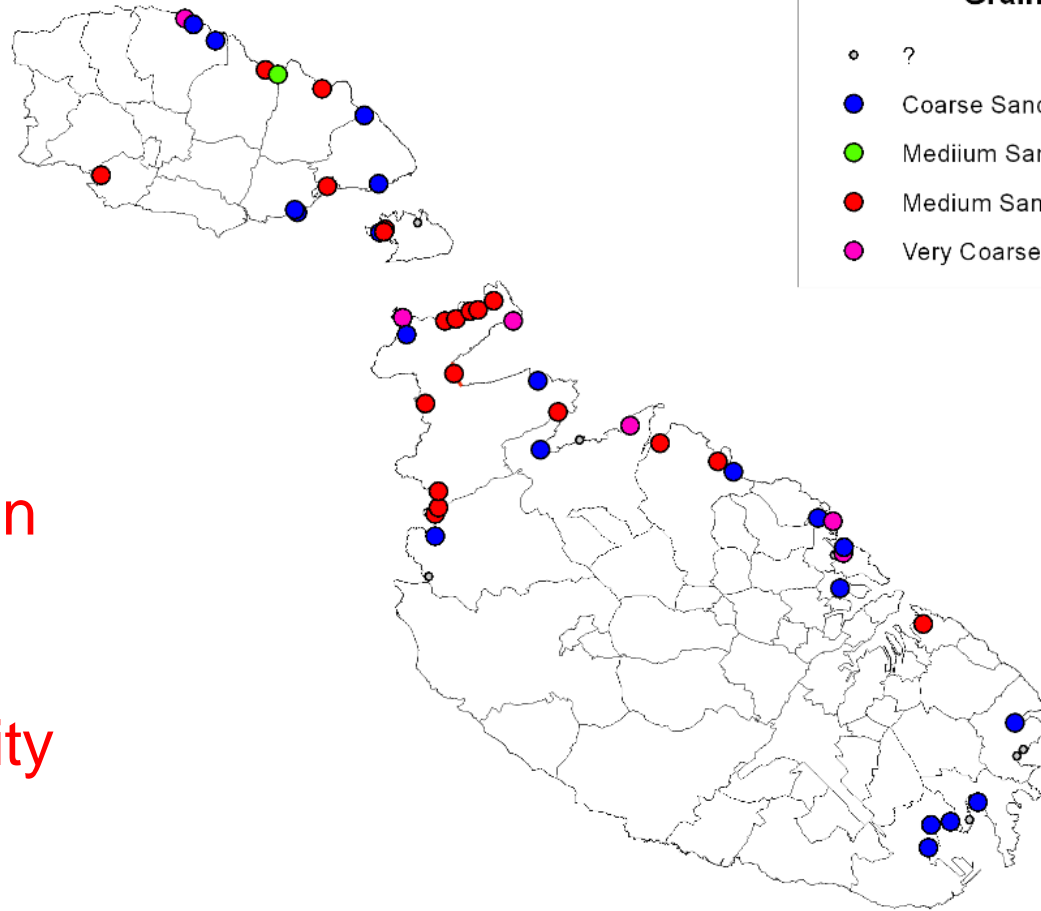
Information
related to
resource
value



N



Sandy Beaches (Microscopy Grain Size, Deidun et.al, 2013)



Information
related to
resource
vulnerability

0 5 10 20 Km



Multi-dimensional Strategic Approach

- Rapid response – timely for immediate and urgent needs
- Visionary and strategic –affording us long-term wellbeing
- Scientific and integrative – evidence-based and socially inclusive



Multi-dimensional Strategic Approach

Coastal Erosion Risk Management:
Vision and Strategic Direction

RESPONSIVE TO
IMMEDIATE NEEDS

Capacity for **rapid response** to
ad hoc and unforeseen situations and
focus for research & planning

SCIENTIFIC & INTEGRATIVE

Vision for evidence-based and
comprehensive planning of
long-term actions and measures

IMMEDIATE & COMPREHENSIVE:

proactive scoping for danger hot spots

fixing of signs to raise awareness

gdb

Reform DSR System:
expediency, vetting, follow-up,
data capture, on-line access, monitoring

Strengthen Basis with:
comprehensive site-by-site risk assessments
and strategic planning, of project interventions,



Recent Initiatives

- Raising risk awareness and promoting safety through caution
- Re-engineering and modernization of workflows
- Commitment to research
- Capacity building

- Worst things first: identifying risk in the most-used areas



FIRST-TIME ORGANISED INSPECTIONS FOR CE RISKS JAN-MAR 2018

All Data later Compiled onto GIS Layers



2019 Follow-up with pre-Summer Monitoring of all Installations made in 2018: Signs/ Fencing requiring maintenance

Inspection of signs

Inspection 1

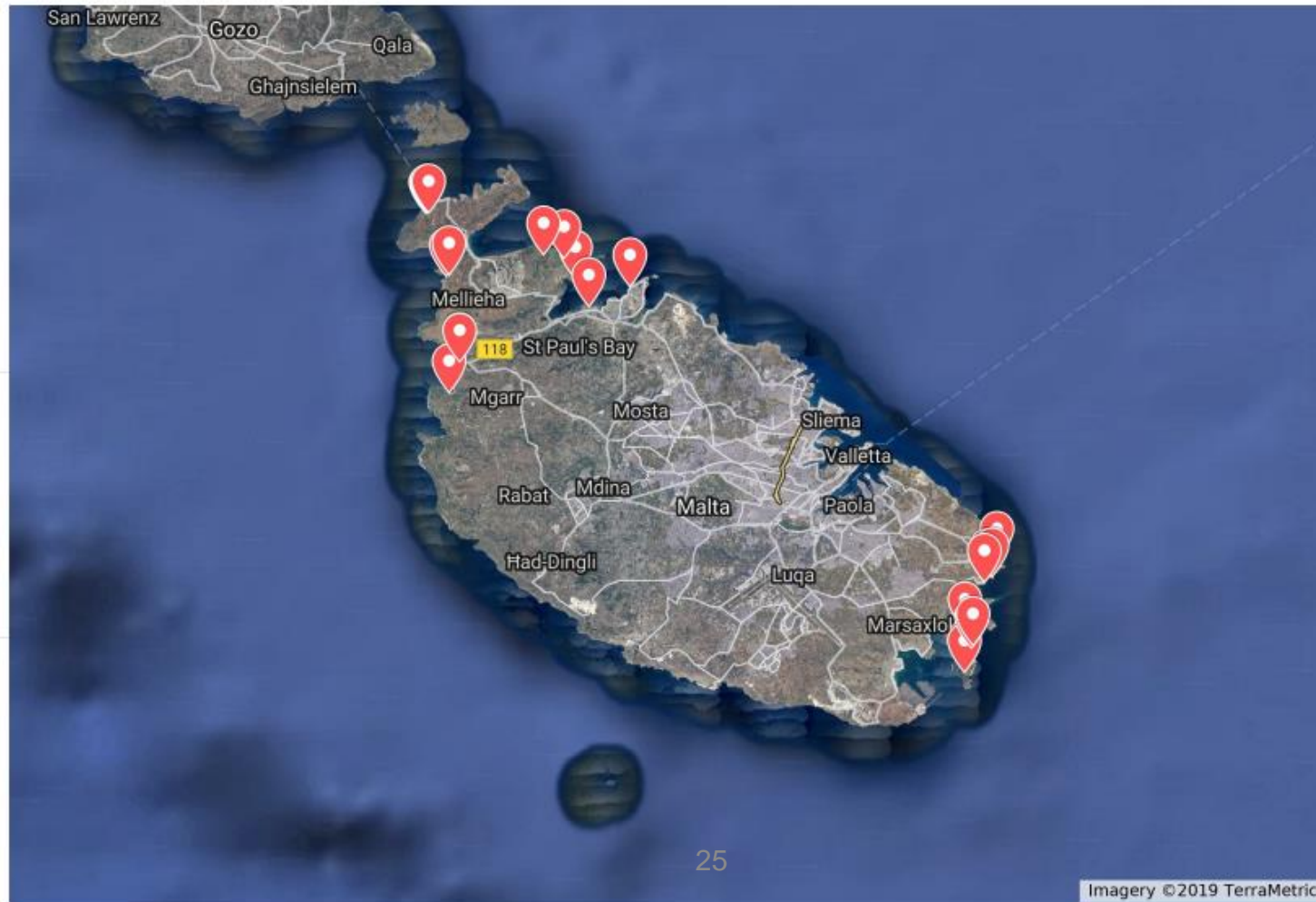
- Point 2- St Peter's Pool
- Point 11- Kalanka
- Point 75- Ras il-Fniek
- Point 78 St Peter's Pool
- Fence 7- St Peter's Pool
- Point 4- St Peter's Pool
- Fence 8- St Peter's Pool

Inspection 2

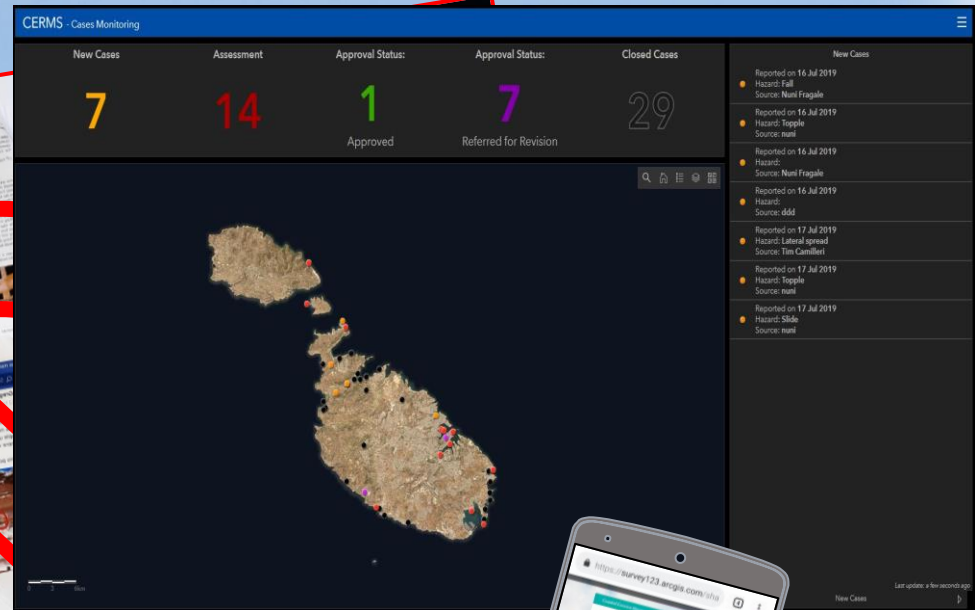
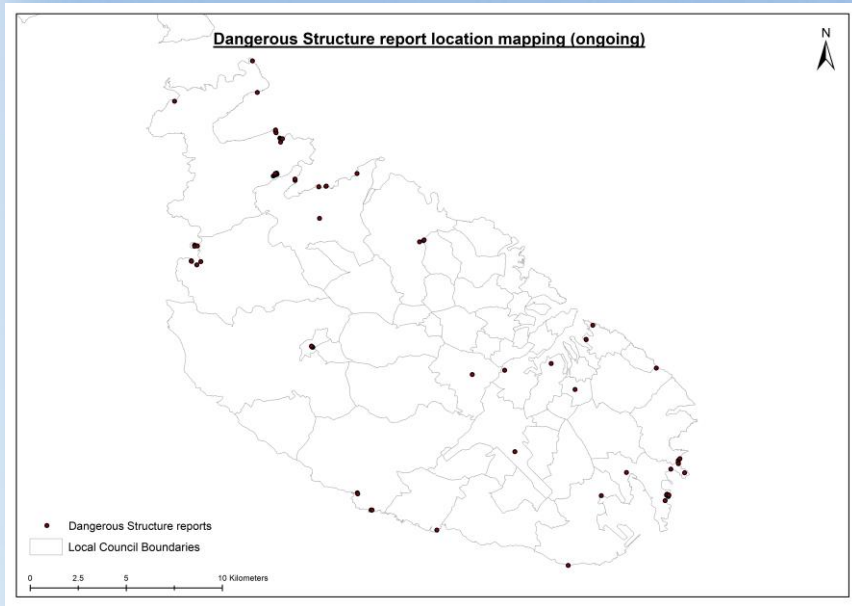
- Point 59- Selmun Mistra
- Point 69- St Paul's Bay
- Point 24- Bugibba Perched Beach

Inspection 3

- Point 33- Gnejna Bay
- Point 34- Ghajn Tuffieha
- Point 35- Ghajn Tuffieha
- Point 39- Anchor Bay
- Point 38- Anchor bay



• Process and workflow re-engineering - work in progress



'Dangerous Structures Reporting'

Rethinking the system for coastal erosion cases

DU/188/1999/2019 (Mamont Island Issue)

Your reference: DU-188/1999/2019
 Our reference: M/142/123

Title: Mamont Island issue

Date of report: _____
 Date of survey: _____

Site description:

Following the report from a citizen to Transport Malta and Għarġuq Local Council regarding the potential danger of sliding of a rock outcrop flanking Triq Għar San-Simeon, Għarġuq, the underground was contacted on the 26th March 2020, to inspect the site to assess the situation regarding the structural fault in the light of any danger to the general public. After contacting the Għarġuq Police Station, it was directed to contact the Mawra Police Station and a site inspection was held over on the same day in the presence of 999-188. The scope of this report is to describe the site in question, show a description of the observed danger as on the date of the inspection (including photographic survey) whilst highlighting the necessary course of action.

Danger assessment:

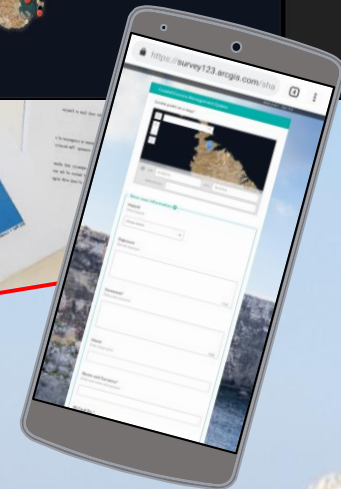
During the inspection held during the evening of 26 March 2020, it was noted that a considerably sized rock wedge constitutes a potential danger of collapse in view of the unusual rock composition characterised by a series of fissures. Heavy rainfall, vibration from vehicular traffic and falling debris may be factors which would trigger the detachment of this rock outcrop and result in collapse with serious consequences. In the light of this, immediate action was taken to close the road in question to vehicular traffic to prevent any danger whatsoever.

Recommended action:

The street is to remain closed off to vehicles until the danger is removed. It is also imperative that any pedestrian passage is also barred. Appropriate signage and barricades/ropes to alert the general public are to be installed accordingly. These shall also be properly illuminated due to the lack of street lighting.

Source:

Ownership:
 Public



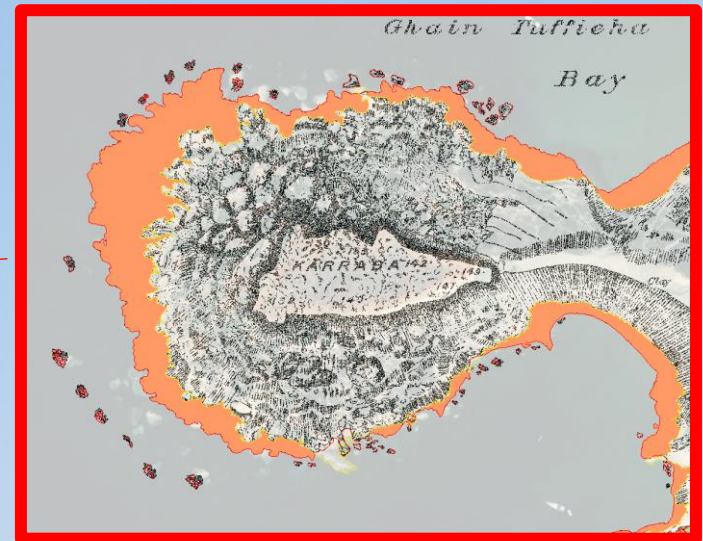
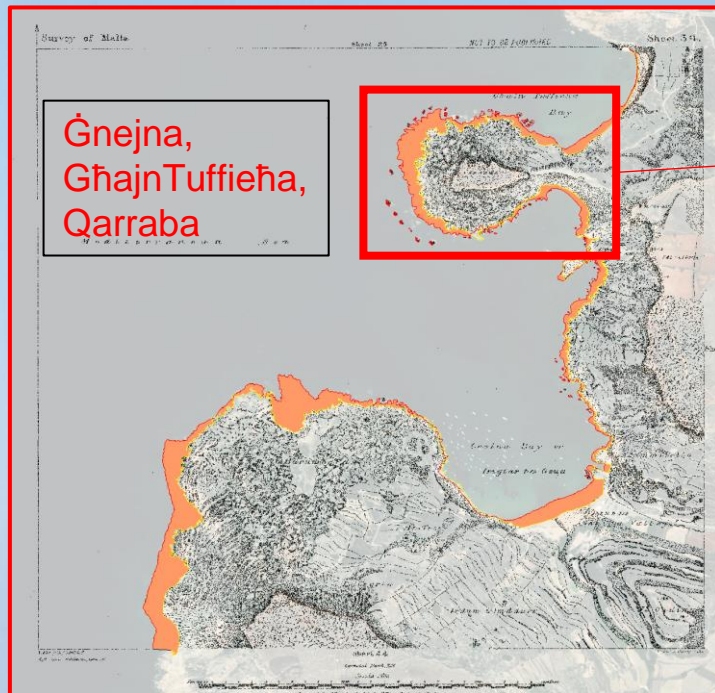
Innovative research initiatives

Study of
Historical
Observations &
Recorded
Erosion

S H O R E timelines

Coastline Retreat CONCERNS

Original In-house Research Study



Legend

- Current Coastline (2019)
- Archive Map Coastline (1896)
- Coastal Retreat

Georeferencing archival maps to determine the area lost and coastal perimeter changes at the coast. Strict criteria are used to determine what is loss & what may be erroneous, (e.g. artificial / sandy beaches).

... being continued periodically in the future and compared to satellite imagery

- Commitment to integrated research

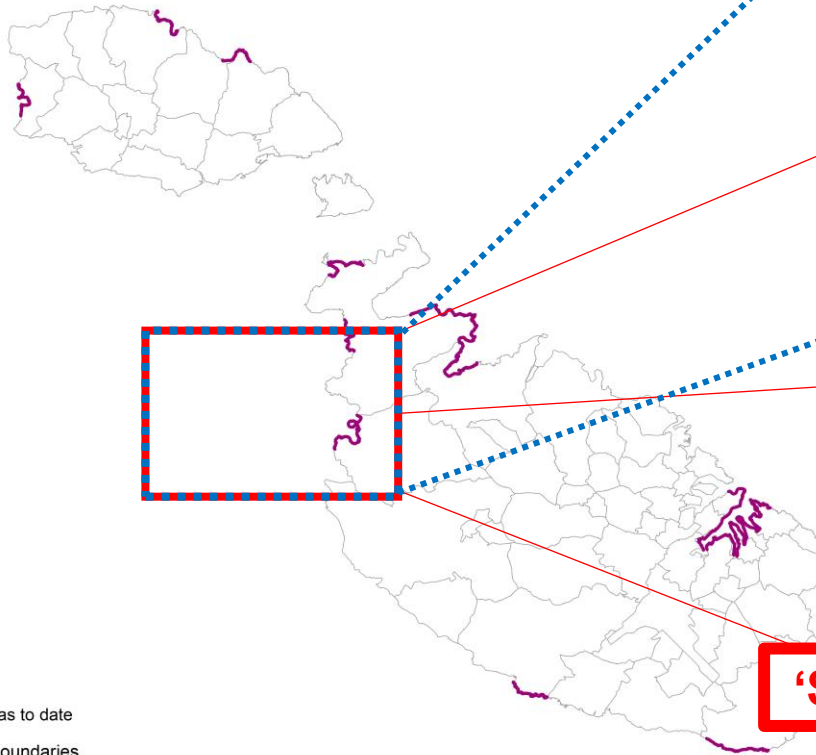


Coastal SAGE



'S H O R E' timelines

Ongoing research using historical information



— Researched areas to date
□ Local Council Boundaries

0 3.5 7 14 Kilometers

... being continued periodically in the future and compared to satellite imagery



Overall Vision and Plan for the Future

- Converge into one direction, one action framework,
- Connect all projects and initiatives,
- Continue filling the gaps



Overall Vision and Plan for the Future

'R&P - all on one canvas'

OUR OVERALL STRATAGEM: Coastal Risk Protection in the Context of Climate Change

Past

Present

Future



'tools'

Satellite-Assisted Governance of Erosion

Coastal SAGE

Geomorphological Dynamic Modelling

3-D Models: Use of LiDAR: Air, Land, Sea

Hydrodynamic Modelling

Climate Change Modelling

'goals & objectives'

'R&P key targets'

Coastal RESEARCH and PLANNING > Ground-Truthing

- Evidence-Based
- Consultative

Coastal RISK PROTECTION STRATEGY

Comparative Coastal –Climate Risk Assessment & Priorities

Action plans for Interventions

Coastal Management Planning.

Coastal Monitoring Programmes



Coastal 'ARM.ing' for **Climate Action** – ERDF and other projects 2021-27
'Adaptation, Resilience, Mitigation' thru' Integrated Knowledge & Governance

Need for a **National Coastal Risk Protection Strategy** instrument



Coastal-Climate Protection Strategy (C-COVER)

Coastal-**C**limate **O**verall **V**ulnerability and **E**xposure **R**isk
National Protection Strategy (C-COVER)

Components

A: national level policies and priorities

B: territorial policies, plans and proposals

C: strategy longevity measures



Coastal-Climate Protection Strategy (C-COVER)

Main components and subcomponents:

A: **national** level policies:

- Geographic and Sectoral Priorities based on risk maps
- Thematic (cross-cutting issues and interests)
- Key sites of national importance

B: **territorial** policies, plans and proposals:

- Higher resolution risk assessment maps
- Phased Master Plans for Prioritized Project Actions
- Coastal Management Plans to Mitigate Risk
- Monitoring Programme

C: **longevity** measures for strategy effectiveness

- Knowledge building, research and innovation, especially for CVA
- Across sectors: capitalize, transfer, replicate for Climate Action
- Capacity assessment and capacity building



Coastal-Climate Protection Strategy (C-COVER)

C-COVER Project:

Preliminarily Selected for EU support



- Technical Support Instrument (TSI)
- Two-year project, to commence shortly, in 2021

Co-ordinated between MTIP and MTCP

- Public Works Department
- Malta Tourism Authority

Widely supported by other entities

- Other Ministries and Government Departments
- National Authorities and Agencies
- Academic Institutions: National and Foreign

Strategically Crucial for Future Action and for Funding

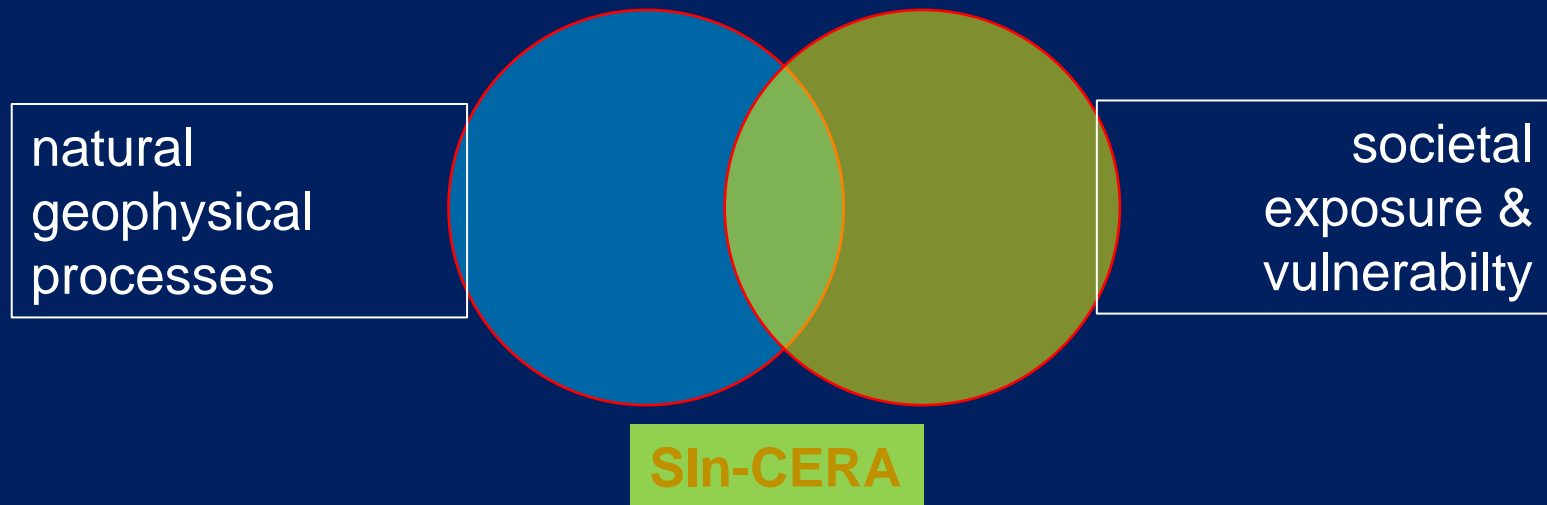


Preparing for the Task

- Initial research and planning work on a framework for **Scientific-Integrative Coastal Erosion Risk Assessment (SInCERA Framework)**
- Testing on Pilot Sites – **Ghar Lapsi** (Part Two of Presentation)
- Organisation and Rationalisation for National Strategy Formulation

within a VISION and STRATEGIC DIRECTION that are:

- **SCIENTIFIC**
To build a multi-disciplinary understanding of the overall geophysical processes
- **INTEGRATIVE**
To factor in issues of exposure and vulnerability of societal values and assets

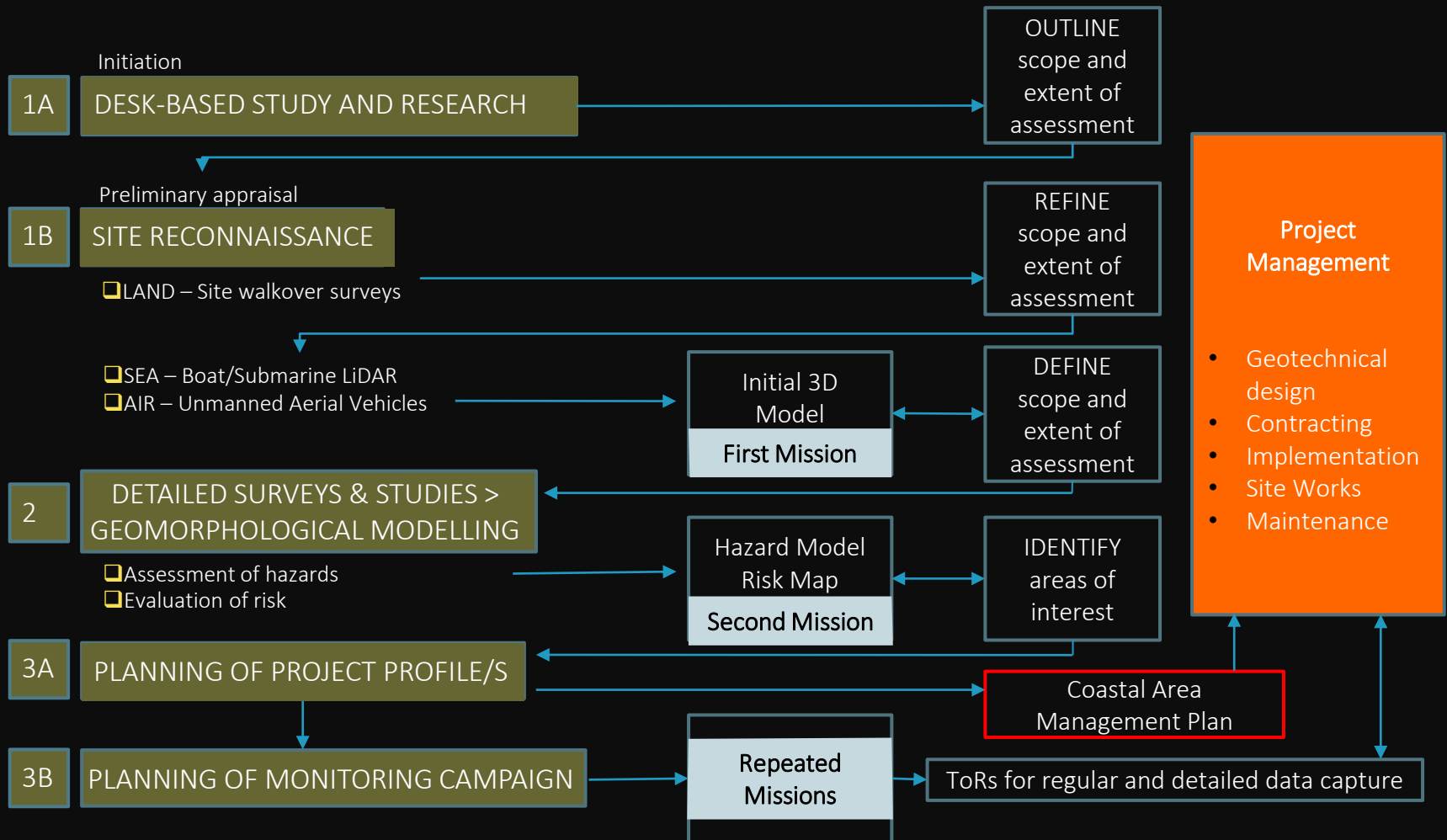


Research & Planning Framework for
Scientific and **I**ntegrative **C**oastal **E**rosion **R**isk **A**ssessment

Planning Framework for Scientific and Integrative Coastal Erosion Risk Assessment

Multi-Stage	Geophysical Features and Processes	Societal Exposure and Vulnerability
Initial Scoping	Generic Site Visit - establish scope of study Desk Study and Data Compilation	General Characteristics Iconic and Unique Features
Stage 1 Preliminary Reconnaissance Site & Desktop Based	Site Walk-Over Reconnaissance Land Cover/Use Survey Elevation Model Geomorphological Survey Spot By Spot: Qualitative Analysis Historical Records: Aerial Photos & Site Plans	General Amenity Values Aesthetic Environmental Quality Policy Context Population Density Recreational Value Local Accessibility Focal/Vantage Points
Stage 2	Digital 3D Terrain Models Historical Records: Old Text Documents Historical Records: Bathymetry Hydrology -Runoff	Visitor Attractions Commercial Value Tourism Market Other Economic
Stage 3	GPR Wave Action -Hydrodynamic models 3D underwater modelling and benthic surveys Spot By Spot: Quantitative Measurements Structural Testing	Industrial Uses Fisheries Agriculture Other resource values Utilities
Other Data Types and Data Collection Techniques	Core Sampling Satellite Imagery Detailed Topographic and Level Surveys other geophysical and morphological data	Critical Infrastructure Land Transport Infrastructure Marine Transport Infrastructure Current Use Intensity Forecasted Use Intensity

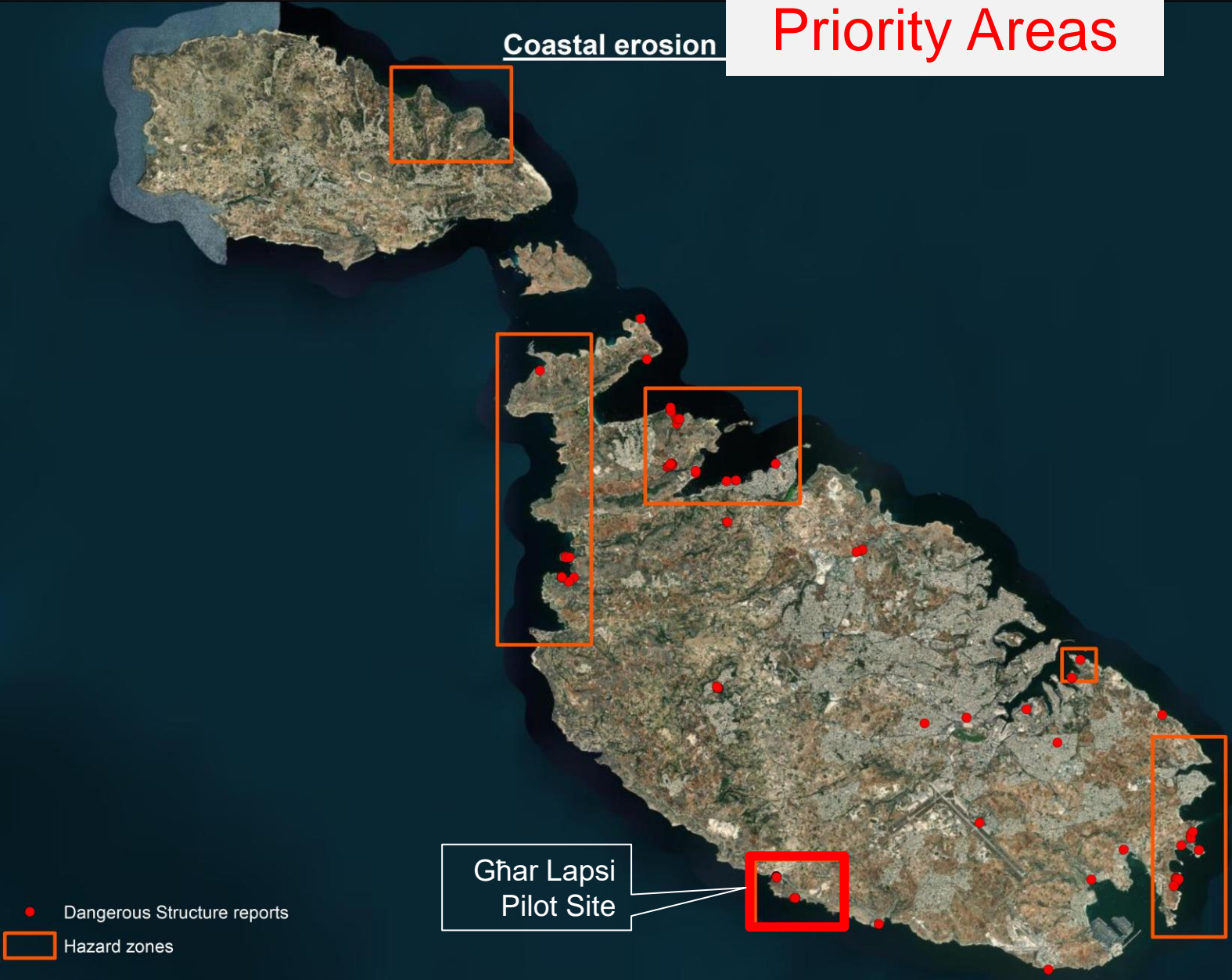
Planning Framework for Scientific and Integrative Coastal Erosion Risk Assessment



Priority Areas



Coastal erosion

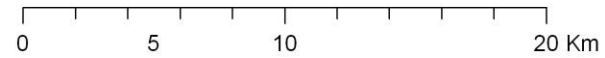
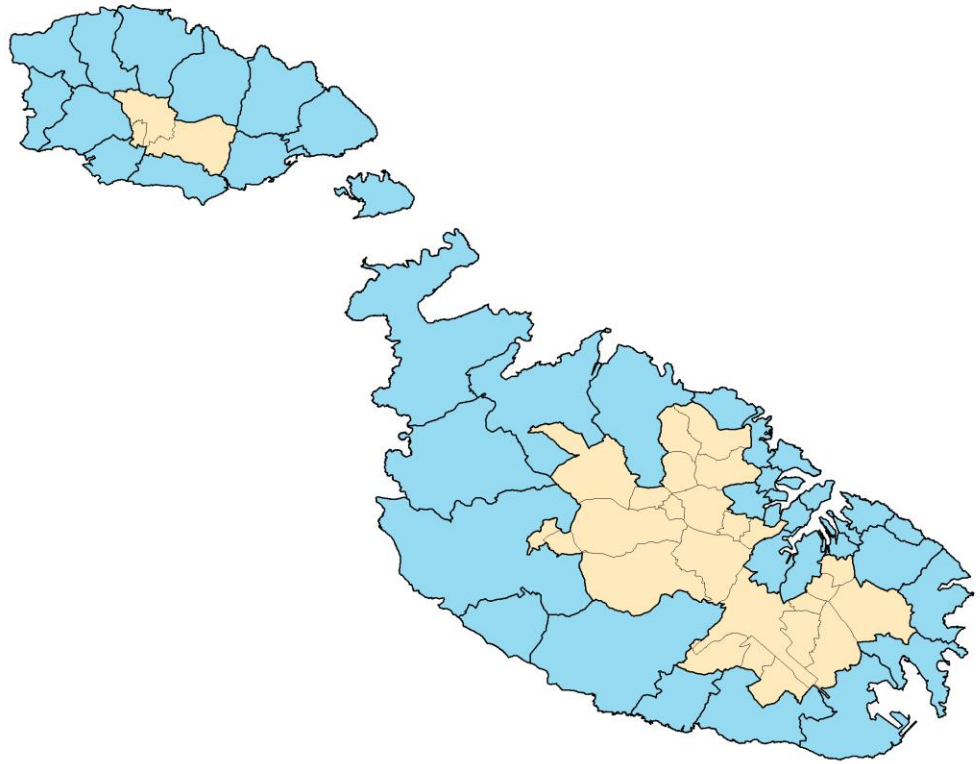


- Dangerous Structure reports
- Hazard zones

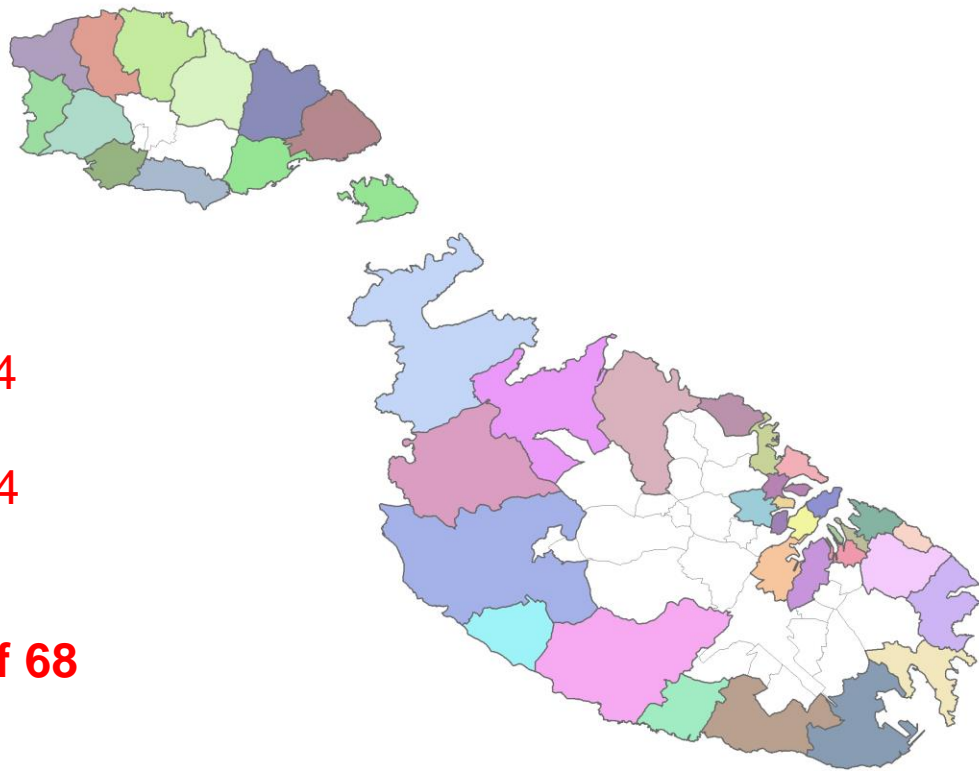
0 3.25 6.5 13 Kilometers

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Local Councils with Coastlines (Blue)



Local Councils with Coastlines



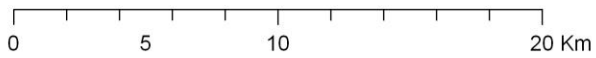
Legend

- Birgu
- Birzebbuga
- Bormla
- Ghajnsielem and Comino
- Had-Dingli
- Haz-Zabbar
- Il-Furjana
- Il-Gzira
- Il-Kalkara
- Il-Marsa
- Il-Mellieha
- Il-Munxar
- Il-Qala
- Il-Qrendi
- In-Nadur
- In-Naxxar
- Ir-Rabat
- Is-Siggiewi
- Ix-Xaghra
- Ix-Xghajra
- Iz-Zebbug
- Iz-Zurrieq
- L-Gharb
- L-Ghasri
- L-Imgarr
- L-Imnsida
- L-Isla
- Marsaskala
- Marsaxlokk
- Paola
- Pembroke
- San Giljan
- San Lawrenz
- San Pawl il-Bahar
- Ta' Kercem
- Ta' Sannat
- Ta' Xbiex
- Tal-Pieta'
- Tas-Sliema
- Valletta

Gozo: 11 out of 14

Malta: 29 out of 54

TOTAL: 40 out of 68

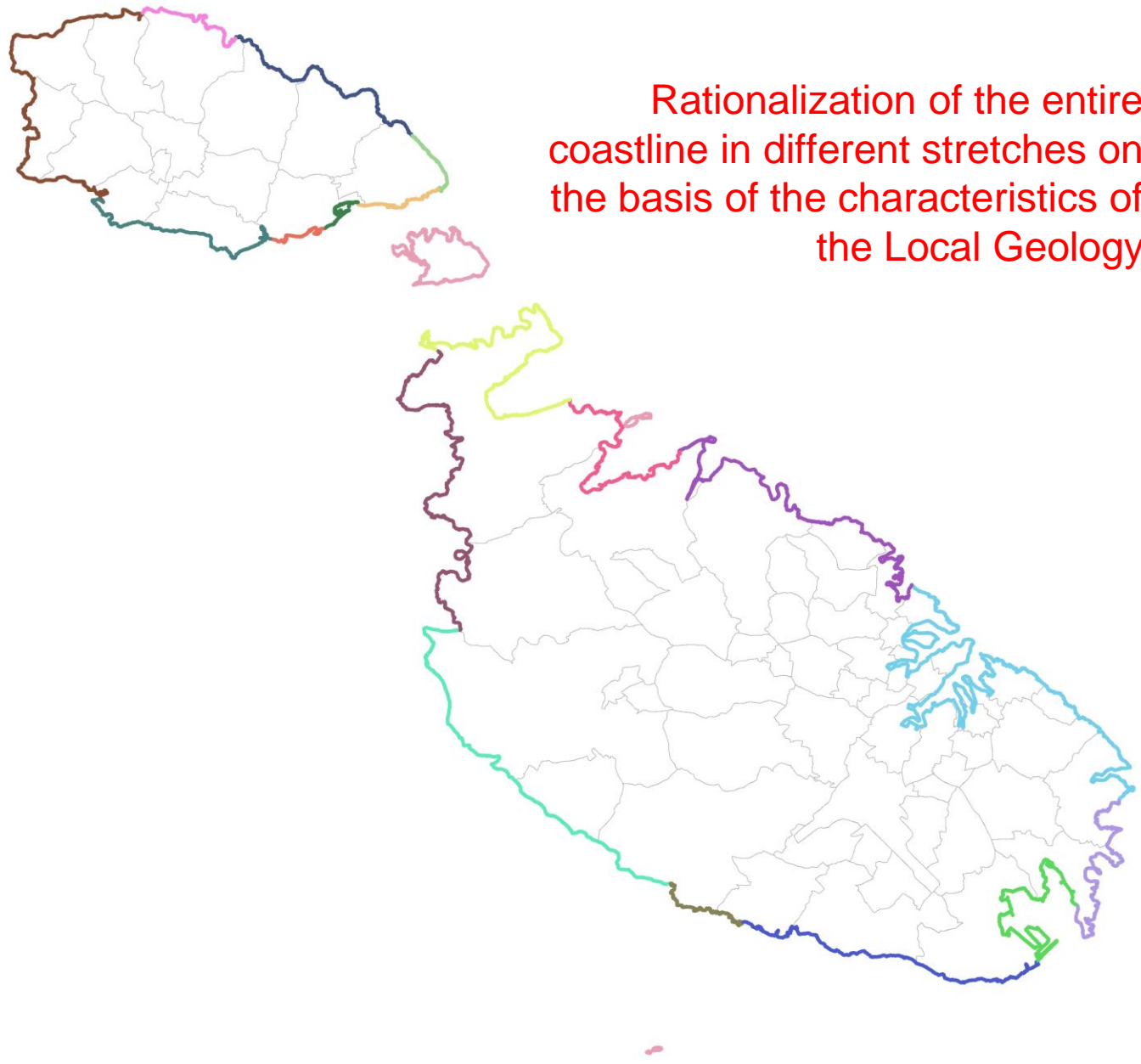


Rationalization of the entire coastline in different stretches on the basis of the characteristics of the Local Geology

Legend

Sector Location

- 1, Dingli
- 2, Ghar Lapsi
- 3, South Malta
- 4, Qajjenza
- 5, Delimara
- 6, Sliema-Marsaskala
- 7, Bahar ic-Caghaq
- 8, Selmun
- 9, Ahrax
- 10, Northwest Malta
- 11, Small Islands
- 12, Nadur
- 13, Ras il-Qala
- 14, Hondoq
- 15, Gozo Harbour
- 16, Xatt l-Ahmar
- 17, Qbajjar
- 18, West Gozo
- 19, Sannat



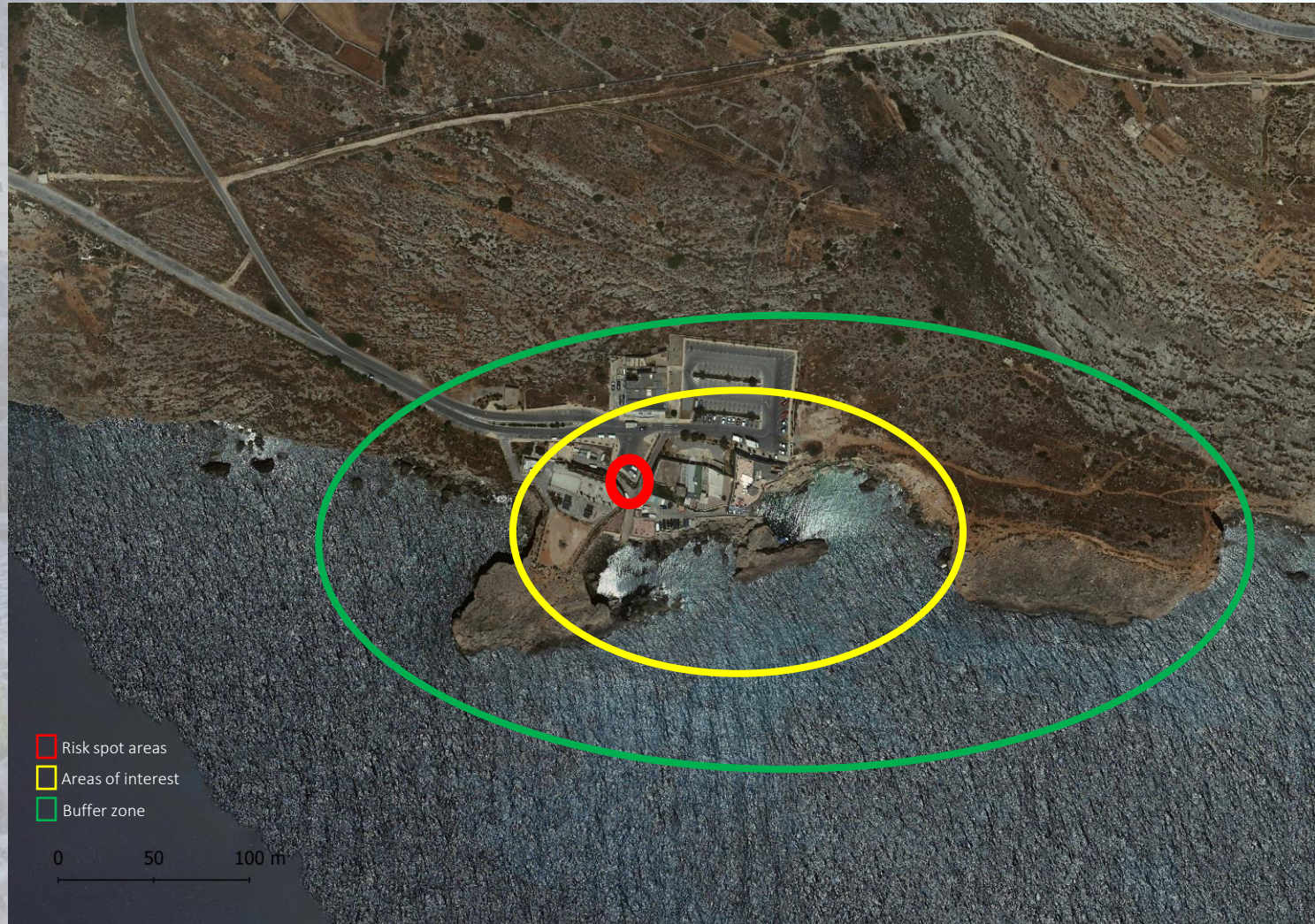
A photograph of a coastal area with a rocky shore, a building on the left, and a bay with people swimming. The text is overlaid on the image.

Pilot Study:
Coastal Erosion Risk Assessment
of Ghar Lapsi

Pilot Study: Coastal Erosion Risk Assessment of Ghar Lapsi

Initial Stages >>> Scope of Study & Area of Interest (AOI)

From already known risk spots to wider scoping to identify study area and buffer zones

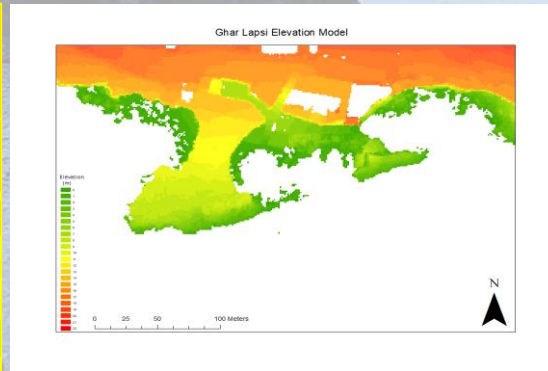
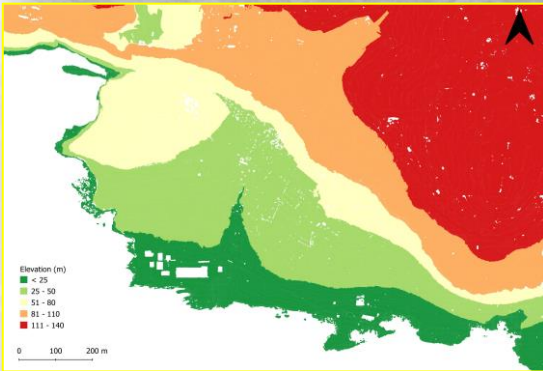




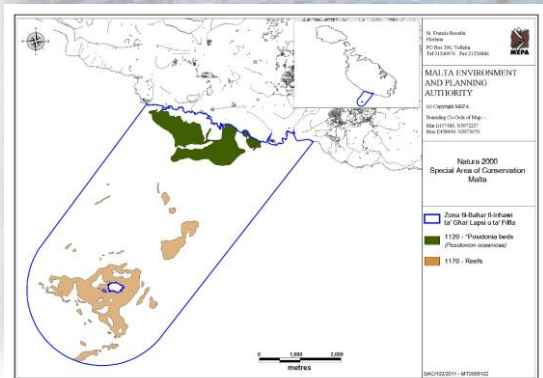
Preliminary desktop data collection



Geology at a larger scale



Elevation at different scales



Conservation Status:
Natura2000

Georeferencing and comparison of old maps to present day

Coastline and boulder comparison 1909 vs 2019

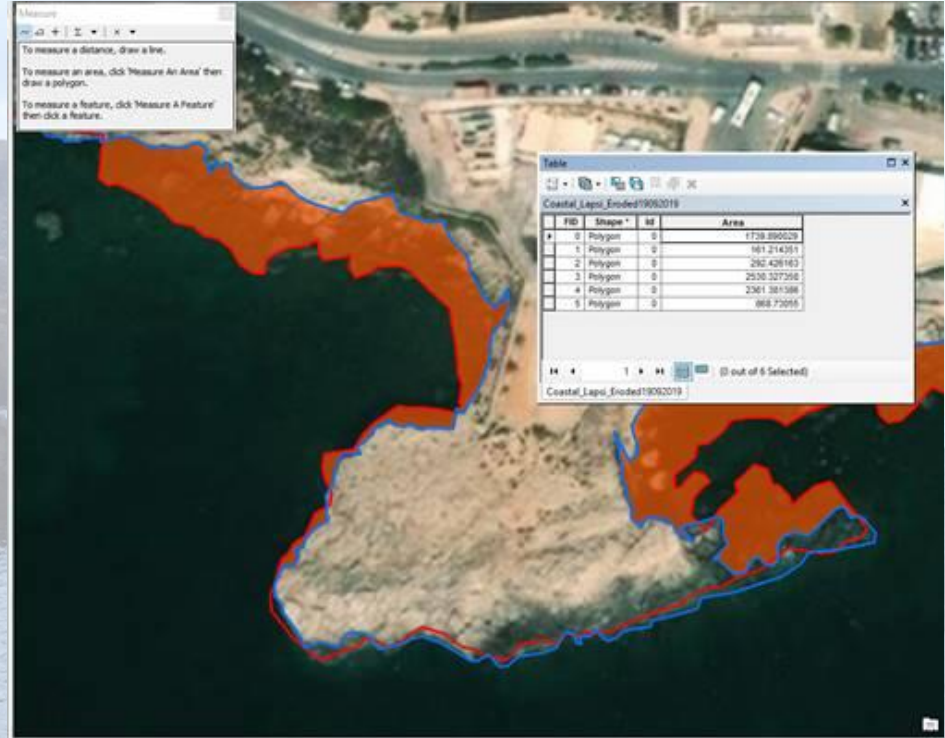


Georeferencing and comparison of old maps to present day (cont.)

Erosion AREA calculations were made by creating polygons between 1909 and 2019 coastlines.

The total area eroded equates to **7,951sqm** (this includes boulder screens).

Shapefiles were plotted using the 1909 survey sheets and ARCMAP's imagery basemap.



Research to date prompts further study ...

Land and boulder scree area eroded in the last 110 years (7,951sqm) prompts further research on this site, and more widely - e.g. TOTAL area being eroded, **NATIONALLY**

Further research includes looking at historical aerial photos as interim snapshots to check the above and study rate of retreat

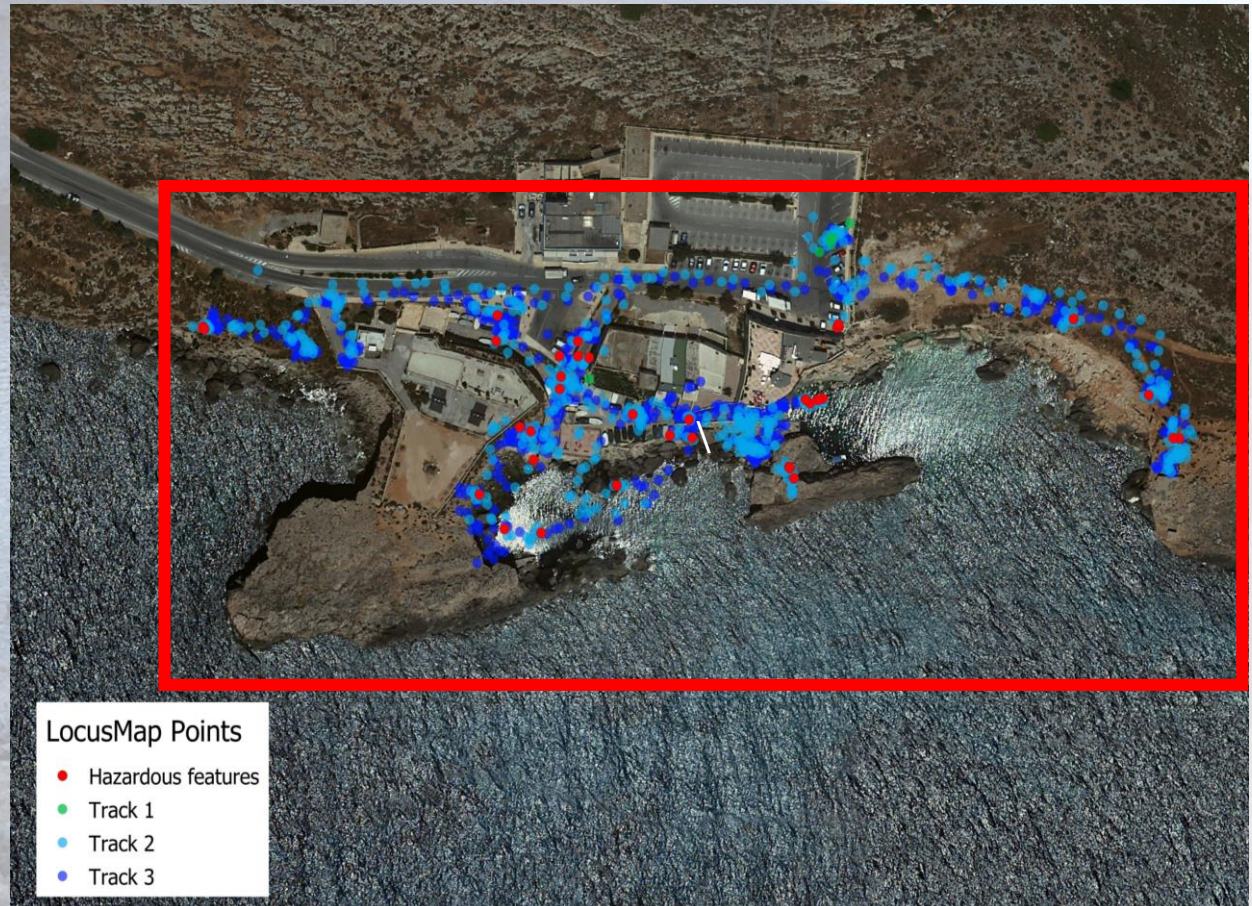
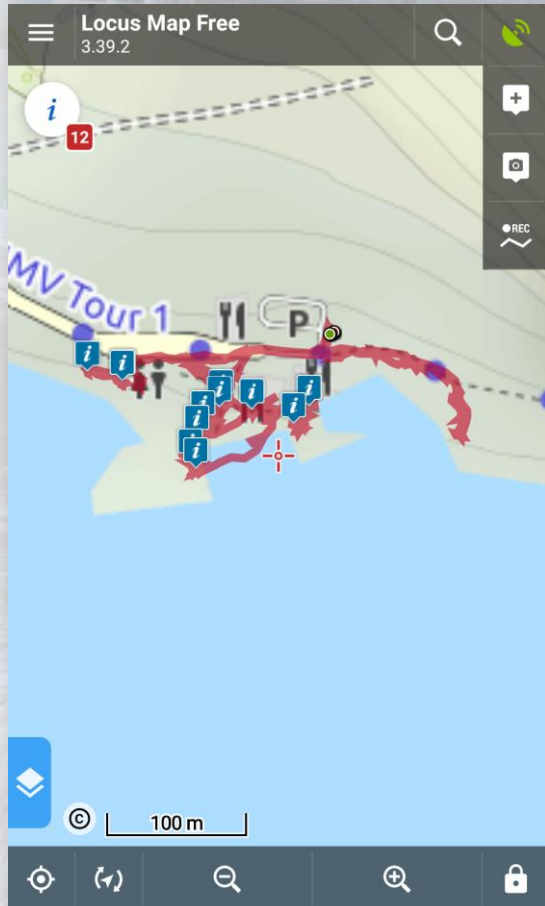
It also includes investigating the rate of material loss at micro scale, through rock measurements, mapping and monitoring



Sample ID:	_____
Location:	_____
Date:	_____
Season:	_____
Environmental Conditions:	
Wind direction & speed -	_____
Air temperature -	_____
Humidity -	_____
Precipitation -	Yes <input type="checkbox"/> No <input type="checkbox"/>
Cloud cover -	Full <input type="checkbox"/> Partly <input type="checkbox"/> None <input type="checkbox"/>
Sea conditions -	Calm <input type="checkbox"/> Moderate <input type="checkbox"/> Rough <input type="checkbox"/>
Visual inspection:	
Rock size (cm) -	_____
Rock shape -	Angular <input type="checkbox"/> Rounded <input type="checkbox"/>
Calculations (in lab):	
Volume of water -	_____
Volume of water with rock -	_____
Density -	_____
Attach Photo (for location)	

Site Reconnaissance & LocusMap points and tracks

Plotted points from Site Walkover on GIS using LocusMap (mobile application)

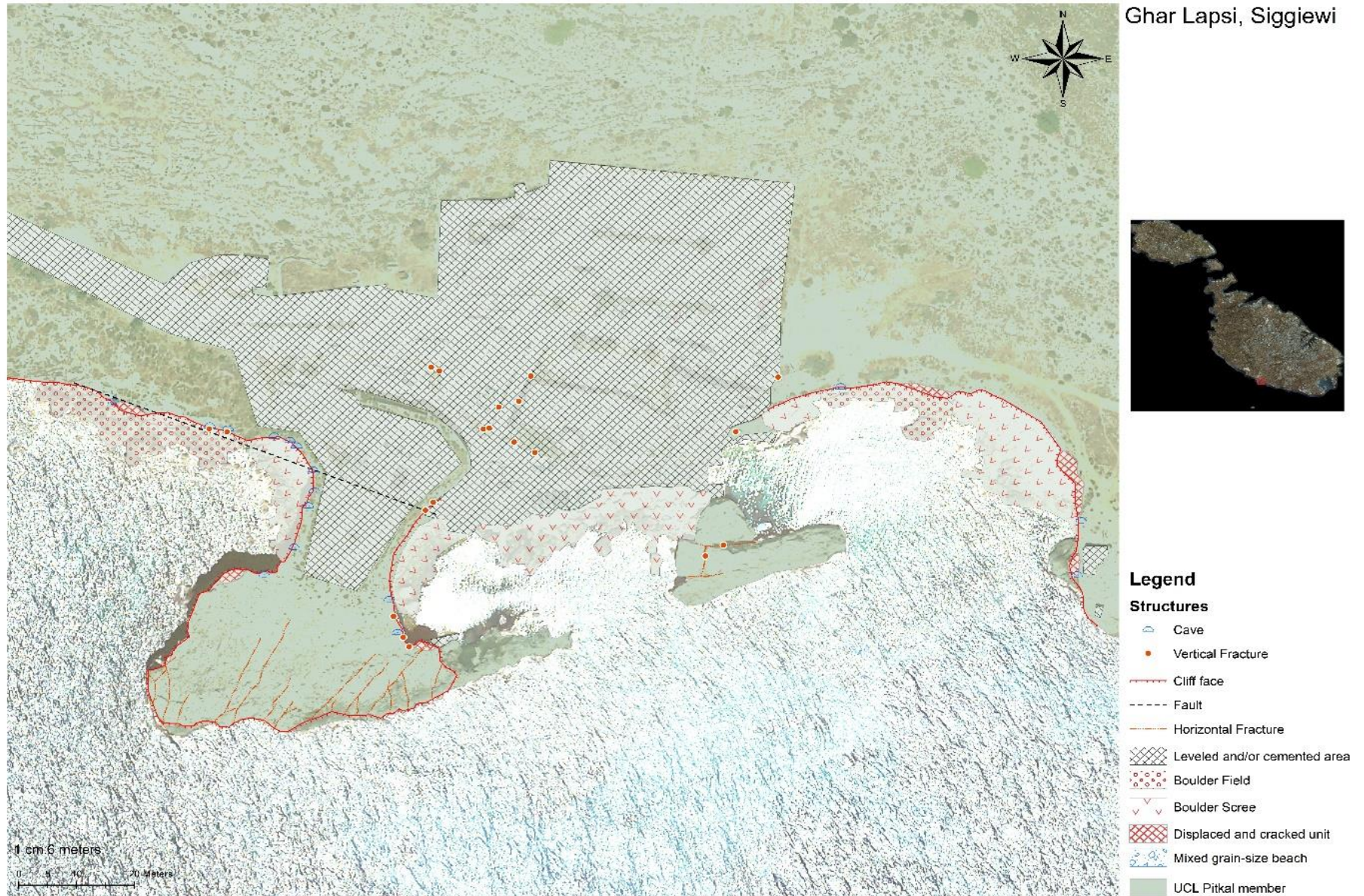


Geomorphology map

Hand-drawn on-site



Geomorphology map (cont.)



Geomorphology map (cont.)

New identified risk spot areas

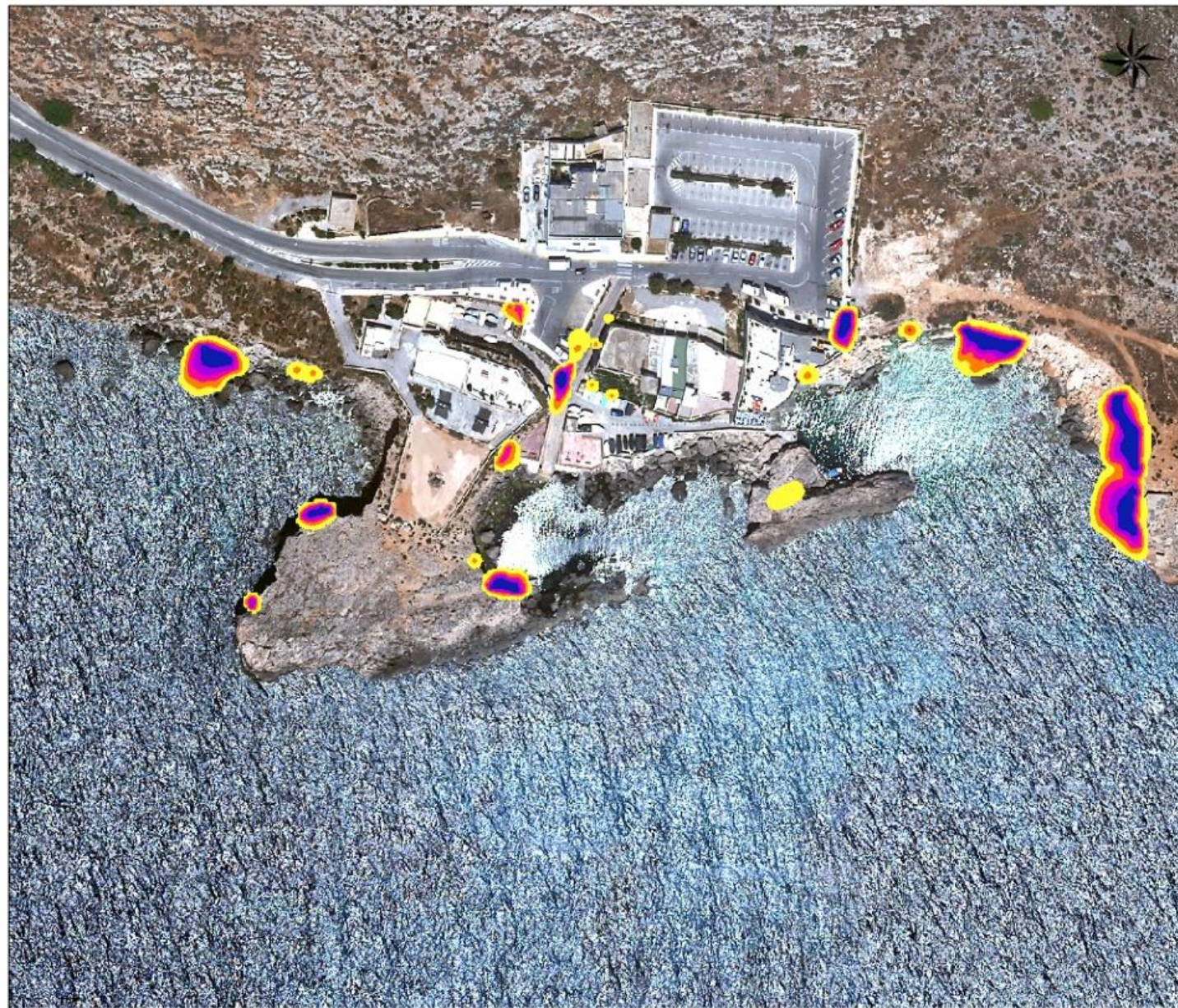
TEN risk spot areas including the **TWO** reported originally as 'dangerous structures'



Geomorphology map (cont.)

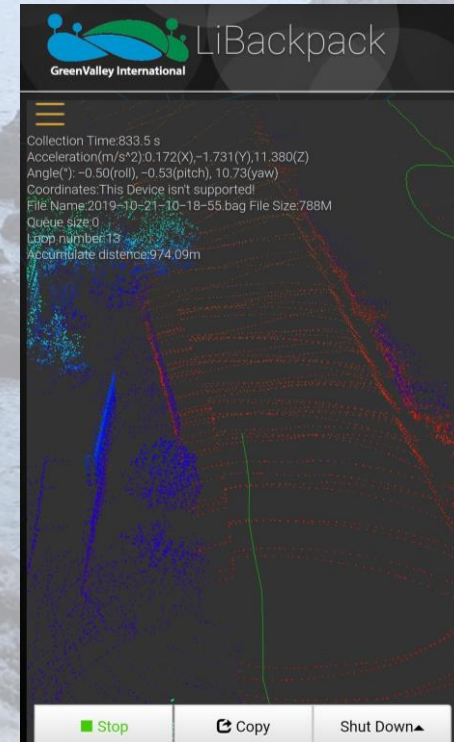


Hazard Mapping: based on additional factors



Use of Digital 3D Terrain Modelling

TLS: Riegl VZ400i
DJI Mavic Pro 2
Greenvalley LiBackpack 50



Land Cover

These are raster images generated via the Normalized Difference Vegetation Index. NDVI is an equation that allows an analyst to quickly distinguish between artificial & natural surfaces. Raw data for these calculations is derived from multispectral sensors (satellite) bands, namely the infrared & red band.

These particular images were generated using SAGA GIS and a satellite with 3 x 3km resolution.

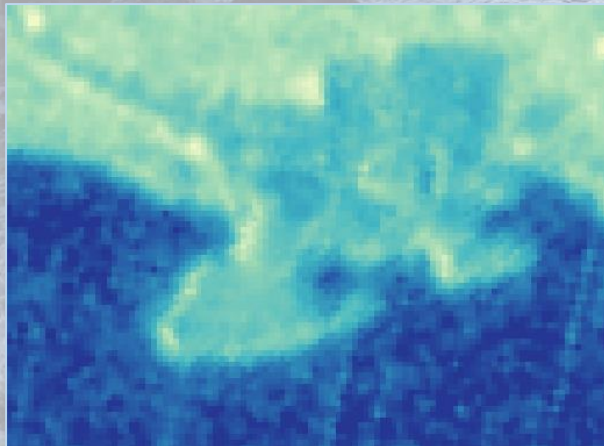


Figure a: NDVI index, where darker shades indicate artificial structures

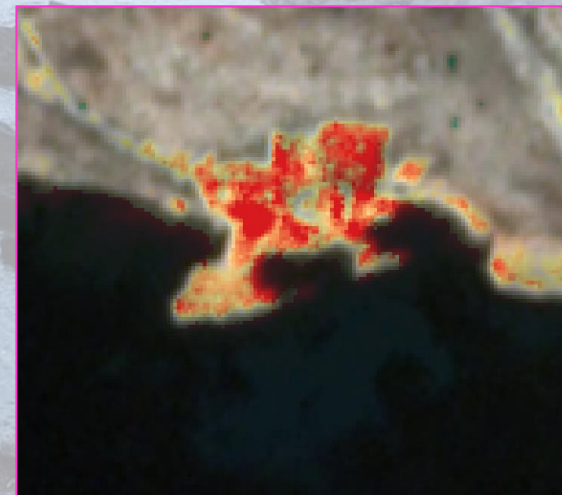


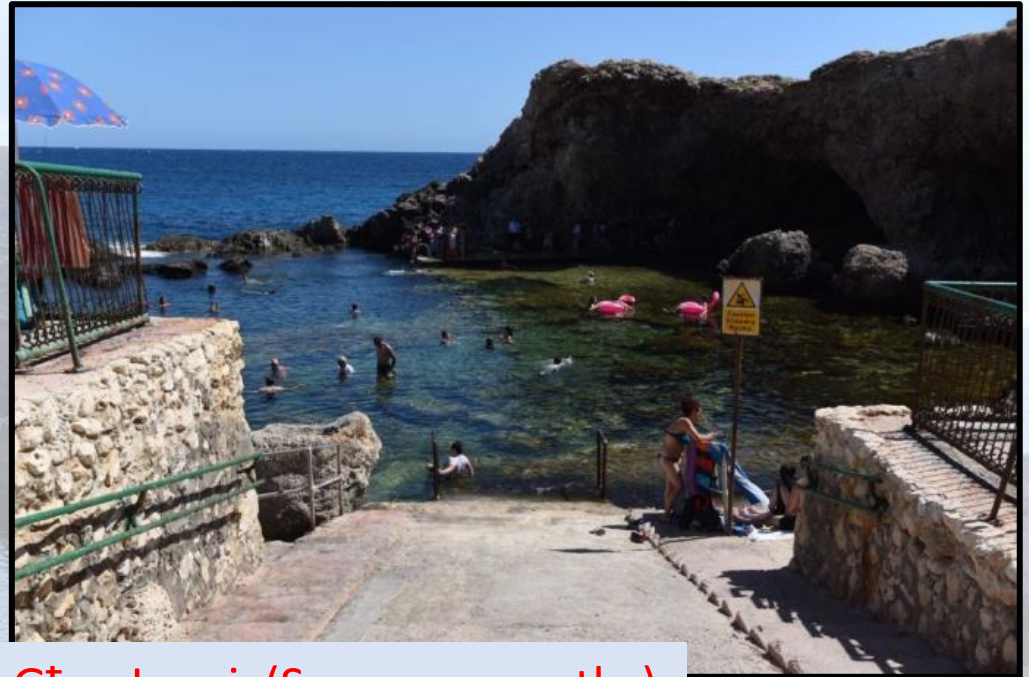
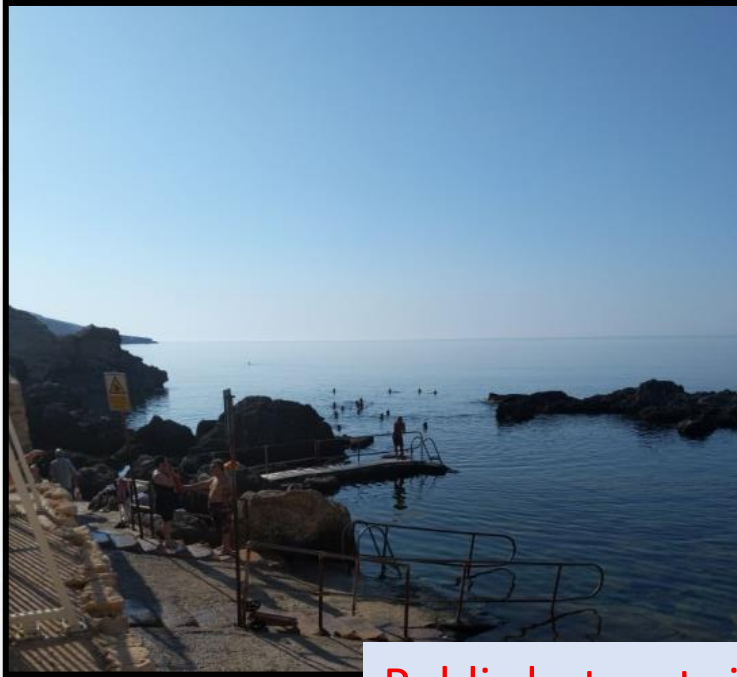
Figure b: NDVI baked onto True Colour Composite (Redder values show artificial surfaces)

(Source: Adam Gauci).

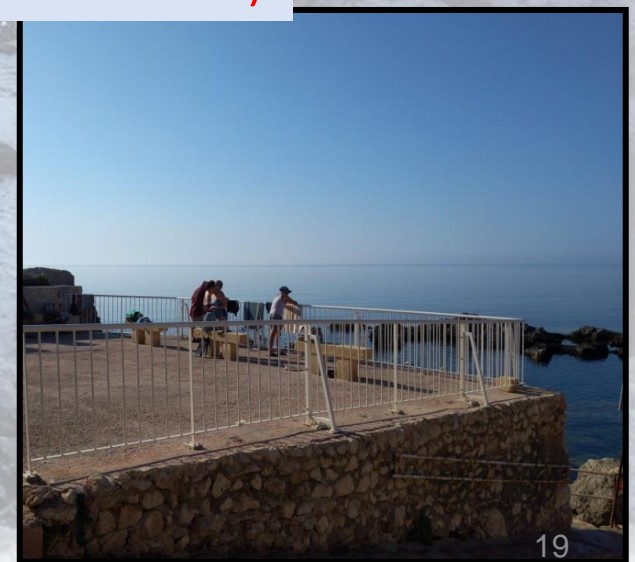
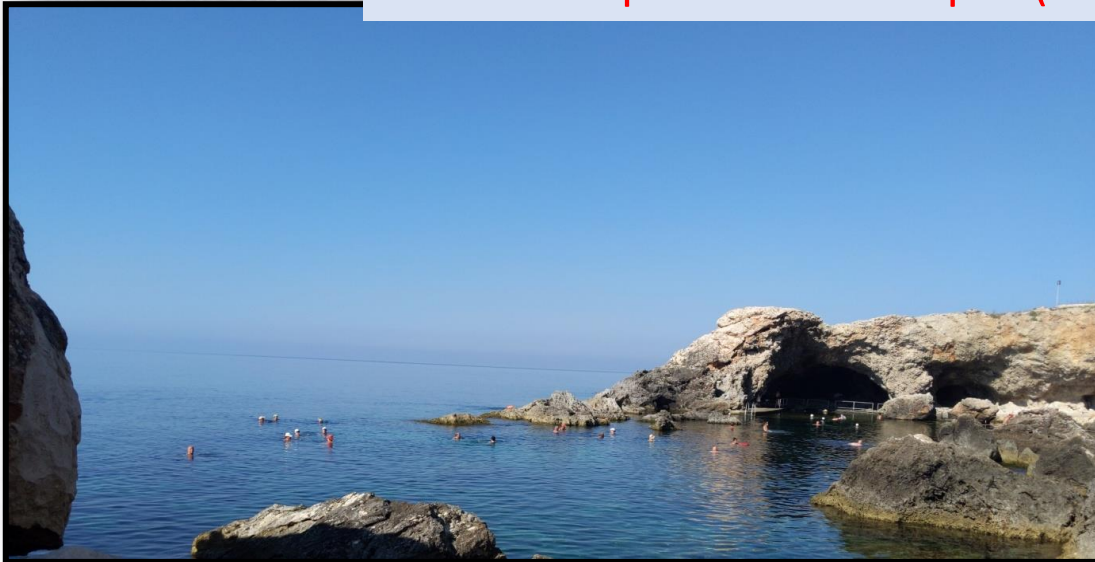
Exposure – Bathing areas



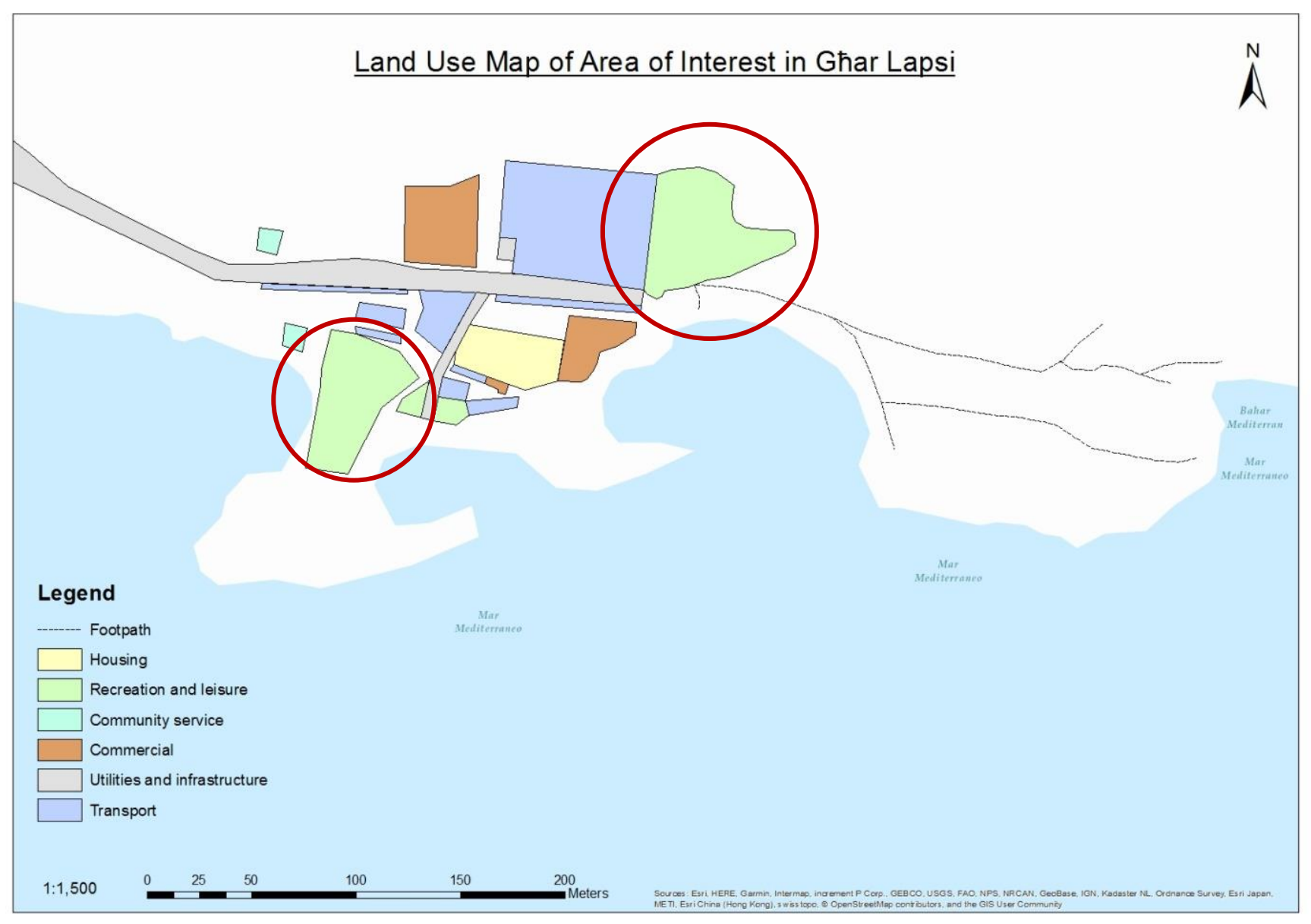
Exposure – Bathing areas



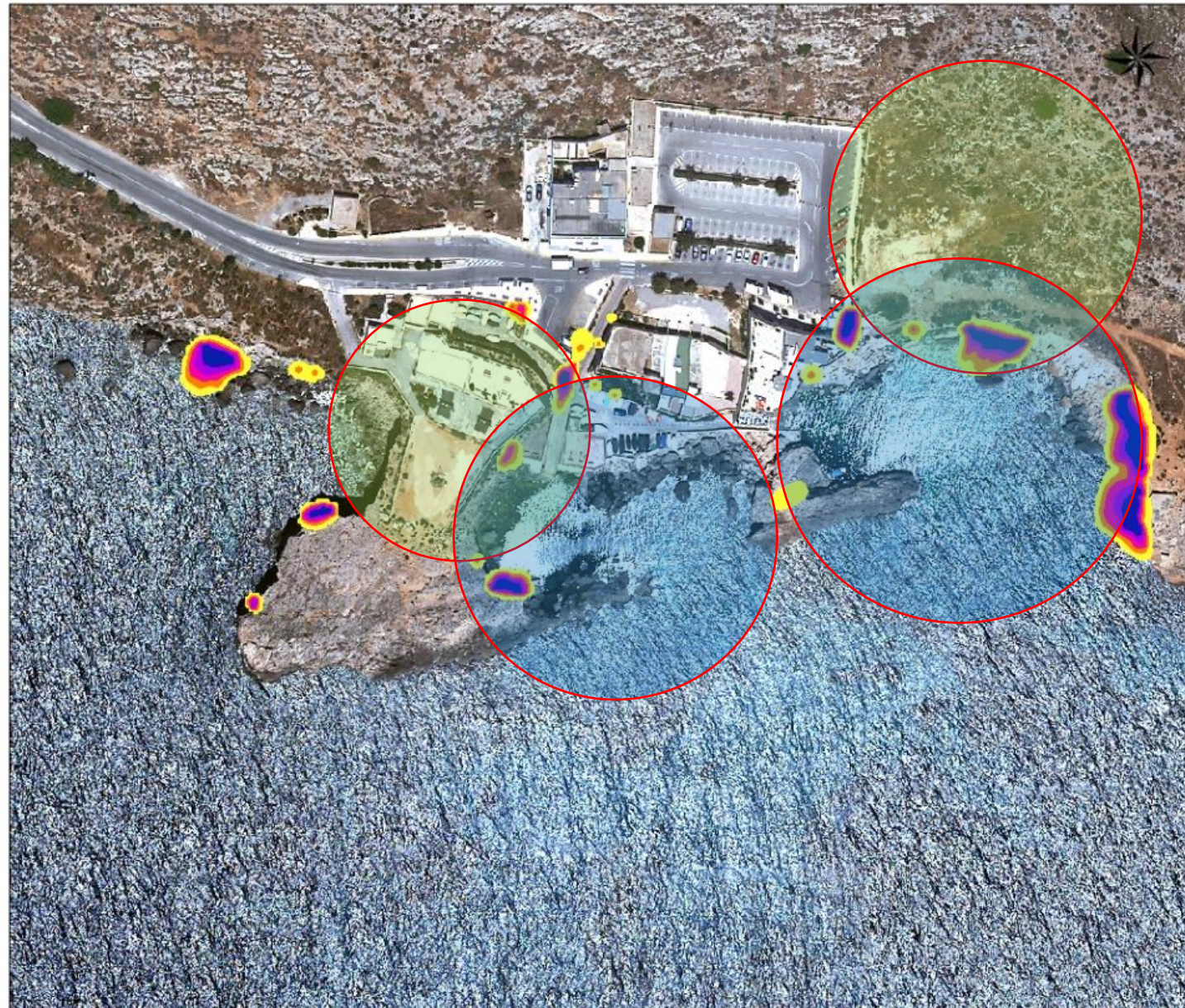
Public hotspots in Għar Lapsi (Summer months)



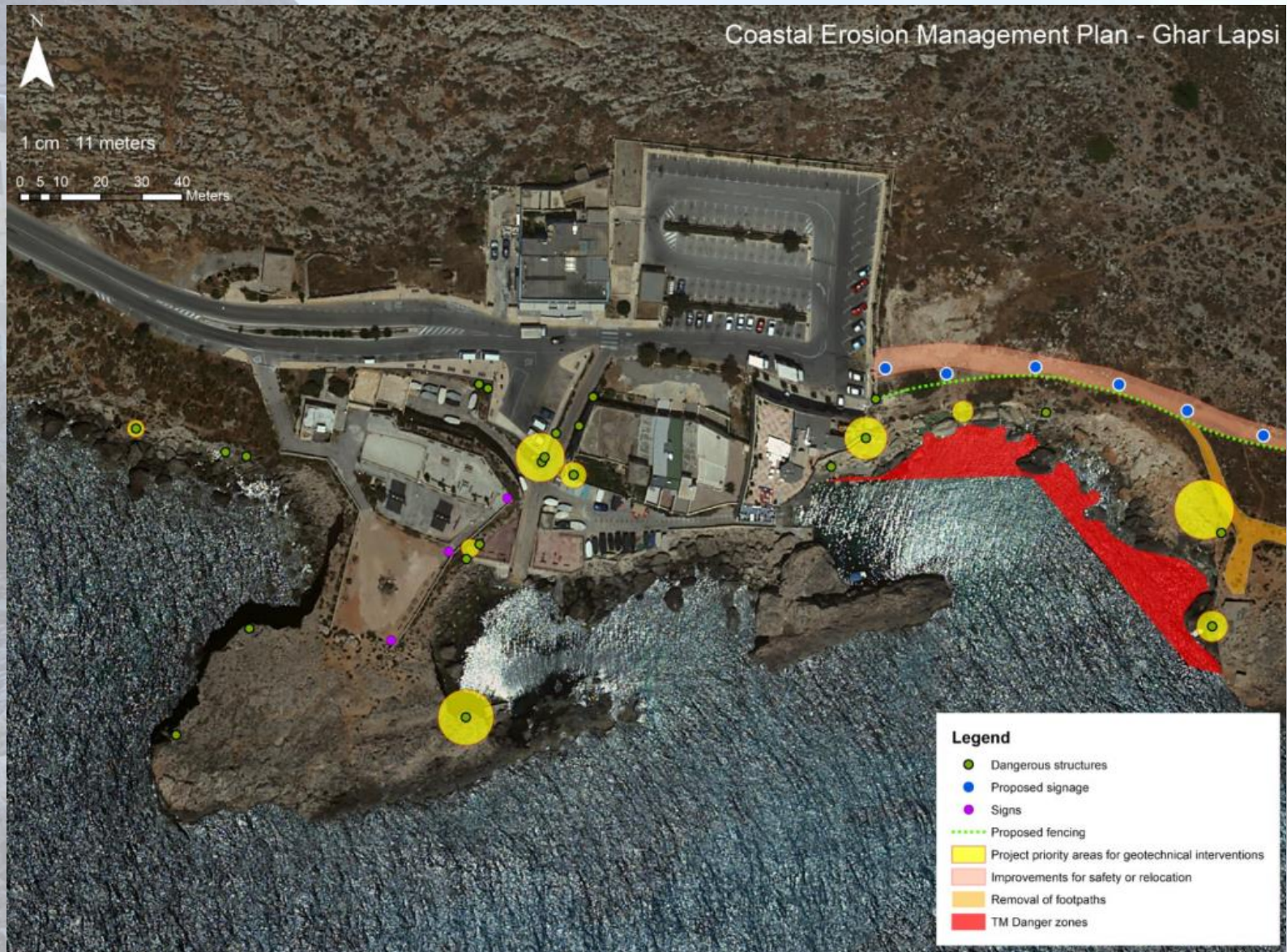
Exposure – Recreation areas



Exposure over Hazard



Proposed coastal erosion management plan



Thank You

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