Geodiversity, geosites and the assessment of abiotic ecosystem services: preliminary results from Magma and Sesia Val Grande UNESCO Global Geoparks

Marco Giardino, Sara Gentilini and Pål Thjømøe

Earth Science Department, University of Torino
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Magma UNESCO Global Geopark

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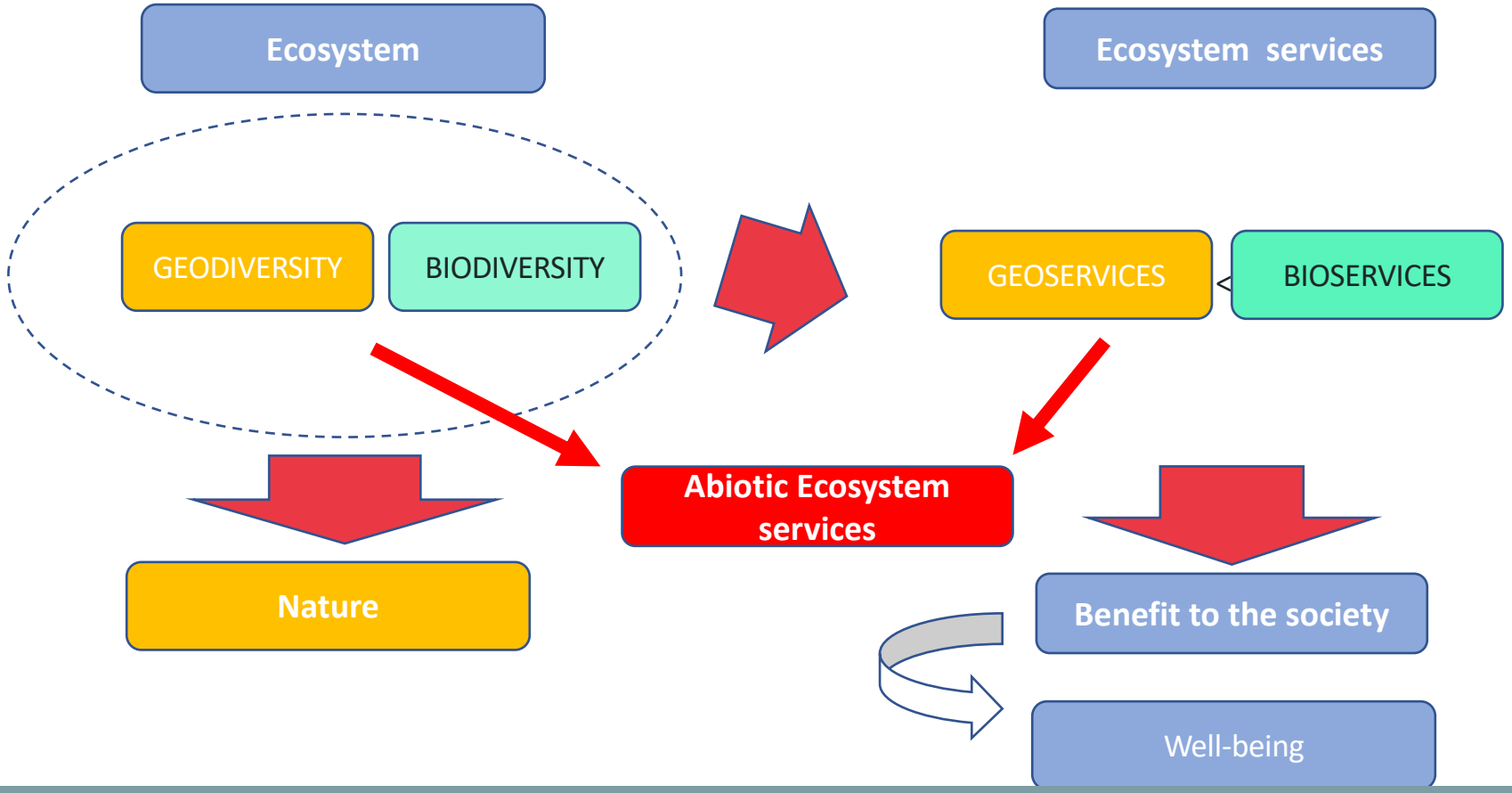
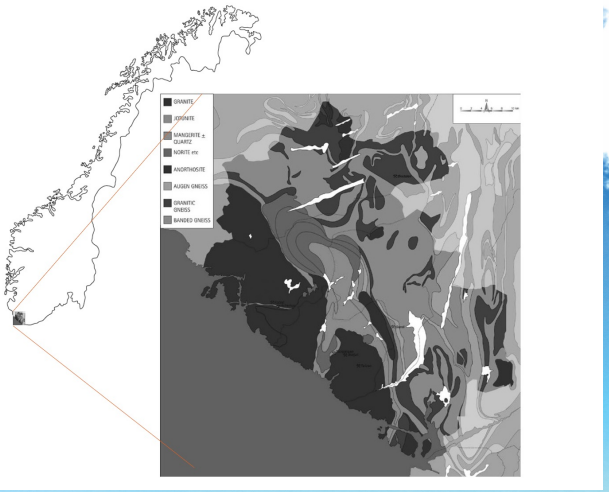
Main goal of the research

The CONCEPTUAL FRAMEWORK



The playgrounds



norway

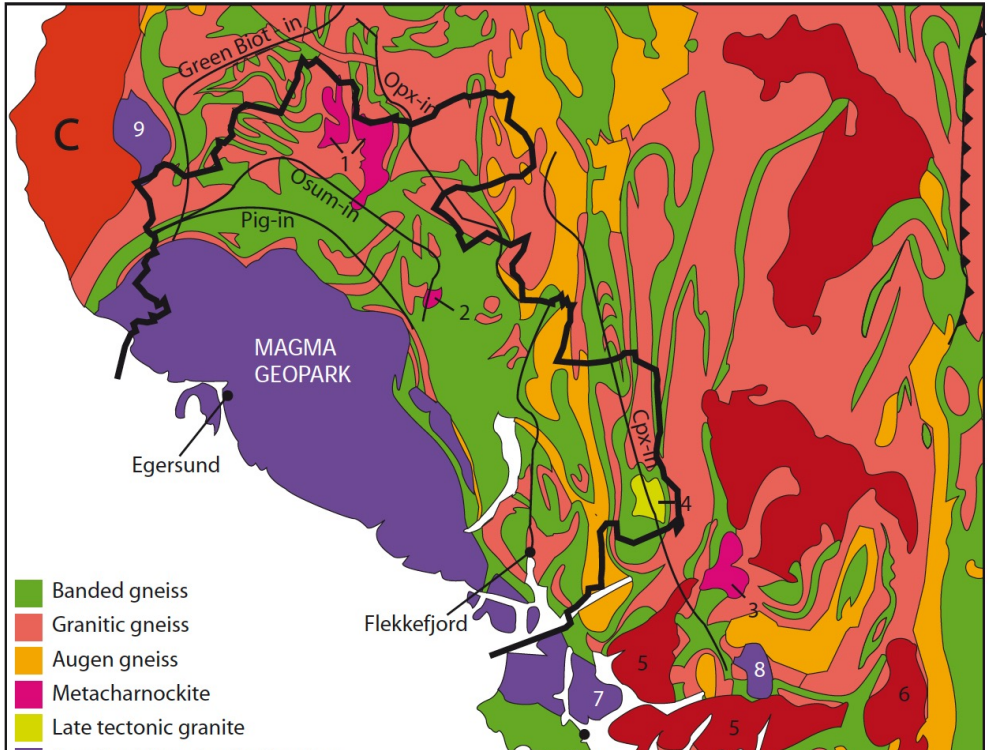
MAGMA GEOPARK

UNESCO Global Geopark since 2010

- Management authority: Magma AS
- Extension : 2.329 km^2
- 5 Municipalities
- Two Counties
- 47 Geosites
- Magma inlcudes the largest layered intrusion in Europe
- www.magmageopark.com

MAGMA GEOPARK

The Geodiversity



The layered intrusion contains a diversity of rock types as well as magmatic structures from crystallising magma

The entire area was strongly affected by glaciation and deglaciation processes (i.e., the onset, pulsations and retreat of a continental ice sheet, and the related post-glacial crustal rebound) during the Quaternary.

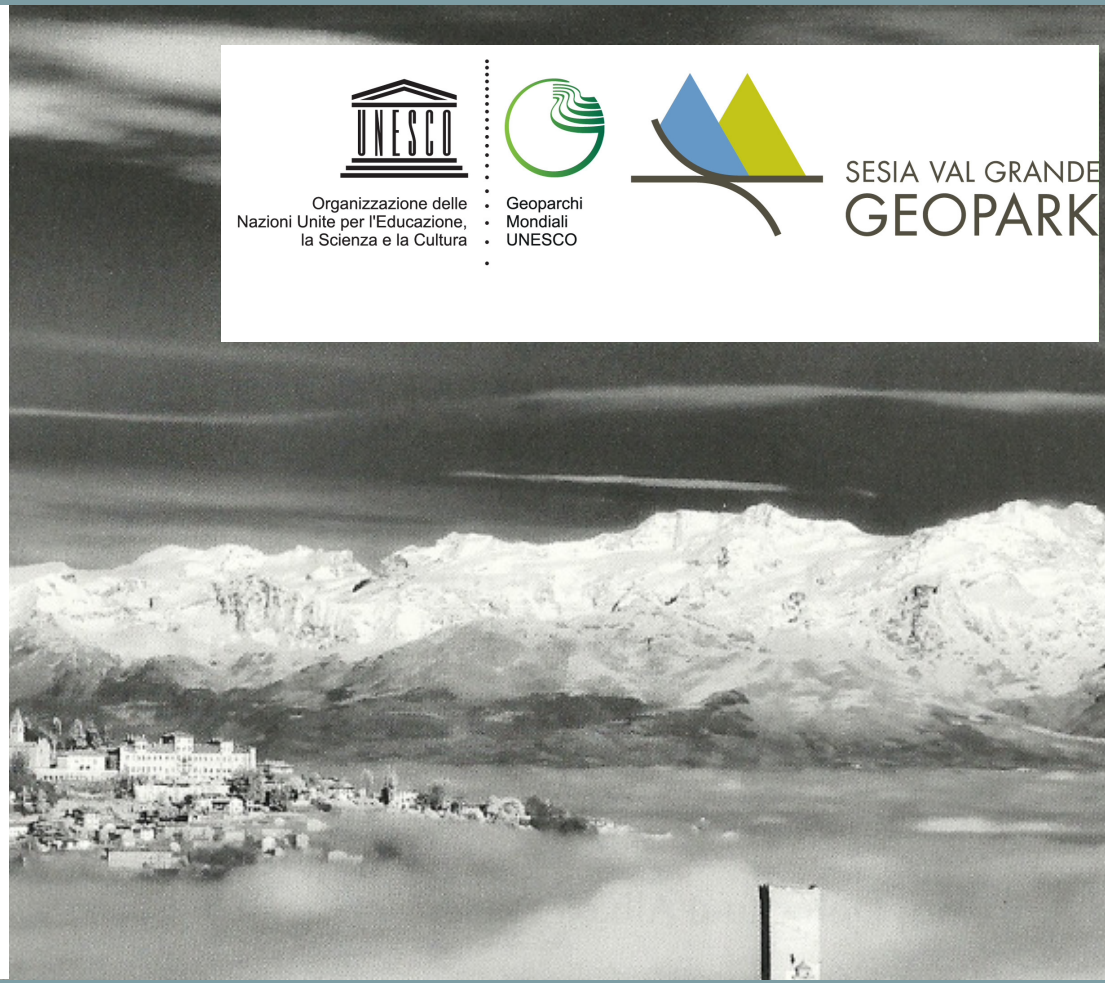
The Geosites

46 Geopark's "locations" selected within the same parameters (but 17 not present in the firstUNESCO Application) - Systematization was needed.

No.	LOCALITIES	SHORT DESCRIPTION	FACILITIES
1	Gloppedalsura	Huge rock fall (gneiss, moraine)	
2	Vinjakula	Mountain (907 m; gneiss, granite)	
3	Storrsheia	Prehistorical Iron Age settlements	
4	Austdalen	A site of geological interest (Ra moraine, gneiss, quartz)	
5	Ørsdalen & Gudlen	Old tungsten mines	
6	Ytstebrød/Hagavatnet	Moonlike landscape (anorthosite)	
7	Solbjørgnipa	Remains from Iron Age (regional geology)	
8	Odlandshøle	A site of geological interest (inclusions, layered intrusion)	
9	Stoplesteinan & St. Olav's road	Stone circle from Iron Age (legends, regional geology)	
10	Åsen & Ravnafjellet	A house from 1740 (regional geology)	
11	Terland Klopp	A stone bridge from about 1840	
12	Vestlandske hovedvei	Old western main road (anorthosite, landscape formed by glacier)	
13	St. Olavsormen	geological formation (unusual moraine, esker)	
14	Storeknuten	A site of geological interest (magma influx, layered intrusion)	
15	Hillforts	Defended settlements from about 500 AD	
16	Jonsoknuten & Mysinghåla	WW2 historical site (layered intrusion)	
17	Mong & others	Basaltic dykes	
18	Løtoft	A site of geological interest (layered intrusion)	
19	Hesten / Taghølt	Acient iron mine (regional geology)	
20	GEObikes	Geological & cultural bicycle trips	
21	Dalane Folkemuseum	Cultural and historical regional museum	
22	Trollpikken	Special geological phenomenon	
23	Gullbergstuva	Regional geology (layered intrusion)	
24	Eigerøy fyr (lighthouse)	Lighthouse (anorthosite, norite, legends)	
25	Egersund	Old wooden houses, Viking history, town history	
26	Auglend	Old settlements in Eigerøy (anorthosite)	
27	Koldal & Ankershus	Old ilmenite mines	
28	Gaudland – DNT cabin	Outdoor activities (anorthosite, dykes)	
29	Glerhaug	Moonlike landscape (anorthosite)	
30	Gursli & Lland mines, Hattesteinan & Gullbergknuten	WW1 molybdenium mines and erratics	
31	Lund bygdemuseum og kulturbank	District museum	
32	Syngjarstein	Special geological phenomenon	
33	Tronåsen, Bakke bru & Bringedal	Steep, old and winding road, Norway's oldest suspension bridge	
34	Kjærsfjell	Regional geology	
35	Jåbeheia	Anorthosite and granite dykes	
36	Rossland	Ancient sculpture, cult place	
37	Blåfjell mines & Ruggesteinen	Old titanium mines, large rocking stone	
38	Sogndalstrand	Old harbour town, museum	
39	Jassingfjord & Helleren	Old wooden houses, outdoor activities, viewpoint	
40	Hellersheia	Fjord (anorthosite)	
41	Tellnes	Open-pit mining site (ilmenite, ore, dykes)	
42	Brufjell Caves	Potholes and caves	
43	Gården Li – DNT cabin	Outdoor activities (regional geology)	
44	Kirkehamn, Hidra Feldspar	Harbour town, mining site, WW2 historical site	
45	Flekkefjord line	Old railway, draisine biking	
46	Flekkefjord	Old wooden houses	

	NAME GEOSITE LOCALITY	DESCRIPTION	RANK			LOC			Protection status					Availability limitations		Treatment	
			International	National	Regional	Education	Geotourism	Science	Nature Protection	Cultural Protection	LNF area	Agreement with Landowner	No protection	Private property	Safety	Yes	No
1	Gloppedalsura	one of the largest rock falls in Europe	x			x	x							x			x
2	Vinjakula	Highest peak in Magma Geopark									x			x			
3	Storrsheia	Prehistorical Iron age settlement							x					x			
4	Austdalen	Geological interest (Ra moraine)									x				x		
5	Ørsdalen-Gudlen	Hidrotermal quartz -citrine vein in gneiss			x		x				x			x		x	
6	Ytebrød/Hagavatnet	Moonlike landscape									x			x			
7	Sølbjørgnipa	Remains from Iron age							x		x			x			
8	Odlandshøle	Geological interest									x			x			
9	Stopleisteinan-Saint Olav	Stone cycle from iron age		x			x				x			x			x
10	Åsen -Ravnafjellet	House from 1740							x					x			
11	Terland klopp	Old Stone bridge									x			x			
12	Vestlandske hovedvei	Old main road, anorthosite			x	x	x		x					x			x
13	St. Olavsomen	Large esker	x			x	x		x					x			x
14	Storeknuten	Geological influx			x	x	x	x			x			x		x	
15	Hillforts	Defended archeological settlement							x					x			
16	Jonsoknuten- Mysinghåla	WW2 site and layered intrusion			x	x	x				x	x		x		x	
17	Mong and others	Basaltic dykes									x			x			
18	Løtoft	Layered intrusion									x			x			
19	Hesten Taghølt	Ancient ancient mine			x		x				x			x			x
20	Rail road -Hellvik	den Gamle Jærbanen-railroad			x	x	x			x				x			x
21	Dalane Folkemuseum	Museum		x		x		x		x							x
22	Trollpikken	Geological phenomena									x			x			
23	Gullbergtuva	Regional geology centre of intrusion			x	x	x				x			x		x	
24	Eigerøy Fyr	Lighthouse				x	x	x	x	x	x	x		x		x	
25	Egersund	Old wooden house, viking town		x		x	x			x				x			x
26	Auglend	Old settlment in Eigerøy			x	x	x	x	x					x			x
27	Koldal-Ankerhus	layered intrusion		x		x		x			x			x		x	
28	Gaudland	Anorthosite			x	x	x				x			x			x
29	Glerhaug	Moonlike landscape			x	x	x				x			x			x
30	Gursli-Lland mines	WW1 mines		x		x	x				x	x		x			x


Sesia Val Grande
Geopark
VCO
Biella
Novara
Vercelli
Torino
Asti
Alessandria
Cuneo
Val Vigezzo
S. Maria Maggiore
Malesco
Domodossola
Val Cannobina
Gurro
Cannobio
Cima Pedum
Monte Zeda
Pieve Vergonte
Vogogna
Val d'Ossola
Ornavasso
Mergozzo
Ghiffa
Verbania
Baveno
Lago Maggiore
Monte Rosa
Carcoforo
Rimella
Val Strona
Rima
Fobello
Val Mastallone
Rimasco
Cravagliana
Alagna
Valsesia
Corno Bianco
Mollia
Vocca
Varallo
Balmuccia
Campertogno
Rassa
Scopello
Quarona
Borgosesia
Monte Bo
Monte Barone
Guardabosone
Serravalle
Pray
Crevacuore
Grignasco
Prato Sesia
Trivero
Valsessera
Romagnano S.
Gattinara
Ghemme
Masserano
Lessona
Confini Geoparco
Parco Nazionale Val Grande
Riserva Naturale Fondo Toce
Parco Naturale Alta Valsesia e Alta Val Strona
Parco Naturale Monte Fenera
Oasi Zegna
Sacri Monti
Supervulcano del Sesia
Linea Insubrica
Principali fiumi
Montagne principali


UNESCO
Organizzazione delle Nazioni Unite per l'Educazione, la Scienza e la Cultura
Geoparchi Mondiali UNESCO
SESIA VAL GRANDE
GEOPARK

Organizzazione delle Nazioni Unite per l'Educazione, la Scienza e la Cultura

Geoparchi Mondiali UNESCO

SESIA VAL GRANDE GEOPARK

UNESCO Global Geopark since 2013

- Management authority: National Park Sesia Val Grande
- 106 Municipalities
- 3 Counties
- Surface: 2202 km²
- 124 Geosites
- 25 km-thick crustal section of a fossil supervolcano
- http://www.sesiavalgrandegeopark.it

Organizzazione delle Nazioni Unite per l'Educazione, la Scienza e la Cultura

Geoparchi Mondiali UNESCO

SESIA VAL GRANDE GEOPARK

Geosite in the Application

- A total of 124 geosites as main Geopark´s features.
- 33 selected geosites, fully described and developed “for their international, national, regional or local value”
- 46 geosites “under preparation for future development”.
- 35 ”Other interest geoheritage sites” from literature, in a separate annex without integration with the main list.

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Geoparchi Mondiali UNESCO

SESIA VAL GRANDE GEOPARK

Systematization of the Geosites from the Application was needed.

NUMBER-Geopark Application (only for Geosites)	Phd team NUMBER				CLASSIFICATION IN THE APPLICATION	NAME	SHORT DESCRIPTION	MAIN TOPIC DESCRIPTION	OTHER DESCRIPTION	PROVINCE	Coordinate Latitudine N (NW) (WGS84)	Coordinate Longitude E (WGS84)	Coordinate Latitudine N (NW) (WGS84) DECIMALI	Coordinate Longitude E (NW) (WGS84) DECIMALI	Quote (m s.l.m.)	RANK (I=international; N=national; R=regional; L=local)	MAIN INTEREST (P=petrography; ST=structural; G=geology of the basement; GM=geomorphology; CH= Cultural Heritage, H=Historical; MP= Metamorphic Petrology, GM= Glacial Morphology, SG=Structural Geology, PMA=Permian Magmatic Acitivity, AG=Alpine Geology, GL=Glaciology, MI=Mining, PM= Peculiar morphology	OTHER INTEREST (SE=Science Education; E=Environmental A=archaeological; H=historical;N=naturalistic)	CONSERVATION ISSUE
19	3					ANICETI – VARALLO	Mafic Complex	porphyritic gabbro with plagioclase phenocrists.		Aniceti, Varallo, VC	45°49'28"N	8°14'52"N	45,824444	8,247778	476 m slm	I	G; P; SG	N;SE;E	NO
	4				To be developed	ARA "Giardino delle Grotte"	Basin of Dolomite rocks with the presence of karst caves			Ara, Grignasco, Parco naturale Monte Fenera, NO	45°41'46"N	8°19'42"N	45,696111	8,328333	415 m slm	R			
16	5					BALMUCCIA	The outcrop of Balmuccia peridotites	The outcrop of Balmuccia peridotites of the surface coat, in an excellent state of conservation. Massive, inhomogeneous body, of about 4 kmq of surface		Balmuccia, Varallo, VC	45°49'12"N	8°9'9"N	45,82	8,1525	555 m s.l.m.	I	G; P; SG	N; SE; E	NO
	6				To be developed	BALMUCCIA	Geomorphological evidence of the Insubric Line.	Geomorphological evidence of the reactivation of the Line insubrica del Canavese: fault scarp that cuts i river terraces of the Sermenza torrent and the riverbed of the Sesia river		Balmuccia, Varallo, VC	45°49'20"N	8°8'7"N	45,822222	8,135278	circa 580 m.s.l.m.	R			
	7				To be developed	BALMUCCIA – VOCCA (beneath Cima Lavaggio)	Contacts between peridotites and mafic complex			Balmuccia, Varallo, VC						I			
5	8					BED OF THE SAN BERNARDINO RIVER	Large reef with exposed the "Scisti dei Laghi"	Large reef with exposed the "Scisti dei Laghi", with a typical round-shaped morphology, due to the glacial abrasion (roches moutonnées)		San Bernardino Verbano, VI	45° 57' 22.52"	8° 31' 36.14" E	45,9562556	8,526705555	248 m slm	N	G; MP; GM;SG	N; SE; E	YES
	9				To be developed	BETTOLE	Limestone quarry	limestone quarry bulit to produce lime for contruction industries: the Antoniotti quarry		Borgosesia, VC						R			
	10				Religious Site	BOCA	Sanctuary of the Holy cross	Seventeen Century Sanctuary											
20	11					BOCCIOLARO	Mixed diorite and mafic encl	mixed diorite and mafic enclaves that emerge between Gabbro principal and "Dioriti"		Bocciolaro, Cravigliana, VC	45°51'11"N	8°14'17"N	45,853055	8,238056	570 m slm	I	G; P; SG	N;SE;E	NO
32	12					BOCCIOLETO	Tower, shaped by glaciers and erosive water	Characteristic tower, shaped by glaciers and erosive water, immersed in a chestnut grove		BOCCIOLETO, VC	45°50'1"N	8°6'11"N	45,833611	8,103056	1060 m slm	R	PM; SG	N;H;E	NO
	13				To be developed	BOCCORIO	grey-green paragneiss	grey-green paragneiss								R			
	14		Castle-Fortifica	Museum	Religious Site	BORGOSESIA	Sant' Anna Shire	Museum of archaeology	Castle-Fortifications-Montrigone										
8	15				Geosite	CADORNA ROAD	Linear geosite situated around Mount Bavarione	Linear geosite situated around Mount Bavarione, unit where there are exposed all types of rocks of Zona Strona – Ceneri. It was also a system of fortifications during World War		Aurano, VB	From 46° 02'26.7	From 8°34'58.31	45,0407722	8,58091944	1357 m slm; 150	I	G;SG;P;GM	N:SE;E	NO
6	16				Geosite	CADORNA ROAD (OSPEDALETTO)	The Lepynite - amphobolite	The amphobolite Group								R	GM;G;P	N;SE;E	NO
	17				To be developed	CADORNA ROAD	M. Vadà	Augengneiss											
	18			Ecomuseum	To be developed	CAMPELLO MONTI	Nichel quarry	Walser ecomuseum											
	19			Museum	To be developed	CAMPERTOGNO	Terraces	Collection of Sacred art											
			Castles -	Religious Site	Stones and	CANNOBBIO	Orrido	Sant' Anna Church											

The geosites classification from Geological Survey of Norway

The geosite classification schema adopted by University of Turin, Geoheritage&Geodiversity course

Comparison of Methodologies

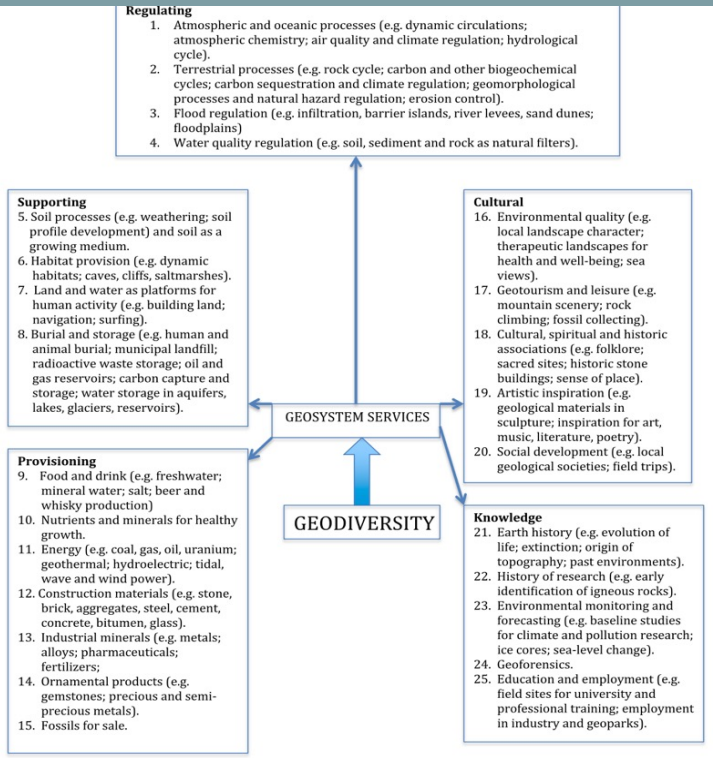
Application-test on selected geosites

Research product 1:
Common framework for geosite classification

Research product 1: Common framework for geosite classification

fx Easy

C	D	E	F	G	H	I	J	K	L	M	N	
Geographic information					Type of geosite					Geological time		
						Scientific interest						
Name	East	North	Zone (UTM)	Shape typology	Main type	First	Second	Third	Geological environment	Eon	Periode- Epoque	Geolo
Eigeroy fyr	55247 55320 55210 55151	582638 582635 582547 582550		Area	Pre quarternary la	Magmatic	Geocultural	Mineralogical	Glacial	Precambrian	Proterozoicum	Toniar
Jossingfjord	62042 62212 62121 62032	582017 581957 581999 581927		Area	Pre quarternary la	Geomorphological	Mineralogical	Geocultural	Glacial	Precambrian	Proterozoicum	Toniar
Storeknuten	63042 62212 62121 62032	582830 581957 581999 581927		Area	Bedrock	Magmatic	Petrographical	Geocultural	Subsurface magmatic	Precambrian	Proterozoicum	Toniar
Sogndalstrand	581933 581931 581909 5819	61700 61715 61721 61659		Area	Quarternary	Geocultural	Magmatic	Geohazard	Coastal	Precambrian	Proterozoicum	Toniar
Varallo Sesia	454915 454907 454856 4549	81518 81539 81523 81512		Area	Quarternary	Geocultural	Geomorphological	Paleoenvironmenta	Glacial	Paleozoic	Carboniferus Permian	
Crevola	454838 454841 454844 4548	81525 81519 81520 81526		Area	Quarternary	Metamorphical	Geomorphological	Petrographical	Fluvial	Paleozoic	Carboniferus Permian	
Balmuccia	454856 454857 454855 4548	80802 80803 80806 80804		Area	Quarternary	Magmatic	Petrographical	Mineralogical	Fluvial	Paleozoic	Carboniferus Permian	
Prato Sesia	453933 453927 453905 4539	82117 82117 82128 82123		Area	Quarternary	Magmatic	Petrographical	Geomorphological	Fluvial	Paleozoic	Carboniferus Permian	



Abiotic Ecosystem System services

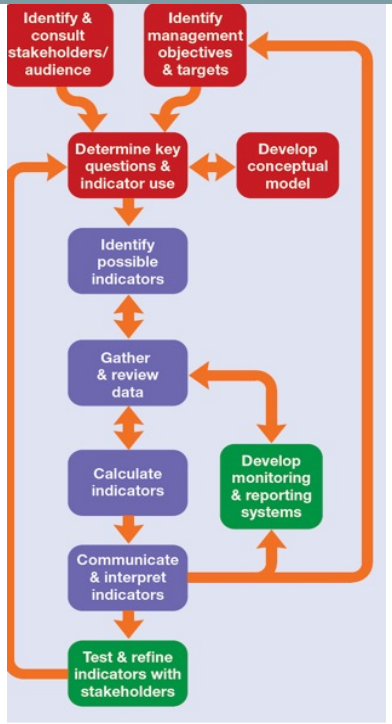
Regulating	1	Atmospheric and oceanic processes
	2	Earth processes
	3	Flood regulation
	4	Water quality regulation
Supporting	5	Soil processes
	6	**Habitat provision**
	7	**Land and water as platform for human activities**
	8	Burial and storage
Provisioning	9	Food and drink
	10	Nutrients and minerals
	11	Fuel
	12	Construction materials
	13	Industrial minerals
	14	**Ornamental pr ducts**
	15	Fossils
Cultural	16	Environmental
	17	
		Cultural spiritual and historic
	19	Artistic inspiration
	20	Social development
Knowledge	21	
	22	
	23	**Environmental monitoring and forecasting**
	24	Geoforensis
	25	

Research product 2:
Provisional abiotic service assessment

Research product 2: Provisional abiotic service assessment

E19 | Quantity and quality of nutrients within rocks and soils

	B	C	
1			
2	**CATEGORIES**	**EXAMPLES (Gray M. 2015-2018)**	**Phd PRELIMINARY QUESTIONS**
3		Formato numero	
4	**REGULATING**		
5	The benefits obtained from the regulation of ecosystem processes, including air quality regulation, climate regulation, hazard regulation. water regulation, erosion regulation, water purification, disease regulation, pest regulation, pollination and natural		
6		Atmospheric CO2 for regulating temperature and shielding ozone and providing atmospheric circulation; from ocean streams to hydrological cycle	Is the geosite's geomorphology influen
7		Carbon cycle , erosion , transportation, deposition and uplift processes that reniew consta	Is the geosite involved in present day act
8		Soil- clay can reduce the erosion, natural physical barriers (river levees, single beach ridges	Is the geosite influencing the flood regul
9		Soil, sediments and rock attenuate polluting substances and helping the water quality bot	Is the geosite influencing the water quali
10	**SUPPORTING**		
11	They are necessary for the production of all other ecosystem services including soil formation, photosynthesis, primary production, nutrient cycling and water cycling.		
12		Soils provide with different services: habitat, interact with many other parts of the enviro	Is soil or pedological processes available
13		The spatial-temporal interrelated site factors of river-floodplain-systems (hydrology in combination with climate, geomorphology, and soil)	Are there habitats in the geosite?
14		land surface: different activities required different typers of platform	Is the geosite has a role on the setting u
15		Physical resources of the land used as human burial and storage underground	is there any undeground storage or hum
16	**PROVISIONING**		
17	The products obtained from ecosystems, including food, fibre, fuel, genetic resources, biochemicals,		



Biodiversity Indicators Development Framework, from Biodiversity Indicators Partnership: (https://www.bipindicators.net/national-indicator-development)

A	B	C
Abiotic Services	**Connected Biotic services**	**Biodiversity Indicators**
Regulating		
N1) Atmospheric and oceanic processes	7) Air quality regulation	Leaf area index NOx-fixation
N2) Terrestrial processes	9) Natural hazard mitigation	Land cover characteristics and similar
	10) Water regulation	Water-storage (buffer) capacity in m3
	12) Erosion protection	Denitrification (kg N/ha/y); Immobilization in plants and soil
	13) Soil formation and regeneration	Vegetation cover root-matrix e.g. bio-turbation

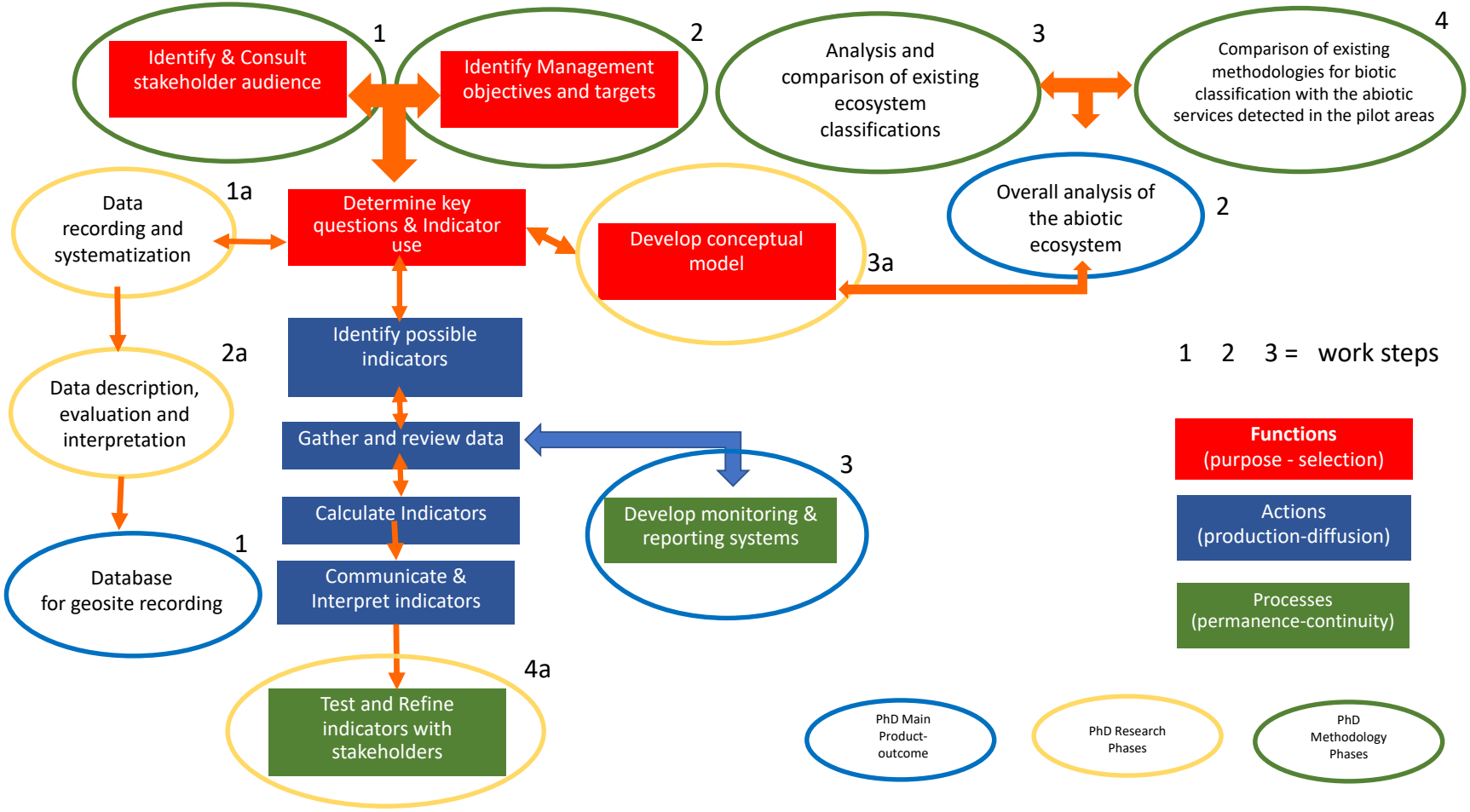
Selection of the space and time framework for the evaluation of each single ecosystem service

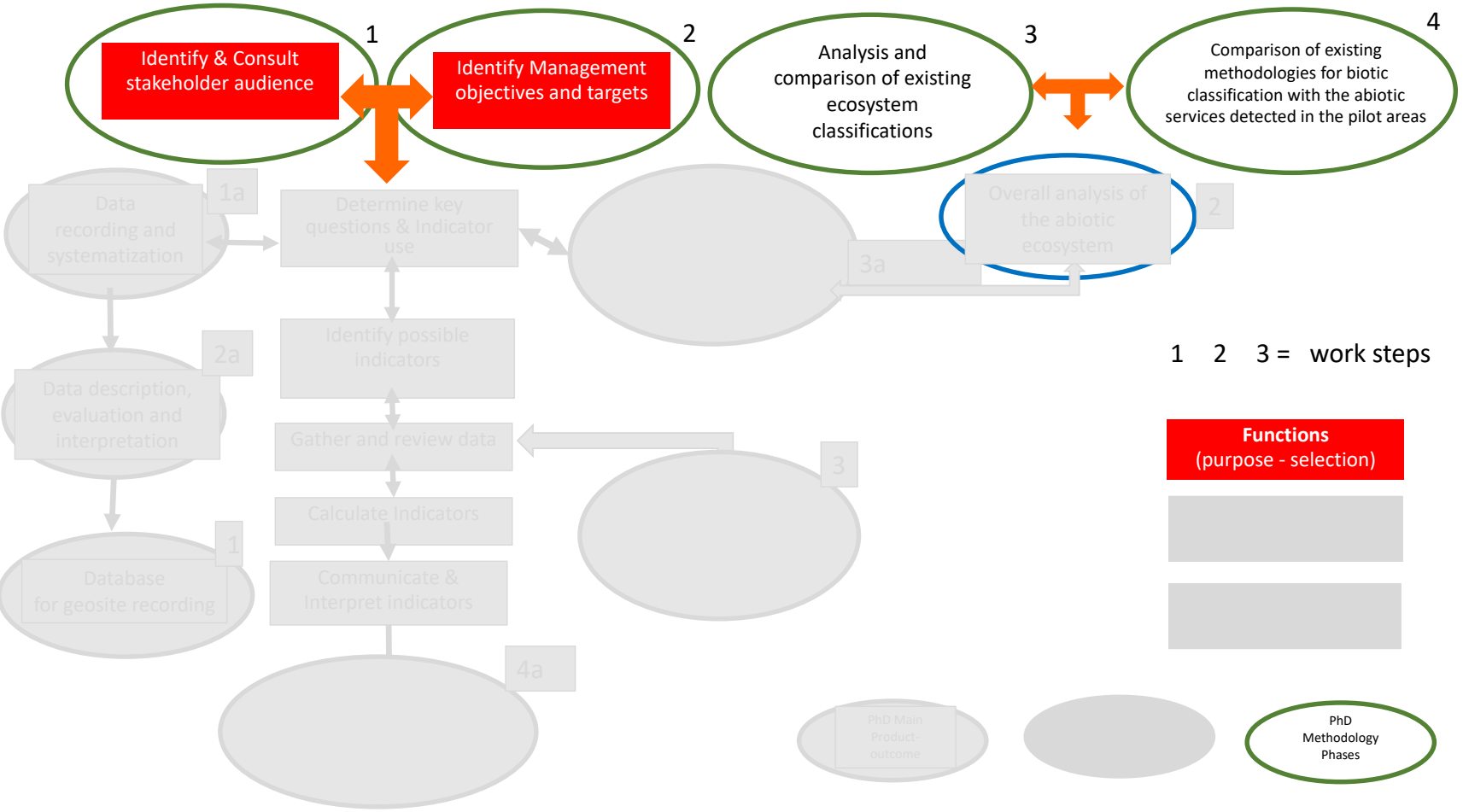
For each service- selection of the geological process influencing the service

Selection of a scale, selection and calculation of each indicators

Benefits for the society and projects

SELECTION OF PROVISIONAL INDICATORS - RESEARCH PRODUCT 3


1
Identify & Consult stakeholder audience
2
Identify Management objectives and targets
3
Analysis and comparison of existing ecosystem classifications
4
Comparison of existing methodologies for biotic classification with the abiotic services detected in the pilot areas
1a
Data recording and systematization
Determine key questions & Indicator use
Develop conceptual model
3a
Overall analysis of the abiotic ecosystem
2
Identify possible indicators
2a
Data description, evaluation and interpretation
Gather and review data
Calculate Indicators
Communicate & Interpret indicators
3
Develop monitoring & reporting systems
1
Database for geosite recording
4a
Test and Refine indicators with stakeholders
1 2 3 = work steps
Functions (purpose - selection)
Actions (production-diffusion)
Processes (permanence-continuity)
PhD Main Product-outcome
PhD Research Phases
PhD Methodology Phases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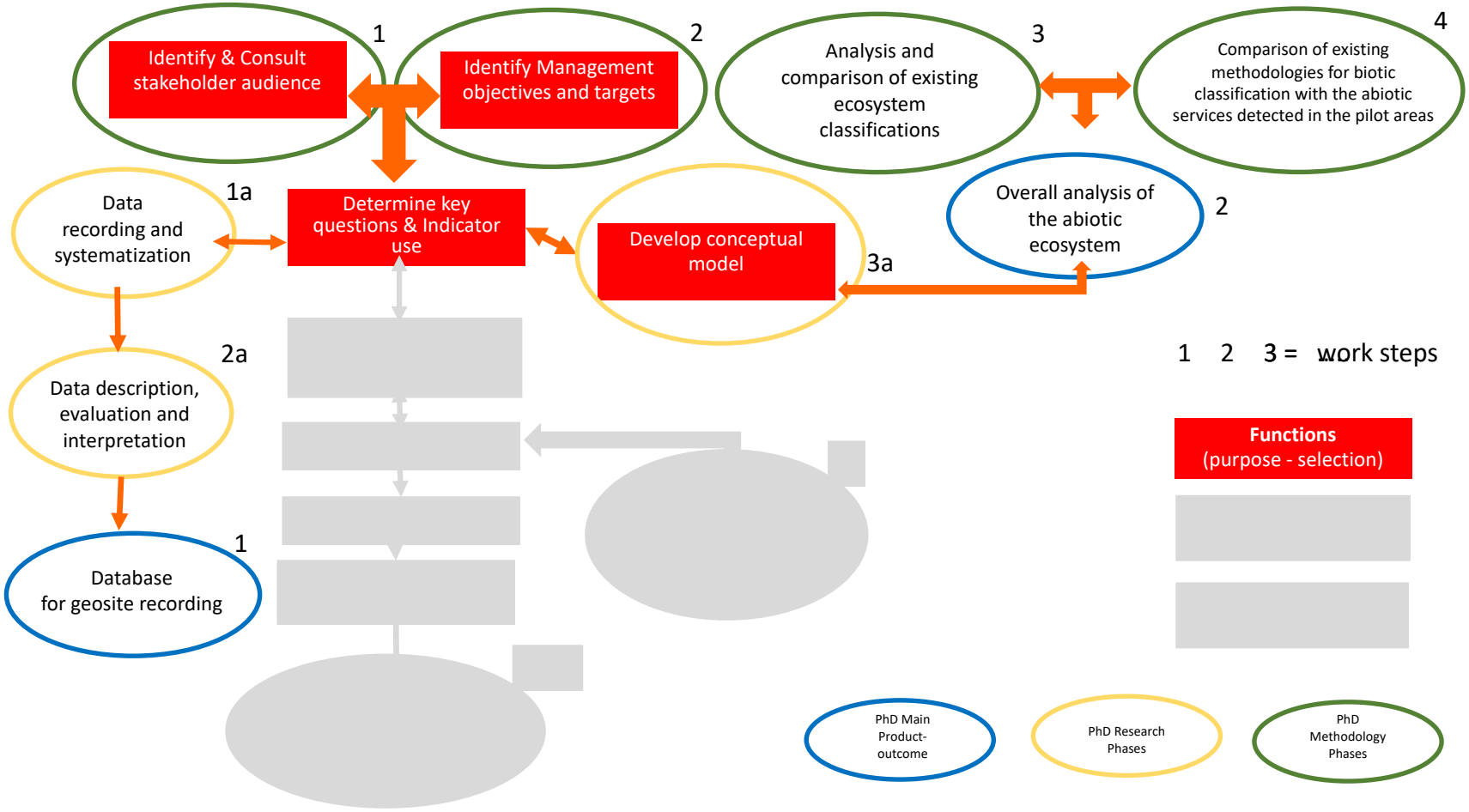
PhD Methodology Phases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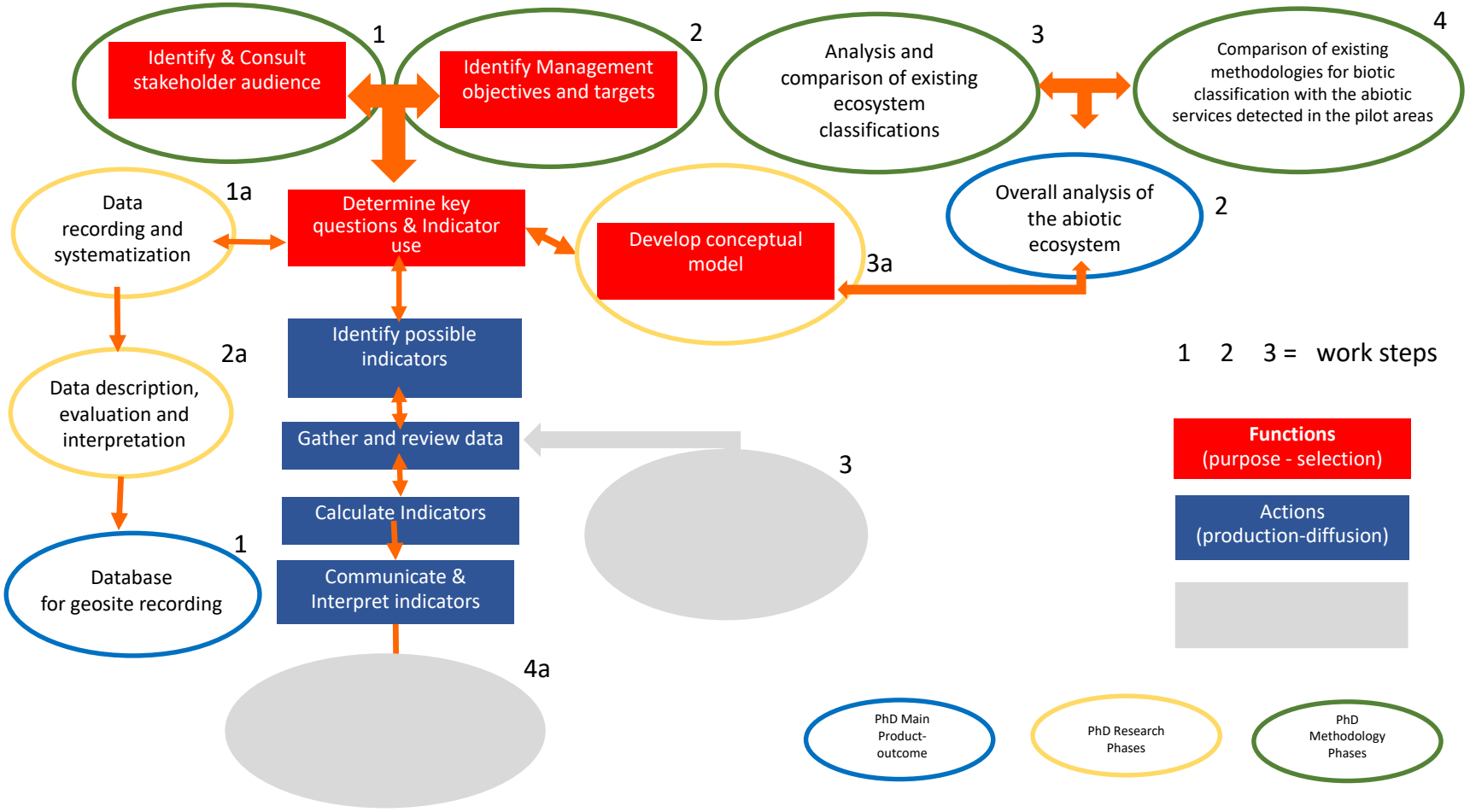
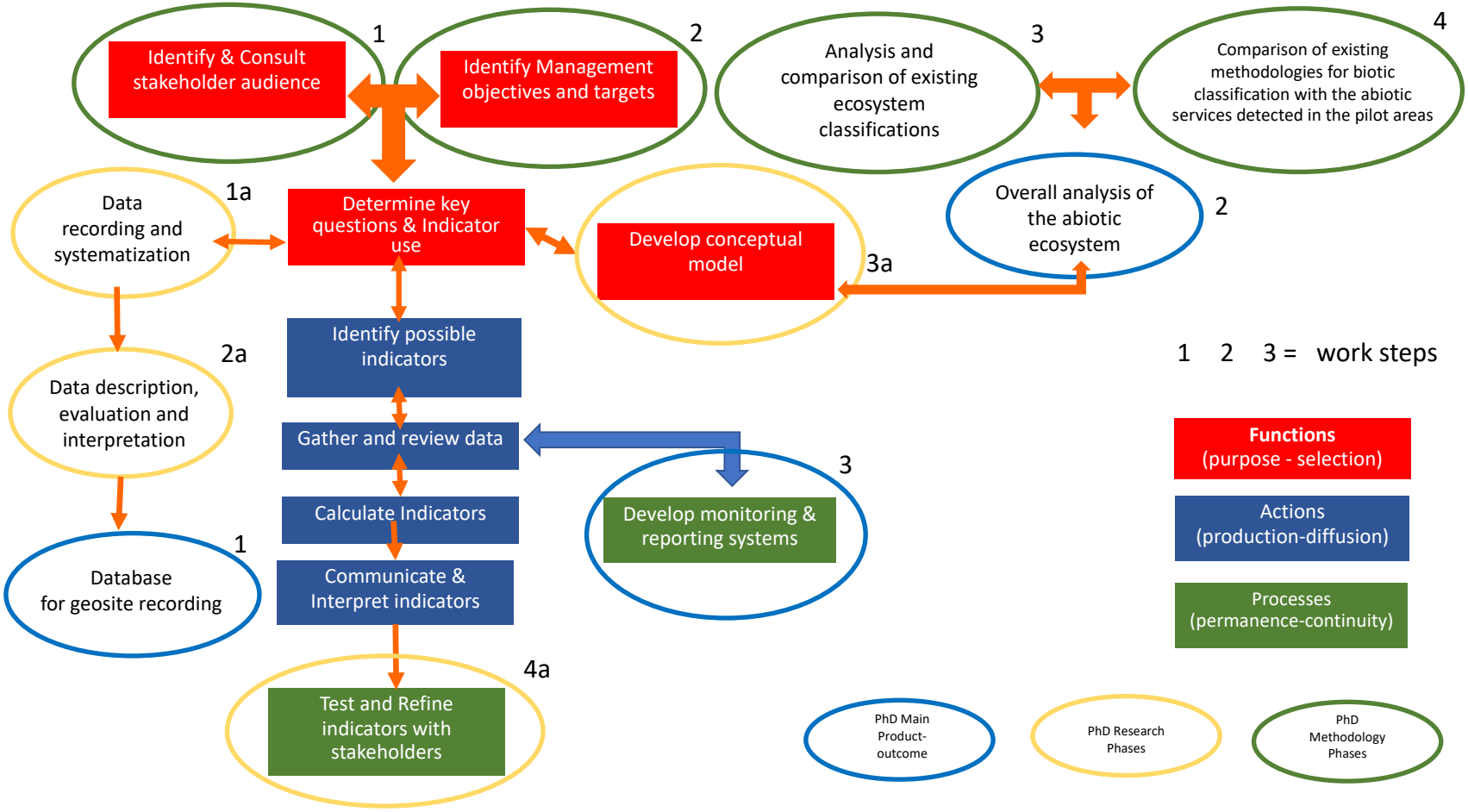
PhD Research Phases
PhD Methodology Phases


Identify & Consult stakeholder audience
1
Identify Management objectives and targets
2
Analysis and comparison of existing ecosystem classifications
3
Comparison of existing methodologies for biotic classification with the abiotic services detected in the pilot areas
4
Data recording and systematization
1a
Determine key questions & Indicator use
Develop conceptual model
3a
Overall analysis of the abiotic ecosystem
2
Identify possible indicators
Data description, evaluation and interpretation
2a
Gather and review data
Calculate Indicators
Communicate & Interpret indicators
Database for geosite recording
1
3
4a
1 2 3 = work steps
Functions (purpose - selection)
Actions (production-diffusion)
PhD Main Product-outcome
PhD Research Phases
PhD Methodology Phases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Determine key questions & Indicator use
Develop conceptual model
3a
Overall analysis of the abiotic ecosystem
2
Identify possible indicators
2a
Data description, evaluation and interpretation
Gather and review data
Calculate Indicators
Communicate & Interpret indicators
3
Develop monitoring & reporting systems
1
Database for geosite recording
4a
Test and Refine indicators with stakeholders
1 2 3 = work steps
Functions (purpose - selection)
Actions (production-diffusion)
Processes (permanence-continuity)
PhD Main Product-outcome
PhD Research Phases
PhD Methodology Phases

Geodiversity, geosites and the assessment of abiotic ecosystem services: preliminary results from Magma and Sesia Val Grande UNESCO Global Geoparks

Marco Giardino, Sara Gentilini and Pål Thjømøe

Earth Science Department, University of Torino
H2020 Marie Curie Tech4Culture Phd Program
Magma UNESCO Global Geopark

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