Morphological changes in wild and less wild rivers in South-East Europe

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RiverWatch EURONATUR FOUNDATION EcoAlbania

International Wild Rivers Science Symposium and

Outline

- Morpho-dynamics = morphological dynamics
- Different timescales ➔ different processes
  - One or few flood events ➔
  - Multi-decadal channel adjustments
- Case studies (wild and less wild)
  - Erzeni, Vermosh, Vjosa rivers (Albania)
  - Lumbardhi Pejes (Kosovo)
  - Prut river (Romania/Moldova)
  - Tagliamento river (Italy
- Multiple stressors ➔ morphological quality (WFD 2000/60)
- What is a wild river?


Trento
Tagliamento
Prut
Lumbardhi
Pejes
Vermosh
Erzeni
Vjosa
di Baviera
Vienna
Bratislava
Salisburgo
Austria
Budapest
Debrecen
Moldavia
Chişinău
Odessa
Одеса
Cherson
Херсон
Ungheria
Oradea
Cluj-Napoca
Seghedino
Slovenia
Trieste
Milano
Verona
Venezia
Padova
Timişoara
Romania
Galaţi
Sebastopoli
Севастополь
Yalta (Jalta)
Ялта
Novi Sad
Нови Сад
Belgrado
Београд
Croazia
Ploieşti
Bucarest
Costanza
Genova
Bologna
Bosnia ed
Erzegovina
Zara
Sarajevo
Serbi
Varna
Варна
Mar Ne
Pisa
San Marino
Firenze
Italia
Sunny Beach
Слънчев бряг
Mare Adriatico
София
Kosovo
Podgorica
Подгорица
Bulgaria
Burgas
Бургас
Corse
Roma
Plovdiv
Пловдив
Distretto
di Edirne
Macedonia
del Nord
Istanbul
Distretto di
Adapazarı
Gebze
Albania
Salonicco
Θεσσαλονίκη
Napoli
Pompei
Matera
Bursa
Ankara
Eskişehir
Distretto di
Çanakkale
Sardegna
Mar Tirreno
Cagliari
Grecia
Distretto di
Afyonkarahisar
Smirne
Konya
Patrasso
Πάτρα
Atene
Αθήνα
Mar Egeo
Denizli
Palermo
Reggio
Calabria
Trapani
Marsala
Sicilia
Catania
Tunisi
Adalia
Google
Dati cartografici ©2019 GeoBasis-DE/BKG (©2009),Google,Inst. Geogr. Nacional,Mapa GISrael,ORION-ME
Mondiale
Termini
Invia feedback
200 km

Channel Incision and coastal erosion in the Erzeni river – Lalzi bay system (1984 – 2015)

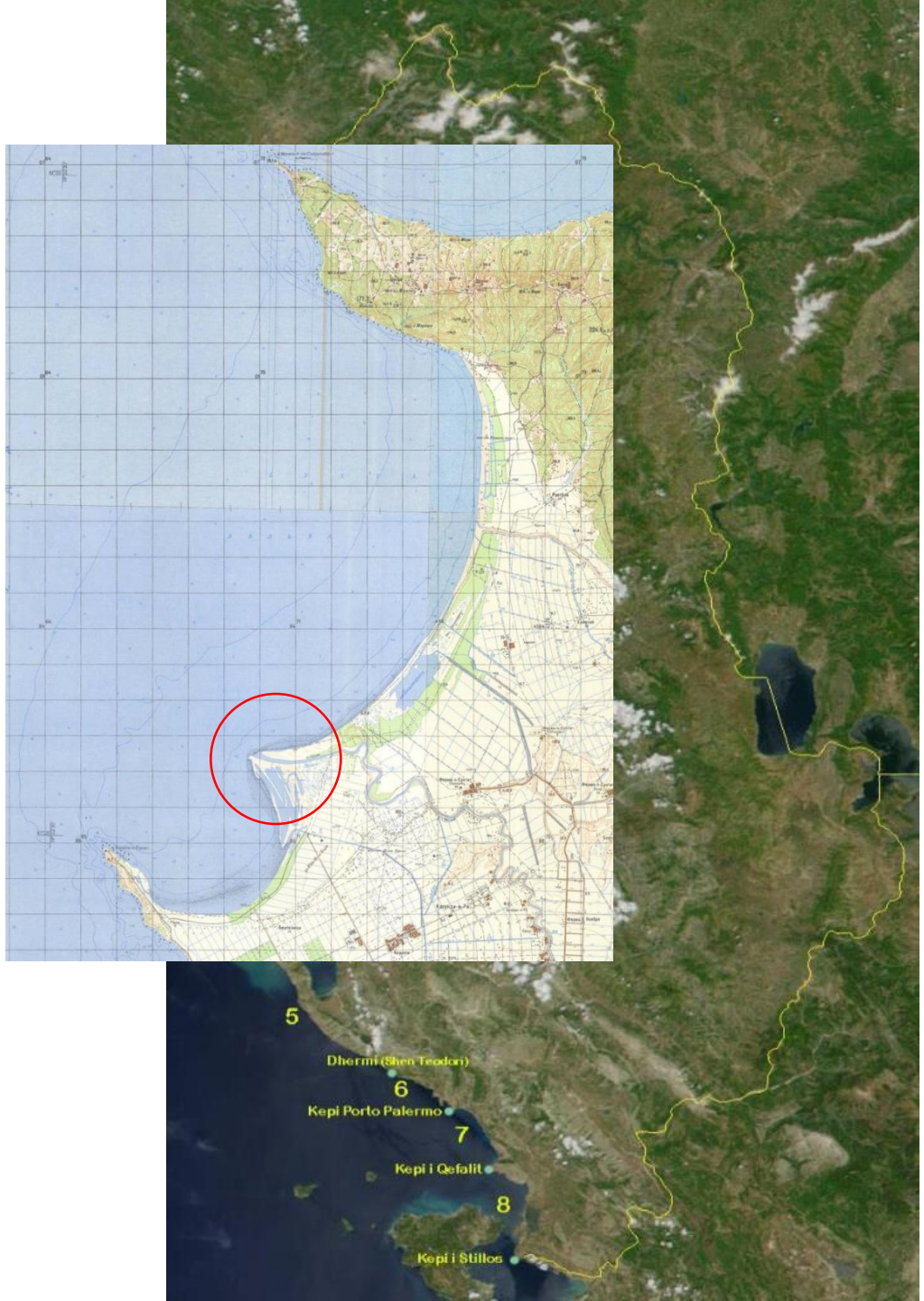
Catchment area: 760 km^2

River length: 109 km

Mean annual flow: 18 m^3 s^{-1}

Mean annual sediment load: $4 \cdot 10^6$ t y^{-1}

Channel Incision and coastal erosion in the Erzeni river – Lalzi bay system (1984 – 2015)



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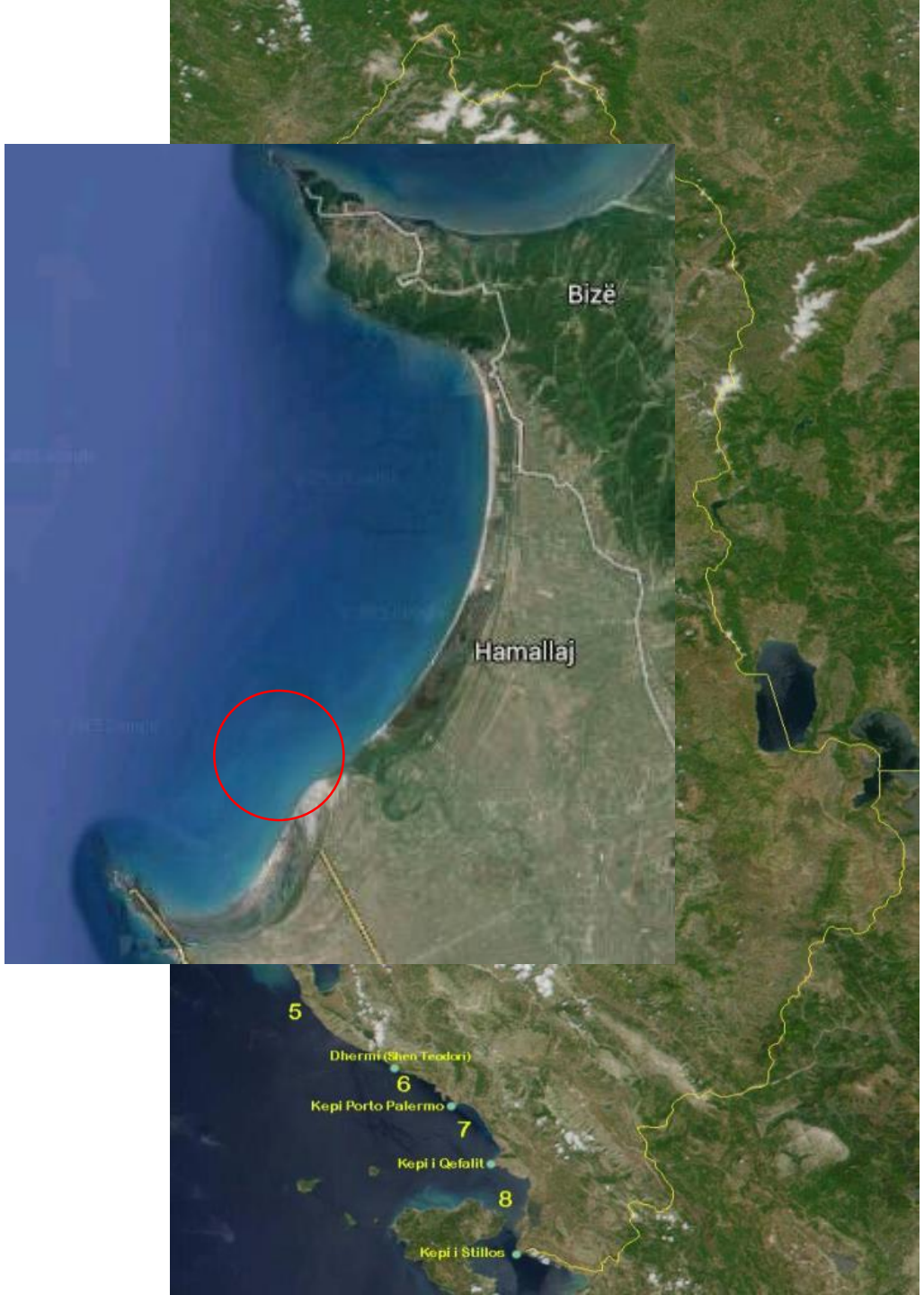

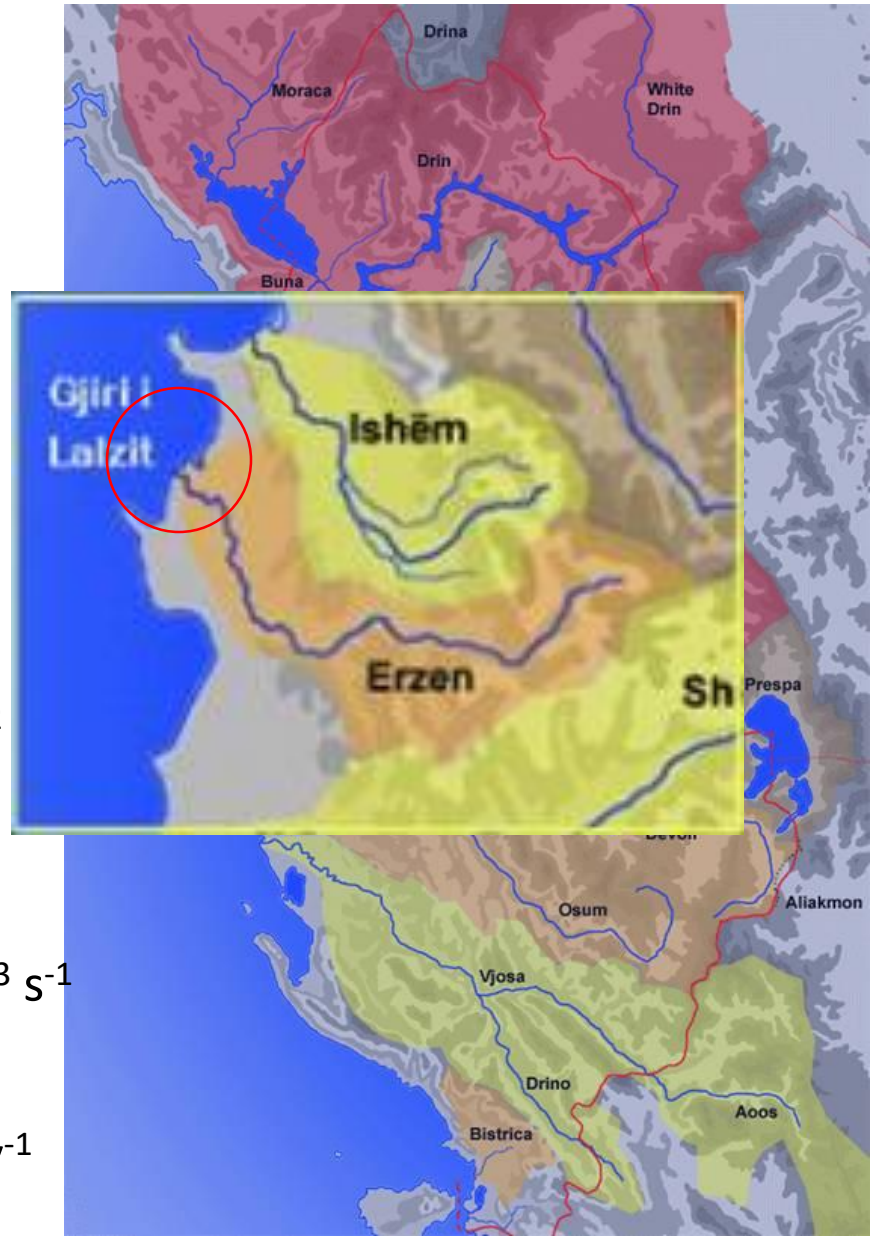

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River length: 109 km

Mean annual flow: 18 m^3 s^{-1}

Mean annual sediment load: 4 · 10^6 t y^{-1}

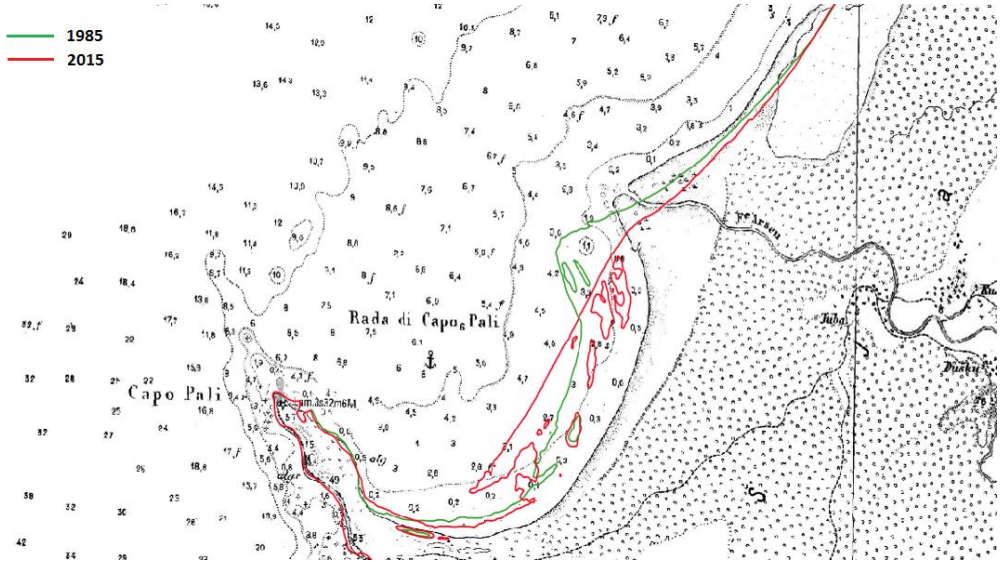
Lalzi Bay: Observations on coastal erosion 1984 - 2015

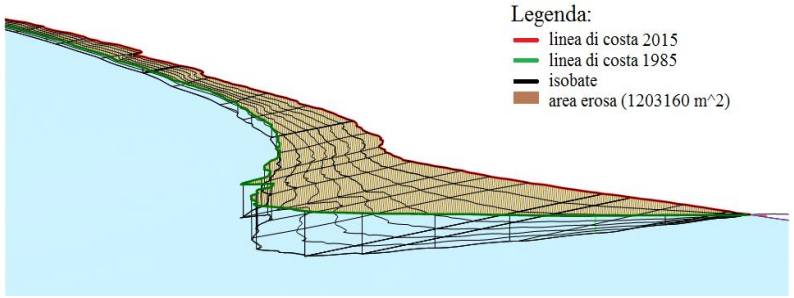
Deleo et al., 2017

Sediments fluvial transport: 2.76×10^3 m / y

Eroded volume: 1.52×10^3 m / y

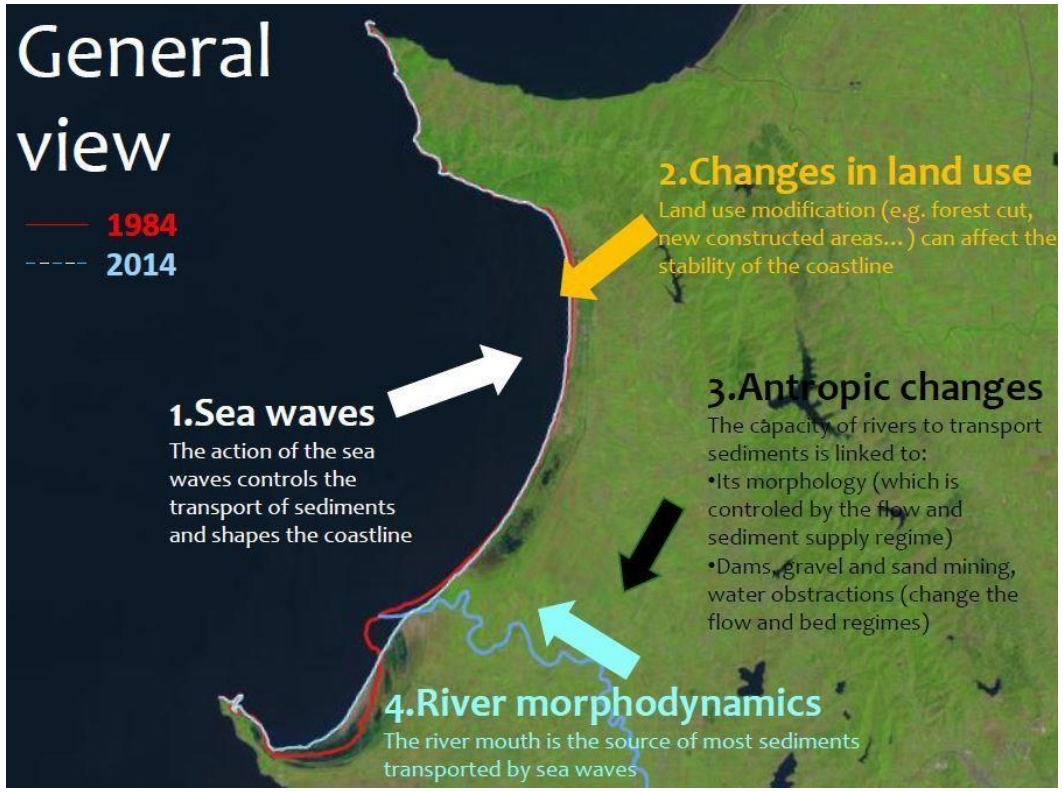
55 % of the total transport ?





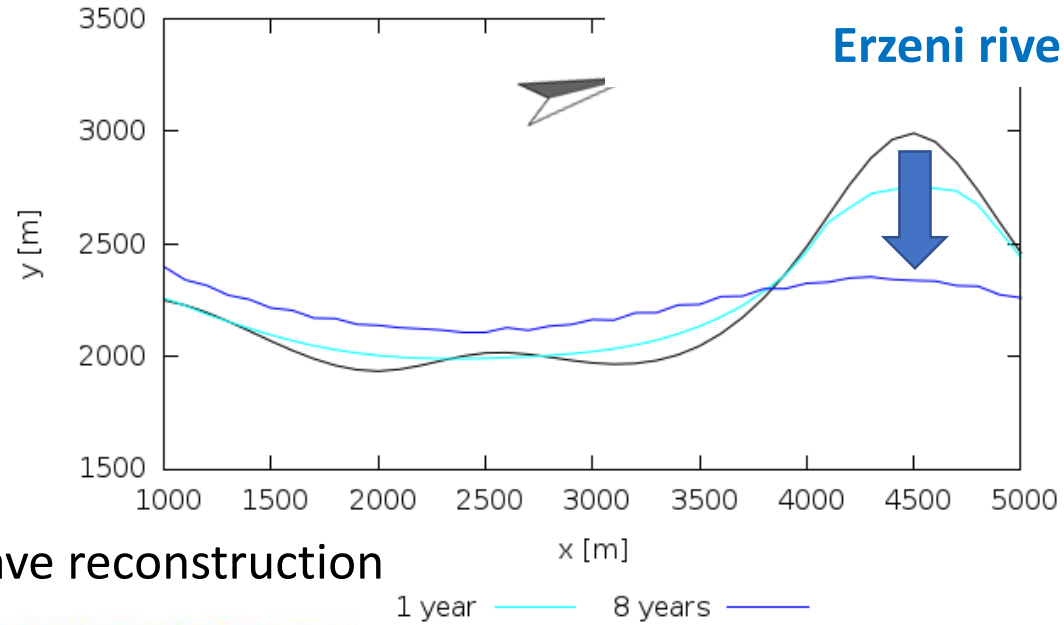
Considering the portion of the beach that was already moving, sediment transport reduction in the Erzeni is about 20 %

Morphodynamic modelling of coastline evolution in response to reduced fluvial sediment supply

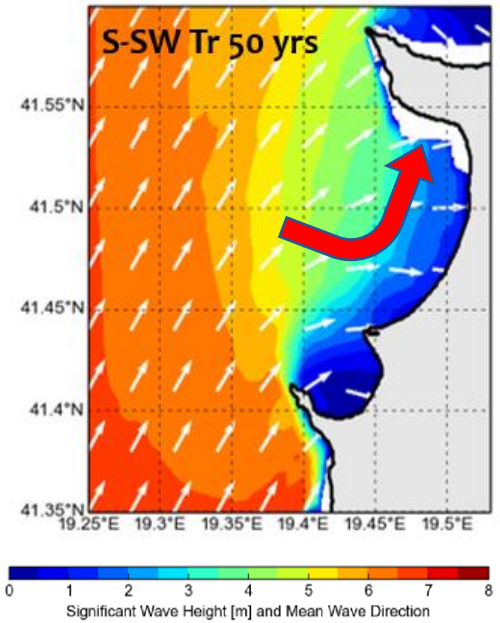


- Intensive field measurements (**250 grain size sampling, interviews, topo surveys)**
- 37 years one-hourly wave dataset
- Morphodynamic model for coastline evolution (Oneline model, Deleo et al., 2017)

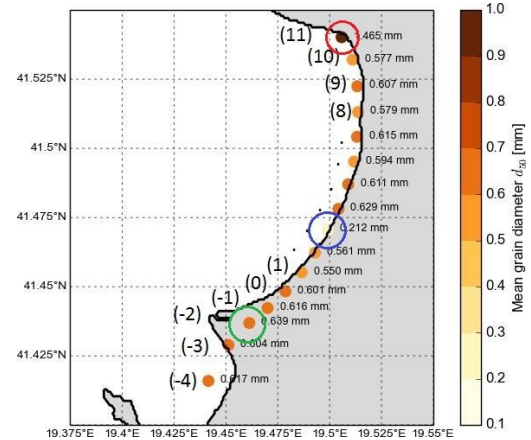
Simulated erosion of the Erzeni river delta



Sea wave reconstruction

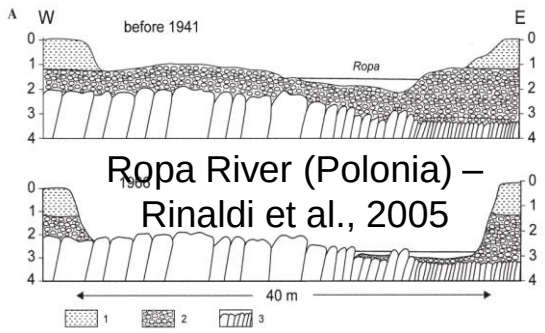


Sediment distribution along Lalzi Bay

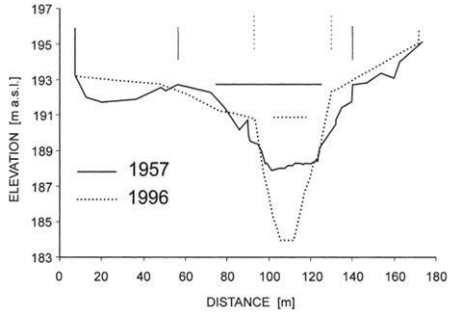


Incision/narrowing of the lower Erzen river (1995–2015)

- Little available data
- Integrated approach: topo surveys, dendrochronology, interviews
- Massive sediment mining from river beds
- Tendency to riverbed incision (2m in 20 years)
- Channel narrowing, encroachment of riparian vegetation in the former active channel



Ropa River (Polonia) – Rinaldi et al., 2005

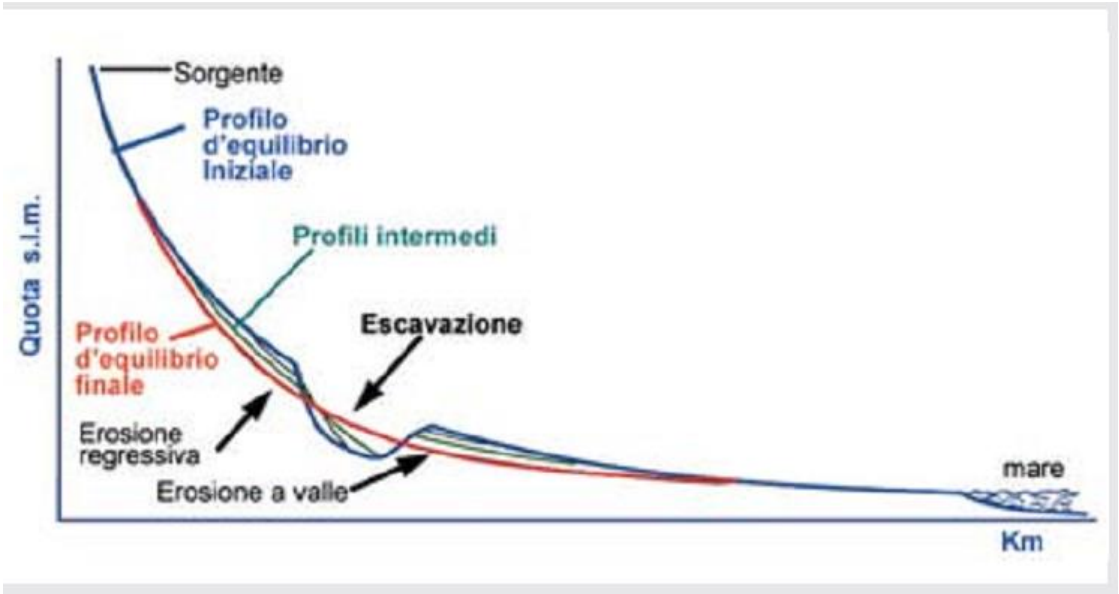


> 50 yr

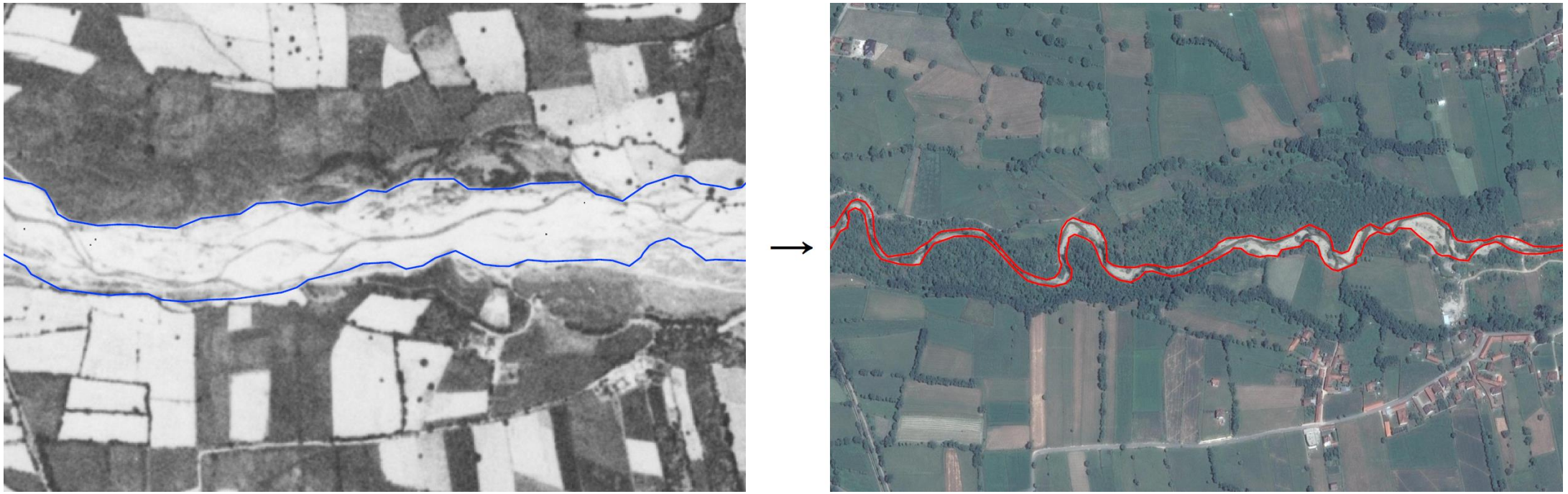
10–15 yr

Morphological effects of sediment mining in rivers

- Upstream and downstream Propagation of riverbed incision “wave”
- Reduced sediment supply to coasts ➔ alteration of coastline evolution
- Ordinary floods disconnected from previously active channel bars, which turn into more stable vegetated landofrms



Channel narrowing in the Lumbardhi i Pejës downstream the town of Peja (Kosovo) 1968 – 2007

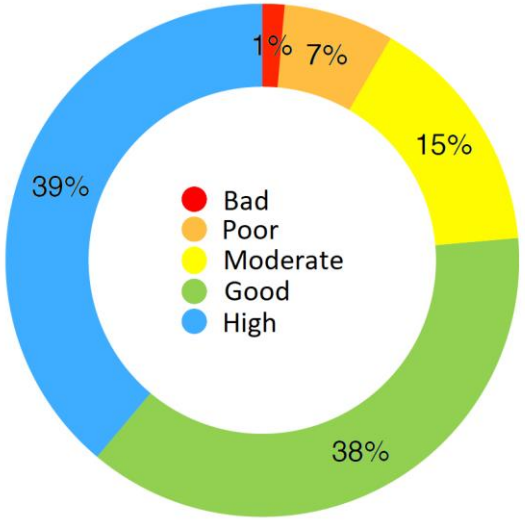


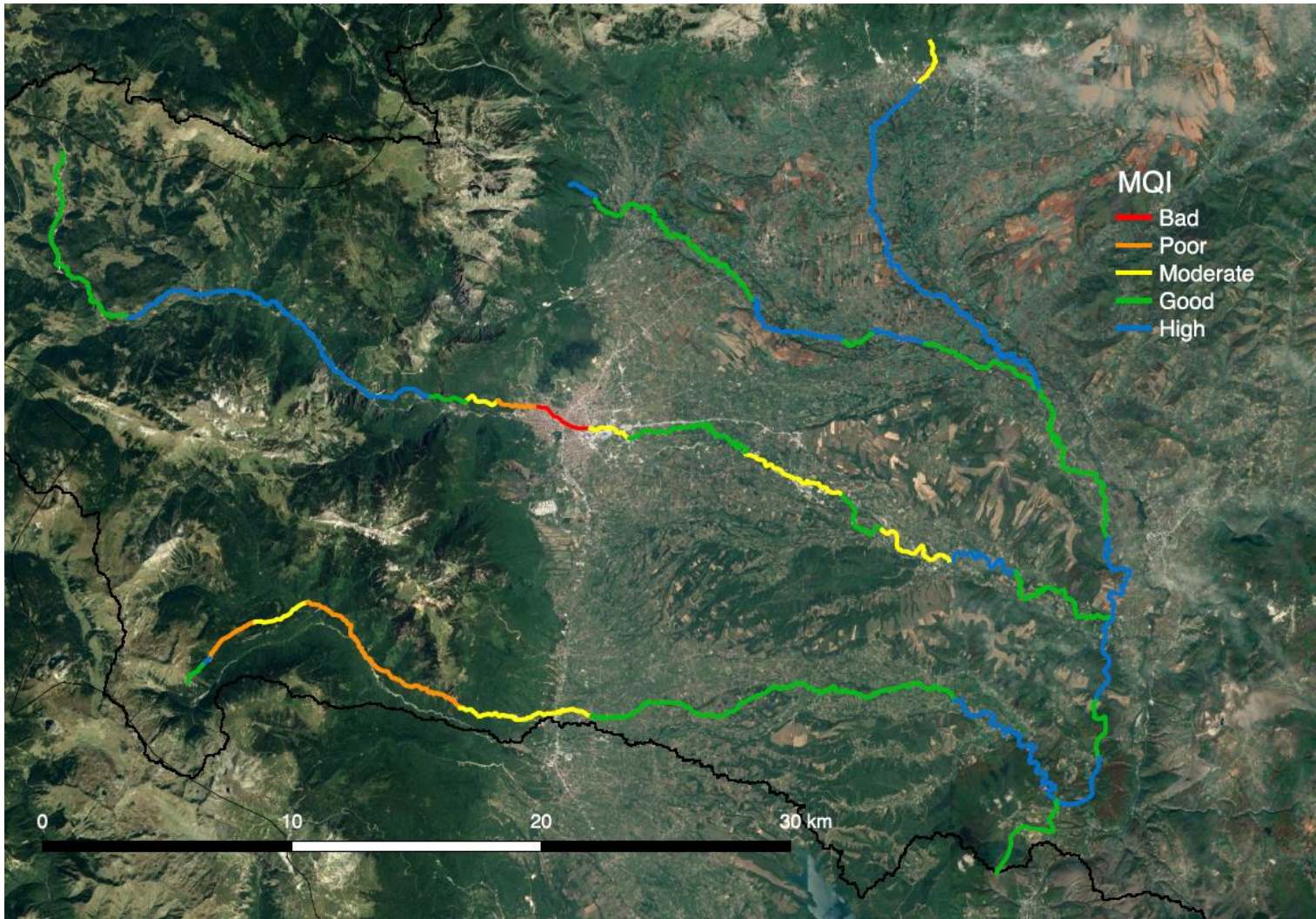
Paderno M., 2017, unpub MSc thesis, UniTrento

Morphological quality of the Upper Drin river basin (Kosovo, 2018)

Paderno M., 2017, unpub MSc thesis, UniTrento

- Heavily affected by sediment mining
- MQI, Rinaldi et al 2016 – WFD implementation (Italy – REFORM EU project
- 72 reaches, 192 river km





Location of Vermosh river

Reported increase in floods and debris flow but no data to assess «climate change» effects

Aggradation in the Vermosh river related to heavy deforestation in the catchment

- Increased flood and intense sediment transport occurring in association with uncontrolled deforestation

  ➔ increase of flood flashiness (higher peak streamflow for the same rainfall)

  ➔ increase in soil erosion, sediment production and sediment transport to downstream areas

Albanian rivers: contrasting styles of channel adjustments?

Opposite river trajectories in relation to dominant stressor in the catchment?

Upper part of catchments ➔ deforestation, little mining ➔ increased sediment supply ➔ **aggradation** ➔ increased flood risk

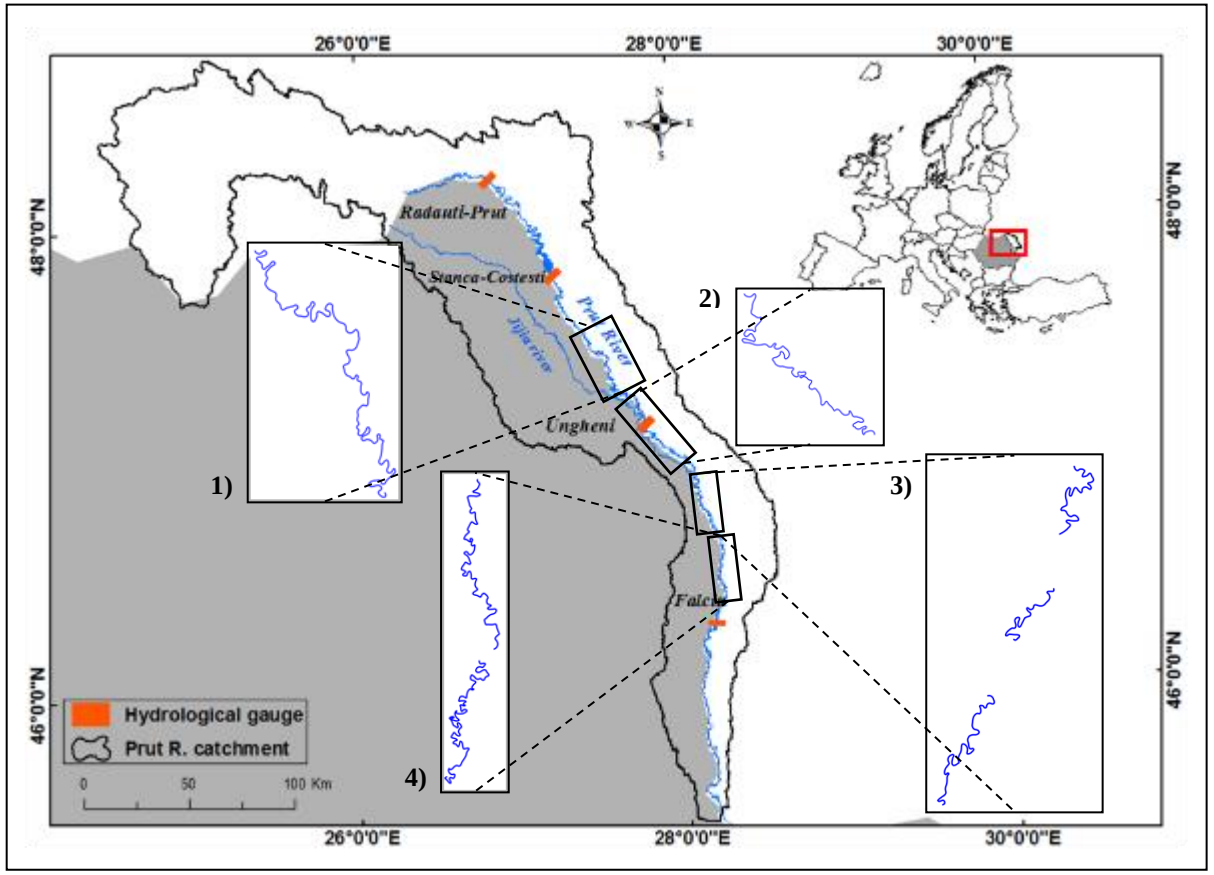
Lower parts of catchments ➔ mining prevalent ➔ reduced sediment supply ➔ **incision and coastal erosion**

Effects of incision

Effects of aggradation (no visible banks …)

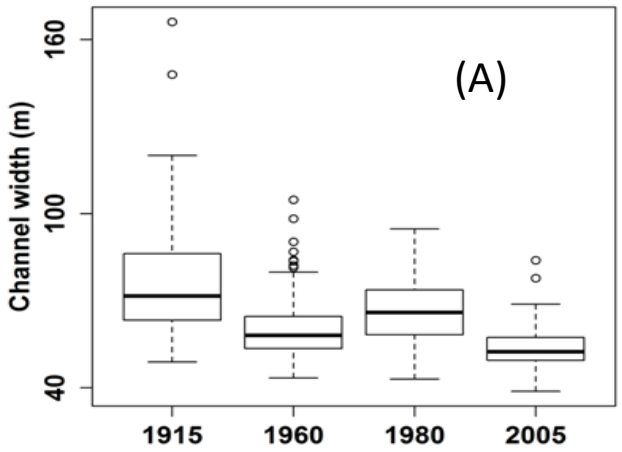
The meandering Prut river at the border between Romania and Moldova

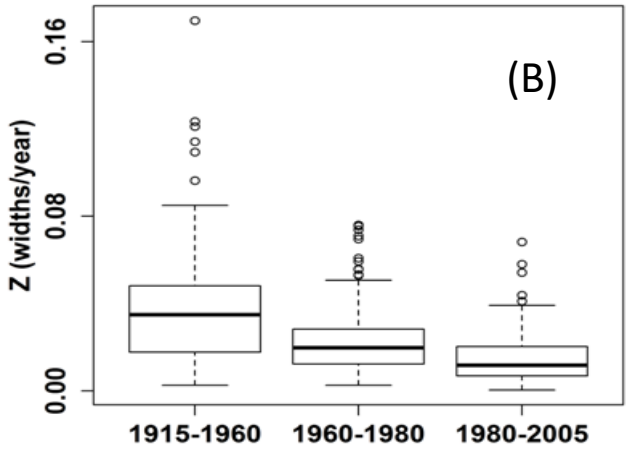
- One of the last long (>300km), partially «free» meandering rivers in Europe
- Reservoir building in 1970s
- Analysis of
  - Historical maps (1915, 1960, 1980)
  - Recent ortophoto (2015)

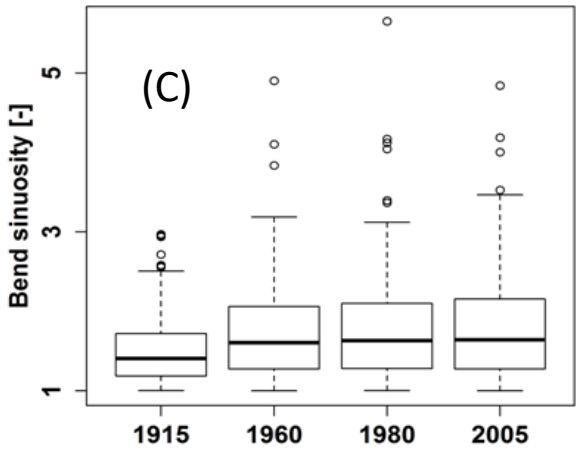


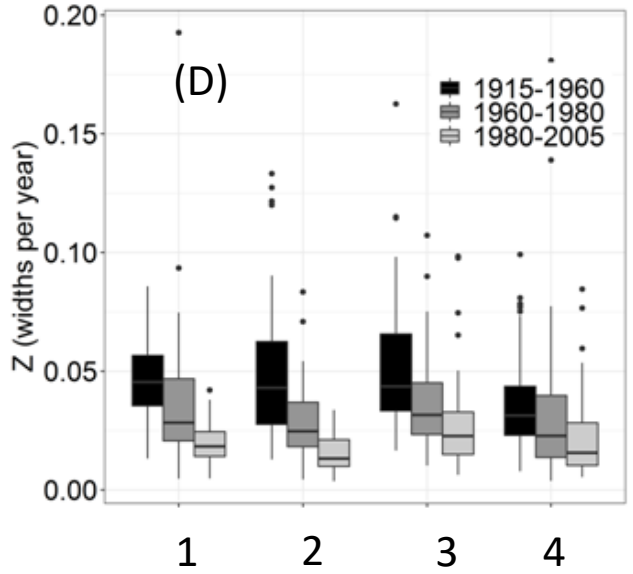
Bisht T., 2019, unpub PhD thesis

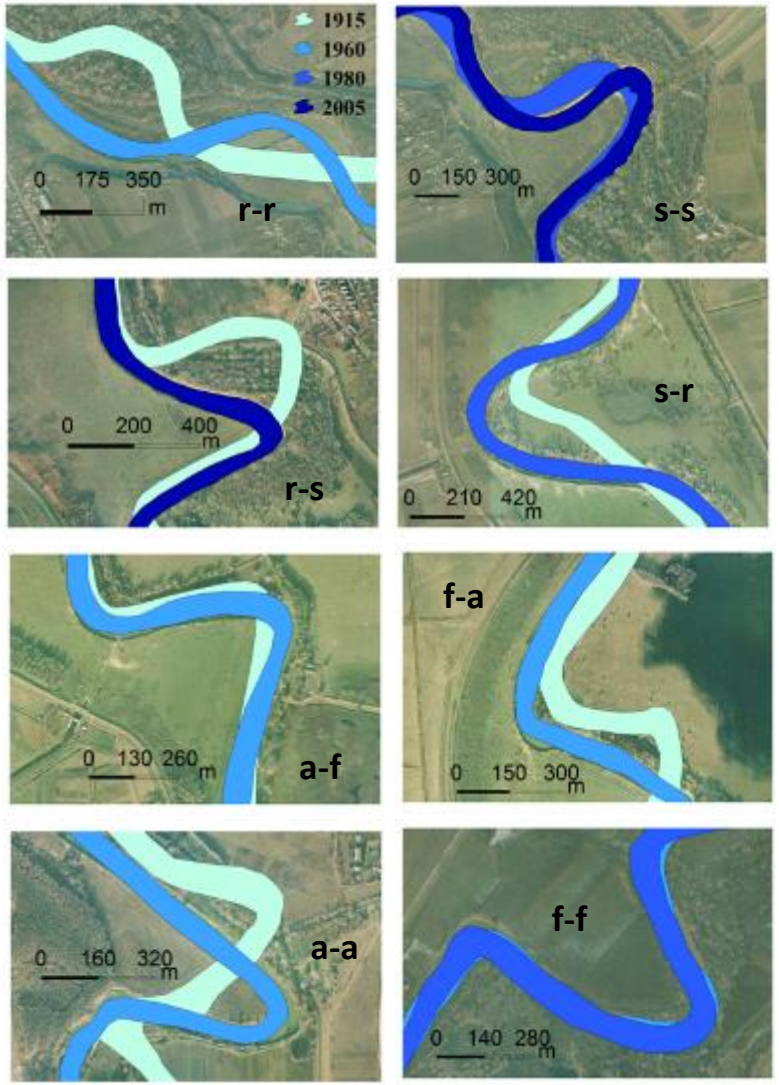
Reduced migration and narrowing of the meandering Prut river following dam construction











Bisht T., 2019, unpub PhD thesis

Channel adjustments in Albanian rivers 1968 - 2015

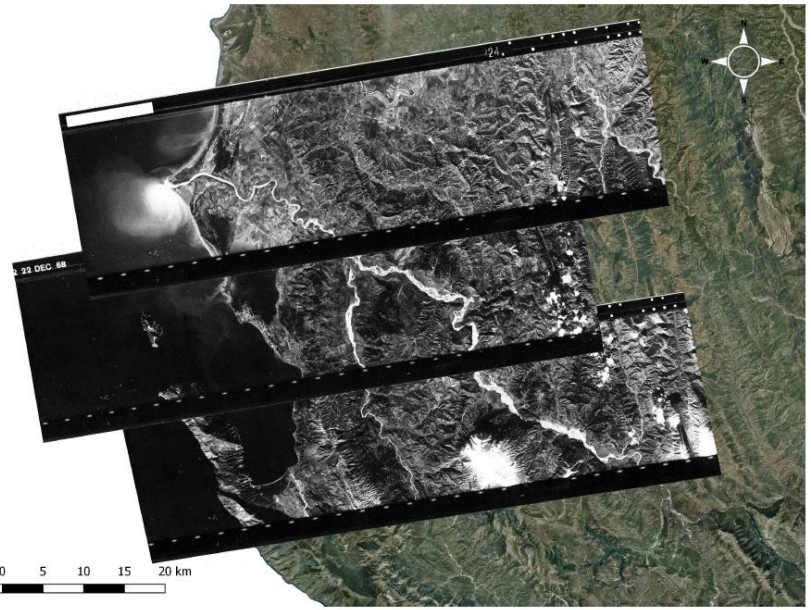
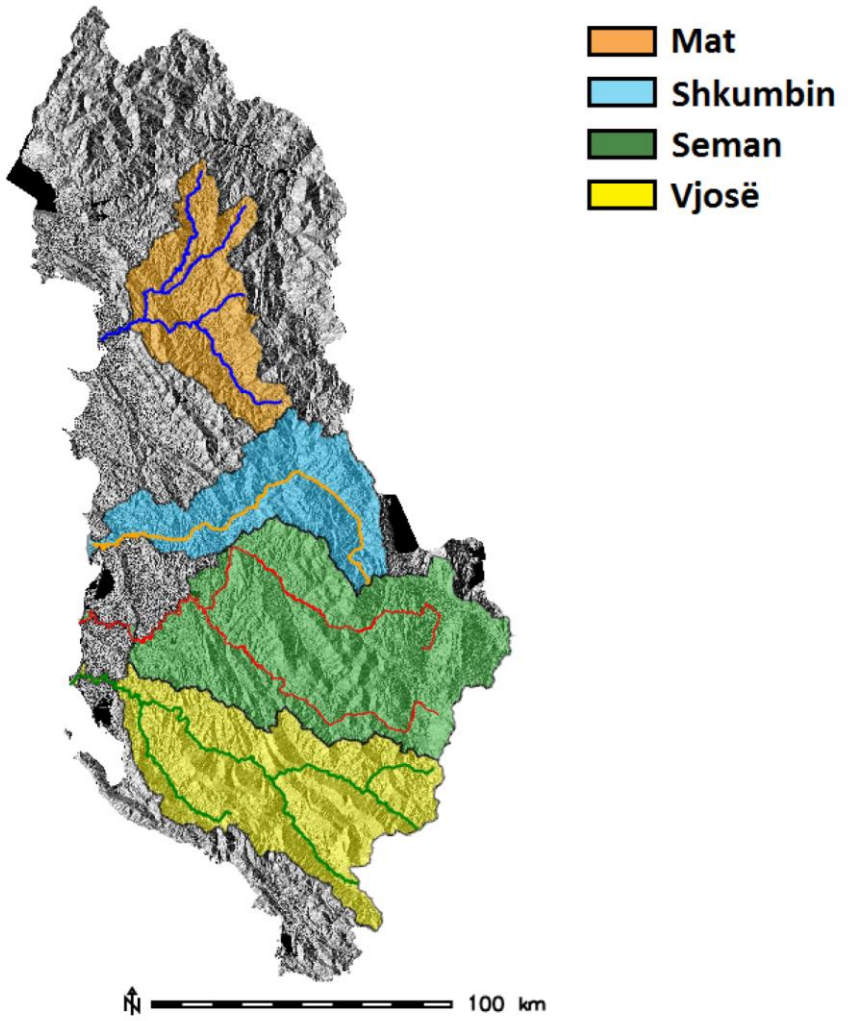


Figure 4.5: CORONA Program aerial imagery georeferenced with QGIS.

Table 4.18: Sentinel-2 downloaded images properties.

Product identifier	Sensing date
S2A_MSIL1C_20150831T093006_N0204_R136_T34TCK_20150831T093006	31/08/2015
S2A_MSIL1C_20151209T093402_N0204_R136_T34TCK_20151209T093400	09/12/2015
S2A_MSIL1C_20160815T093042_N0204_R136_T34TCK_20160815T093218	15/08/2016
S2A_MSIL1C_20161103T093142_N0204_R136_T34TCK_20161103T093703	03/11/2016
S2A_MSIL1C_20161123T093322_N0204_R136_T34TCK_20161123T093317	23/11/2016
S2B_MSIL1C_20171123T093309_N0206_R136_T34TCK_20171123T113550	23/11/2017
S2B_MSIL1C_20171223T093359_N0206_R136_T34TCK_20171223T115756	23/12/2017
S2A_MSIL1C_20180127T093241_N0206_R136_T34TCK_20180127T131509	27/01/2018
S2A_MSIL1C_20180216T093051_N0206_R136_T34TCK_20180216T145646	16/02/2018
S2A_MSIL2A_20180318T093031_N0206_R136_T34TCK_20180318T113722	18/03/2018
S2A_MSIL1C_20180427T093041_N0206_R136_T34TCK_20180427T113935	27/04/2018

+ 10 Landsat images
(1975 – 2015)

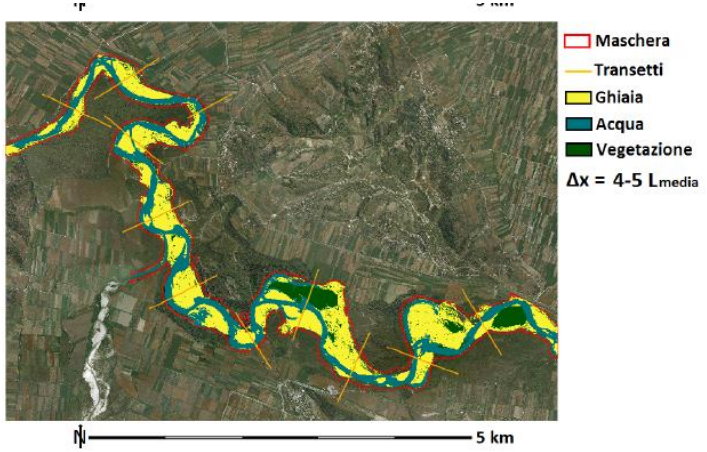


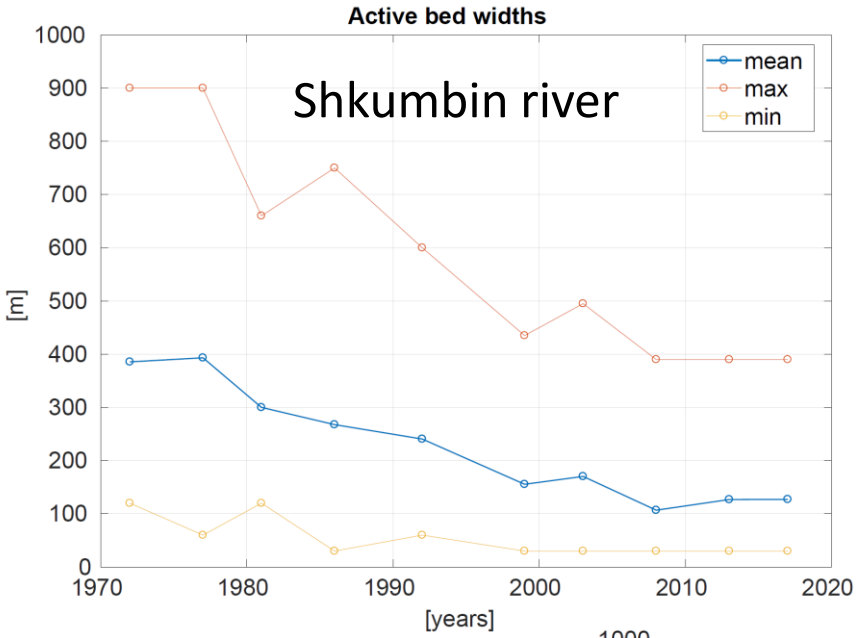
	Anno	
	1968	2007
Risorsa	(U.S.G.S.) EarthExplorer	ASIG GeoPortal
Tipo immagine	foto satellitare b/n	ortofoto digitale RGB
Numero foto	5	2207
Risoluzione [m]	2.75	0.2

Spada, D, 2016, unpub MSc thesis

Regional reduction in mean channel widths 1968 – 2015 («trajectories»)

Automated extraction of morphological parameters (width, length, sinuosity, …





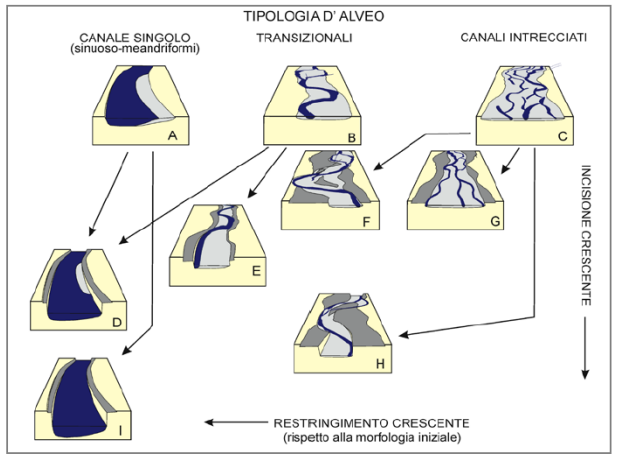
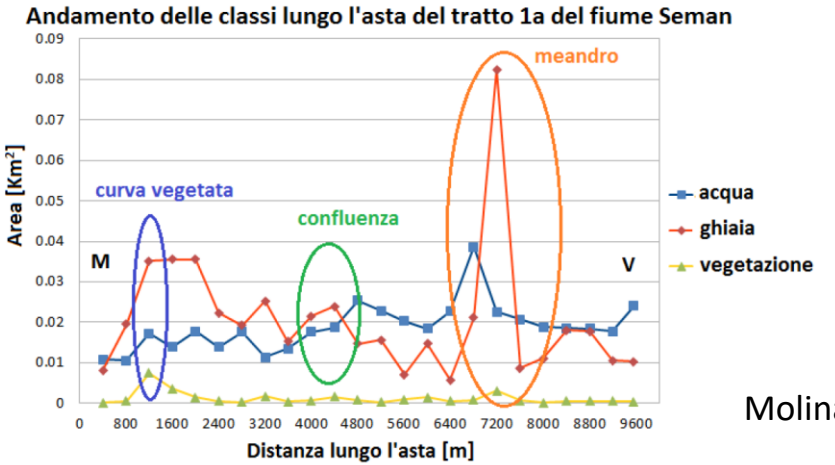
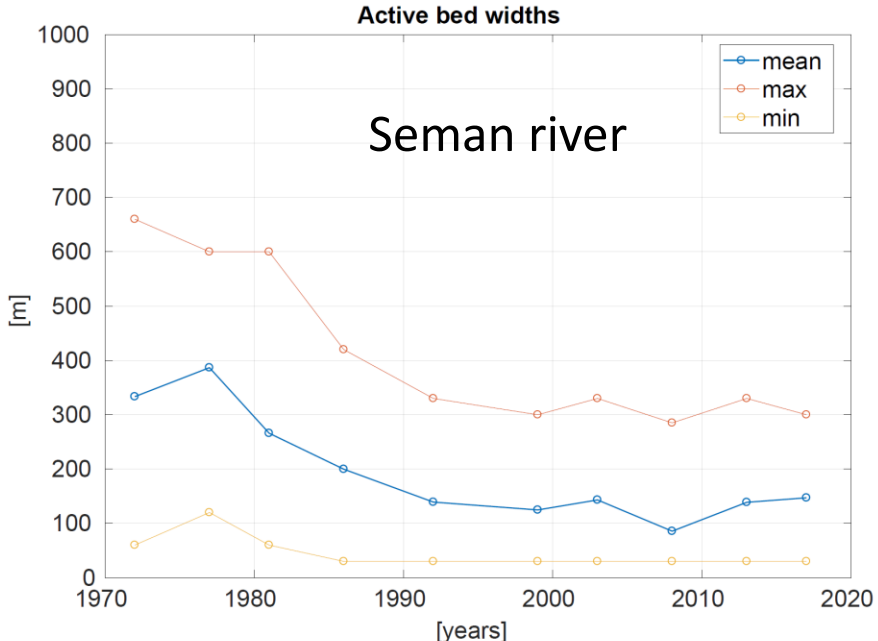


Figura 2.17 – Schema di classificazione delle variazioni morfologiche di fiumi italiani. (Da *SURIAN & RINALDI, 2003*, modificato).

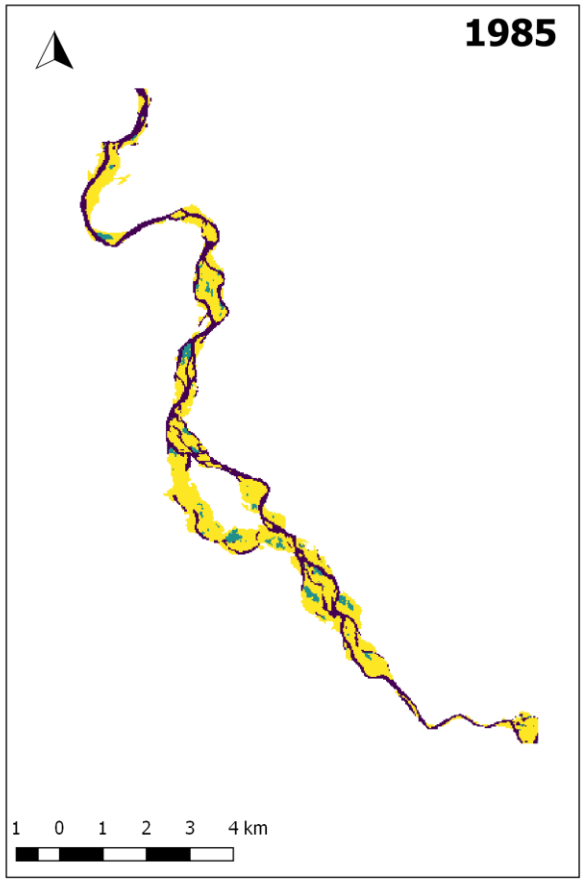
Relative error of classification: < 5%

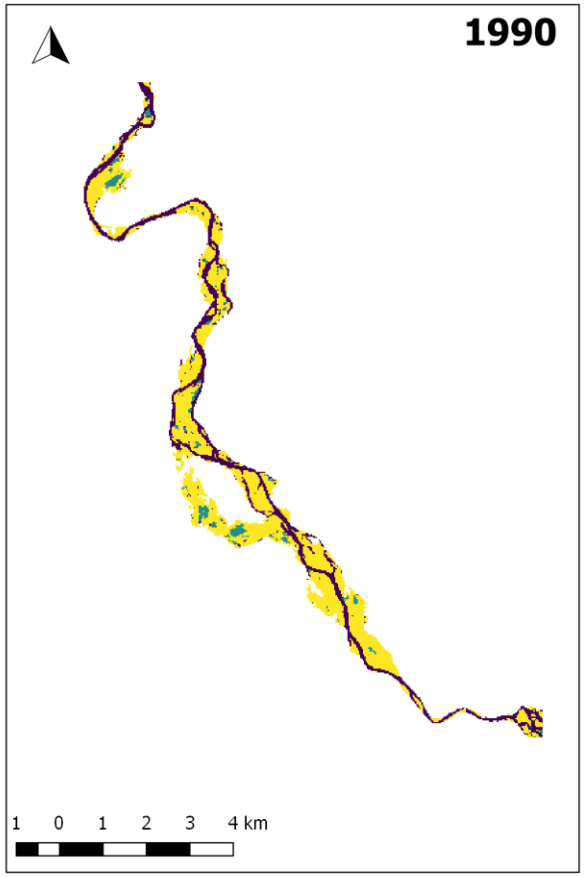


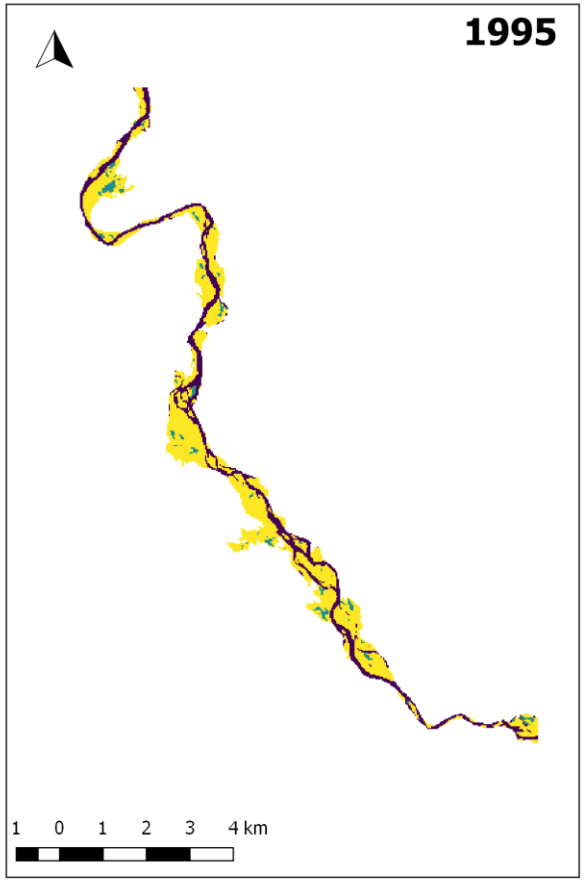
Molinari, P, 2017, unpub MSc thesis

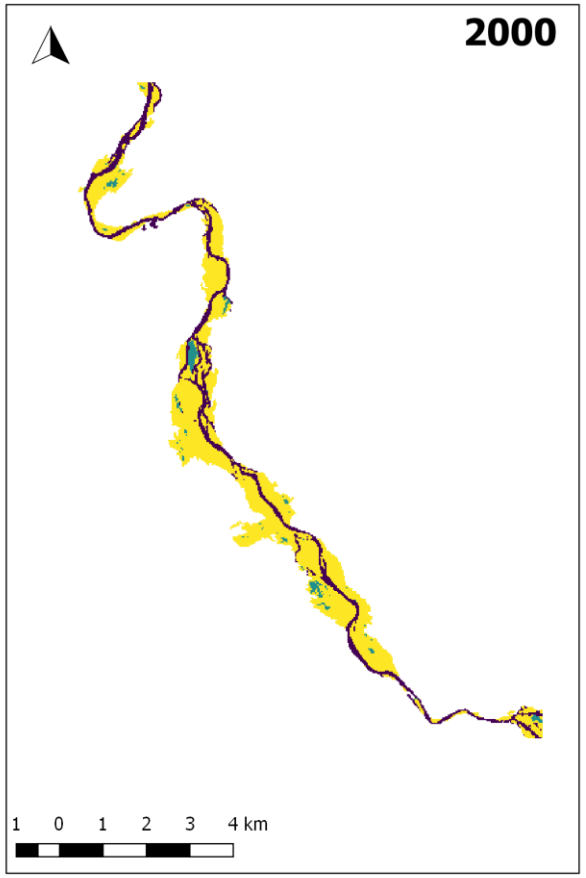


Also wild rivers follow trajectories: narrowing of Vjosa 1975 – 2015(unconfined reaches)



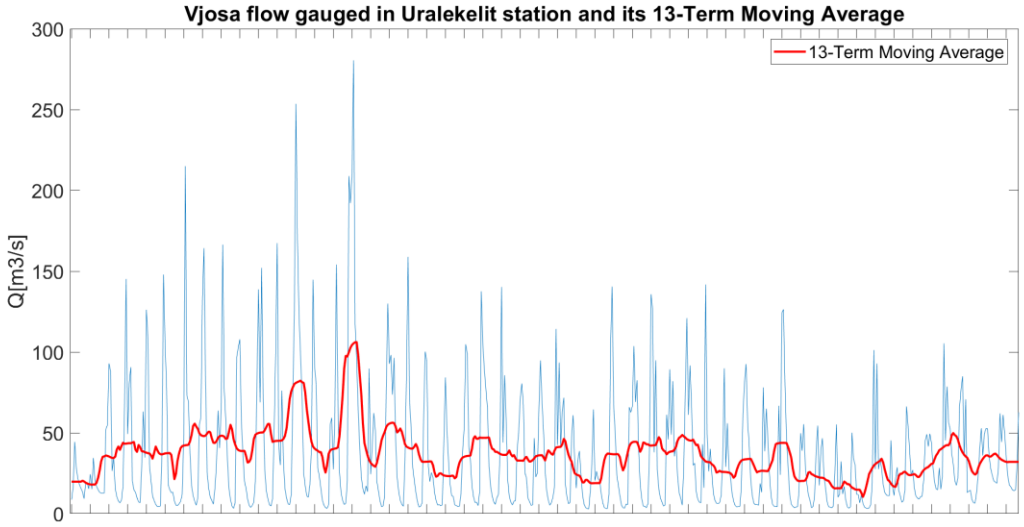




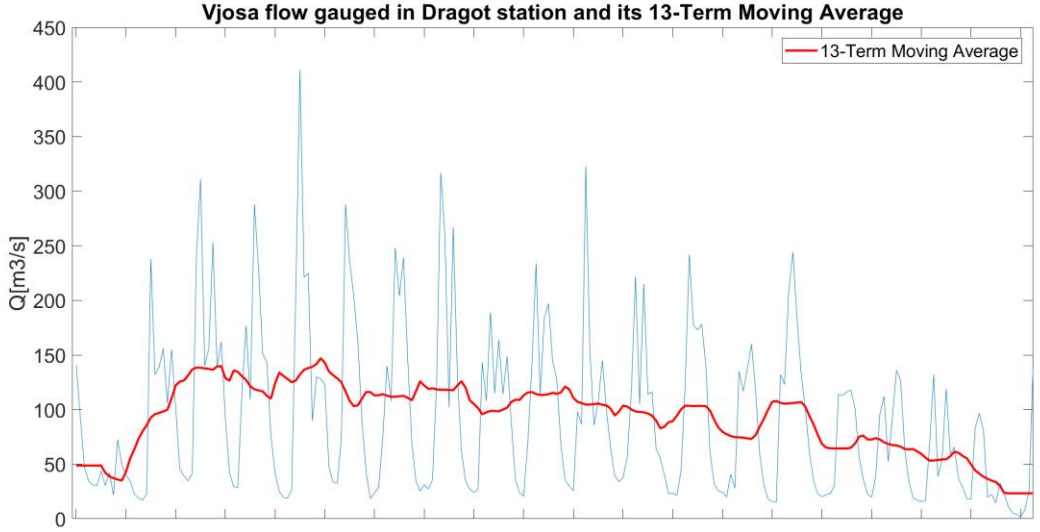


Geomorphological trajectories 1968 – 2015: controlling factors?

Figure 5.9: Adjustments in width and channel pattern in Mifol (at the top), Mesarak (center) and Kuta (bottom). Comparison between the Orthophoto 2015 and the CORONA images taken in 1968.



Decreasing runoff trends 1958 – 1990 ➔ less effective floods?



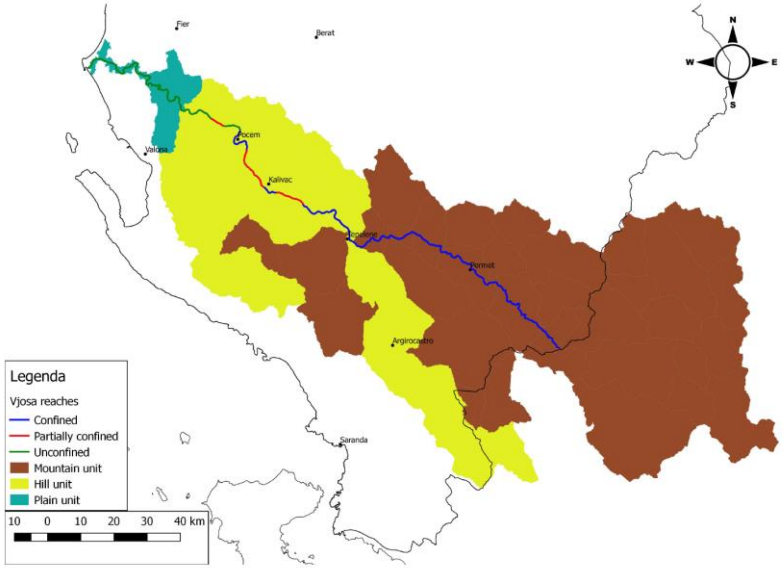


Table 5.2: MQI values for every reach of the Vjosa river. Only good (green) and high (blue) values are found.

Segment 1		Segment 2		Segment 3		Segment 4	
Reach code	**MQI**	**Reach code**	**MQI**	**Reach code**	**MQI**	**Reach code**	**MQI**
1.1	0.920	2.1	0.947	3.1	0.760	4.1	0.873
1.2	0.900	2.2	0.950	3.2	0.877	4.2	0.883
1.3	1.000	2.3	0.930	3.3	0.943		
1.4	0.960			3.4	0.925		
1.5	0.930			3.5	0.921		
1.6	0.980			3.6	1.000		
1.7	0.968			3.7	0.937		
1.8	0.900			3.8	0.877		
1.9	0.980			3.9	0.984		
1.10	0.930			3.10	0.913		
1.11	0.860			3.11	0.871		
1.12	0.900						
1.13	0.955						
1.14	0.920						
1.15	0.960						
1.16	0.980						
1.17	0.960						
1.18	0.950						
1.19	0.960						

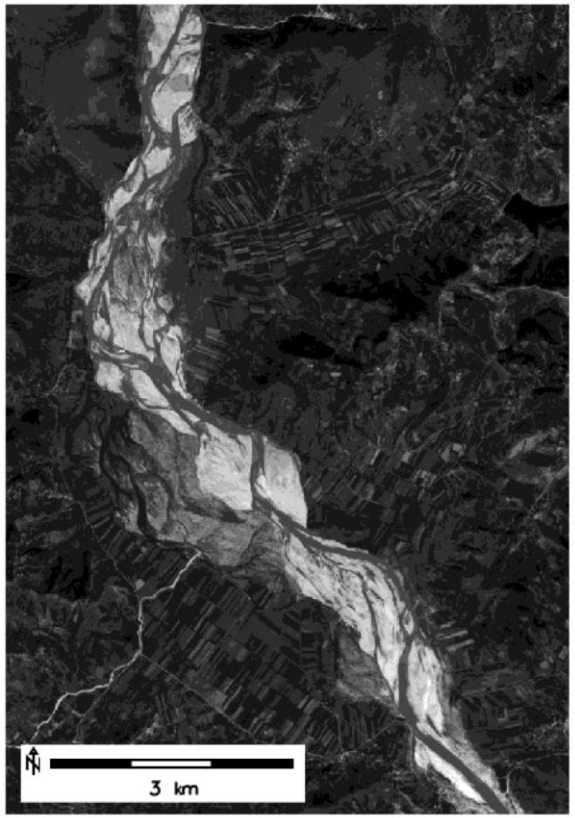
But morphological quality (Vjosa) is very high ➔ so what is a WILD river?

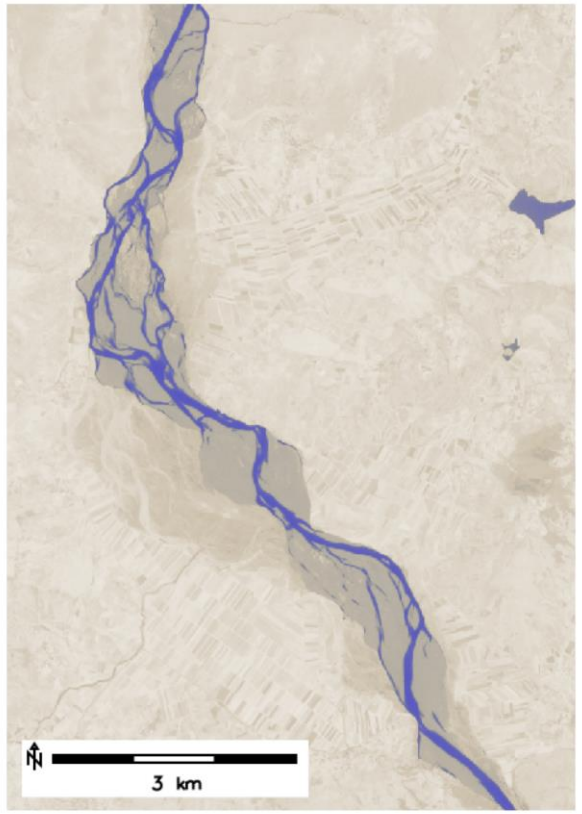
Figure 5.8: Evidence of incision in Novoselë.

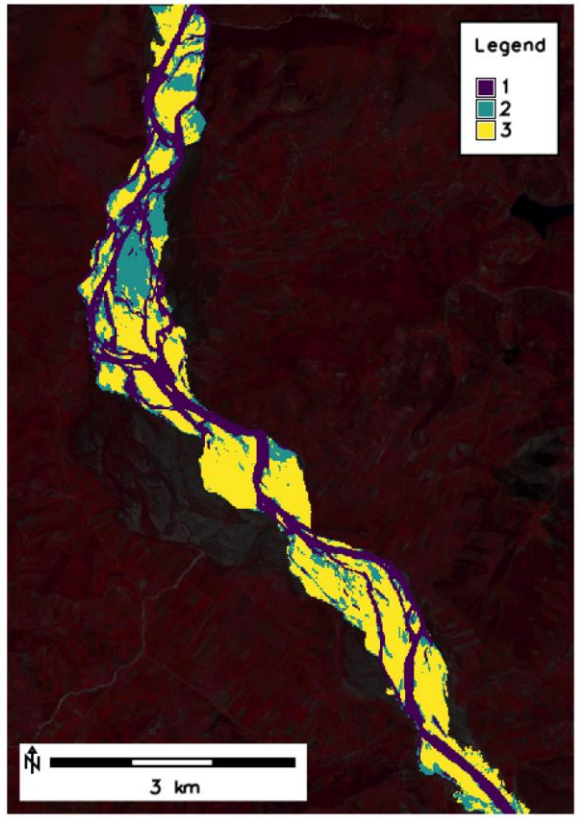
Figure 5.7: Photos of the extraction activities made during photographic champaign: Iliras (left) and Selenicë (right).

Laghetto G, 2019, unpub MSc thesis

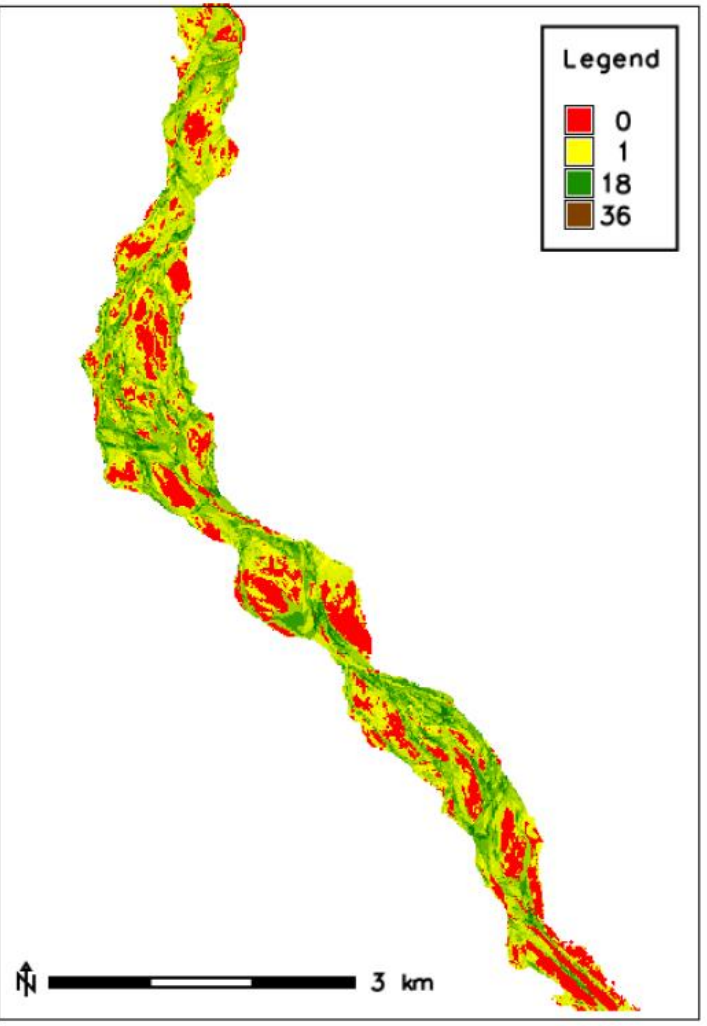
Vjosa river – recent eco-morphodynamics from Sentinel 2 satellite images

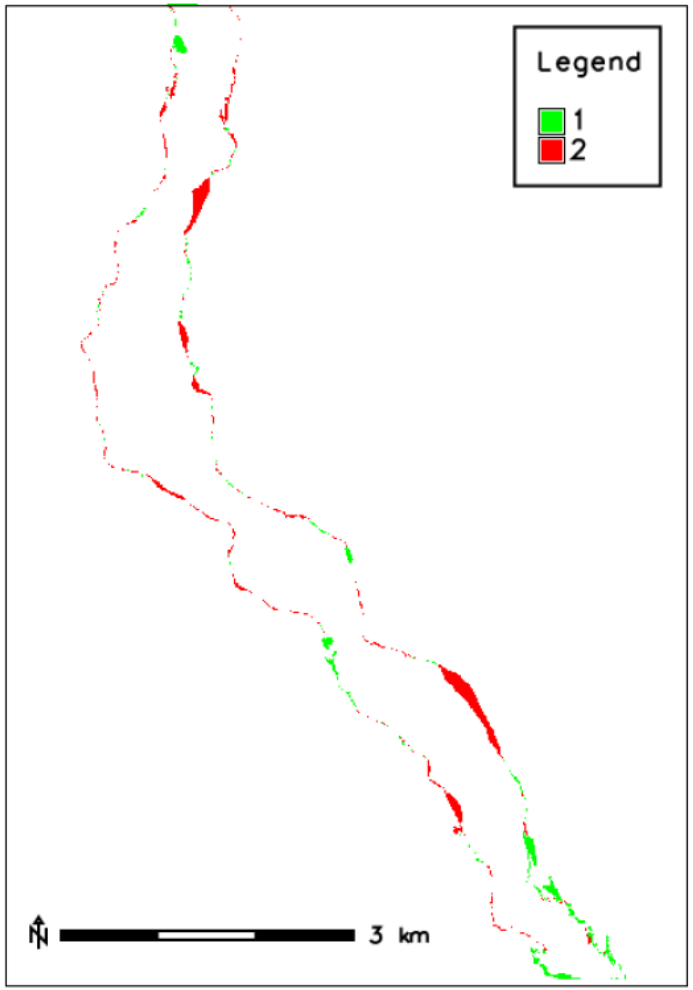


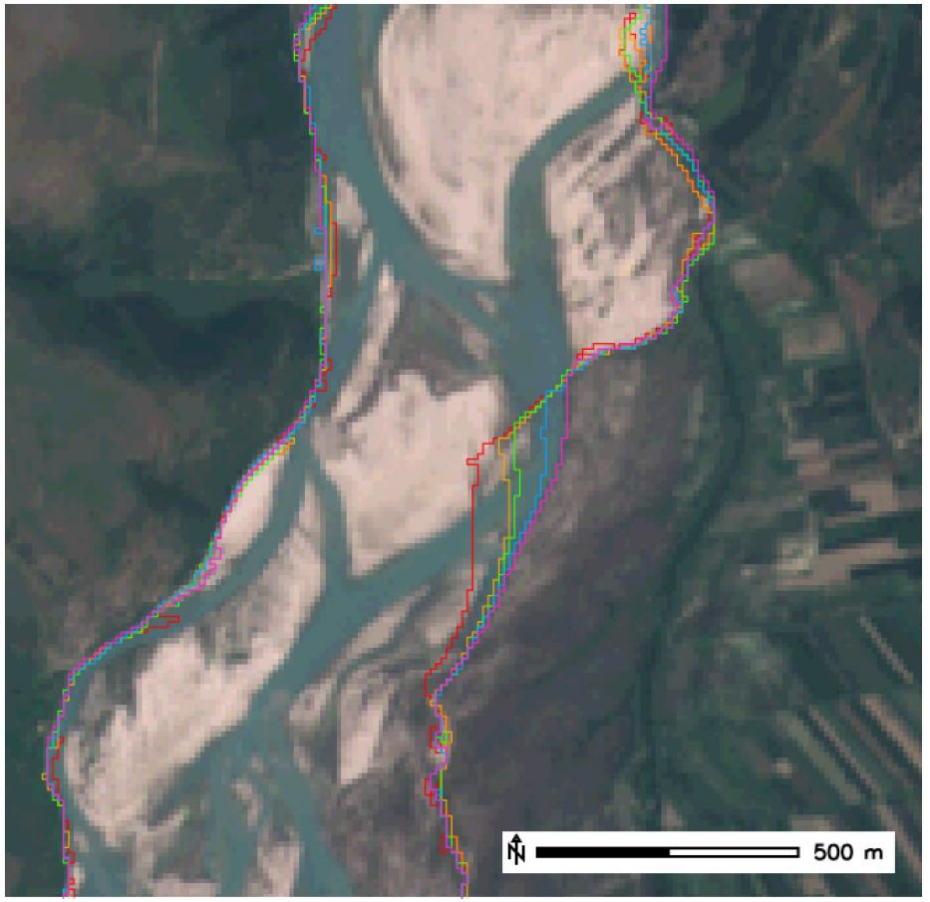




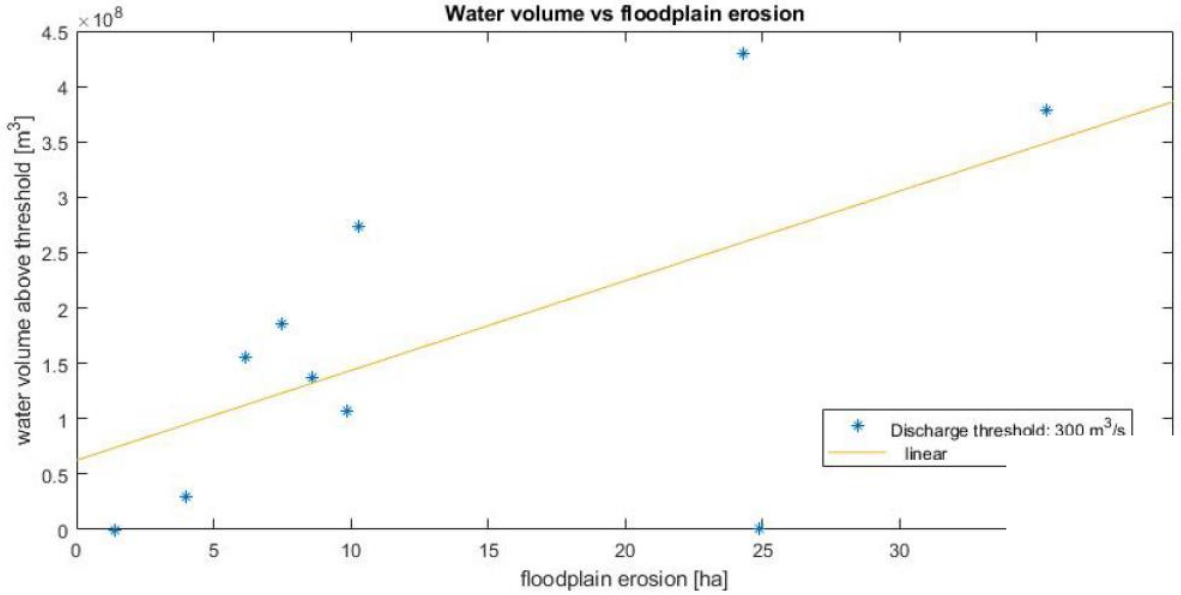
Vjosa river: 2015 – 2018 reach-scale high degree of morphodynamics ➔ «wild» ?!

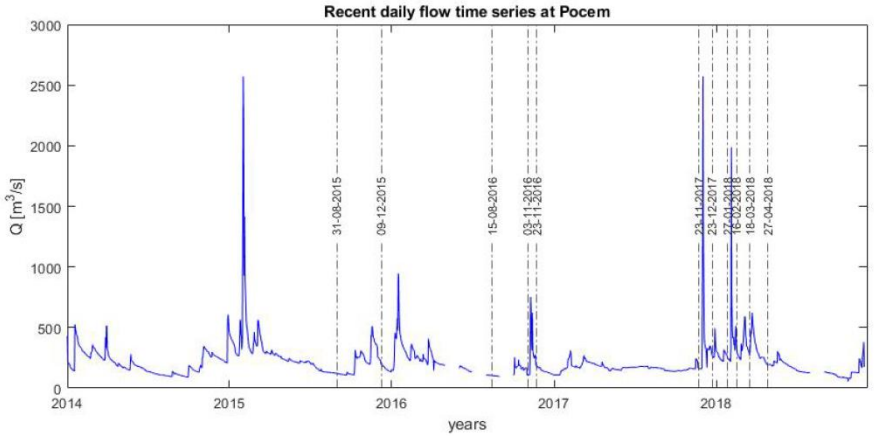


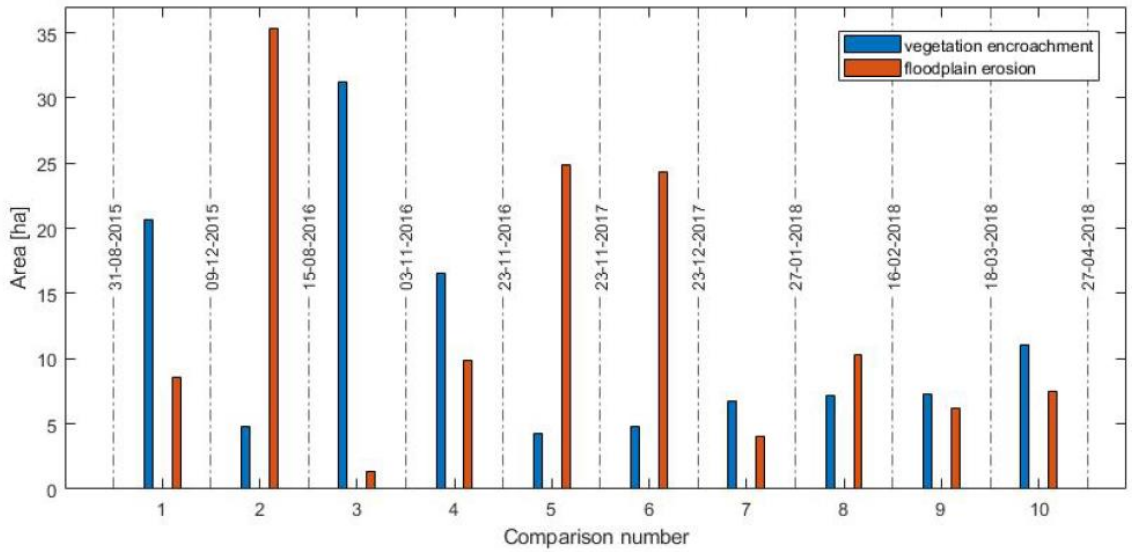




Both duration and peak flood values are important to preserve dynamicity



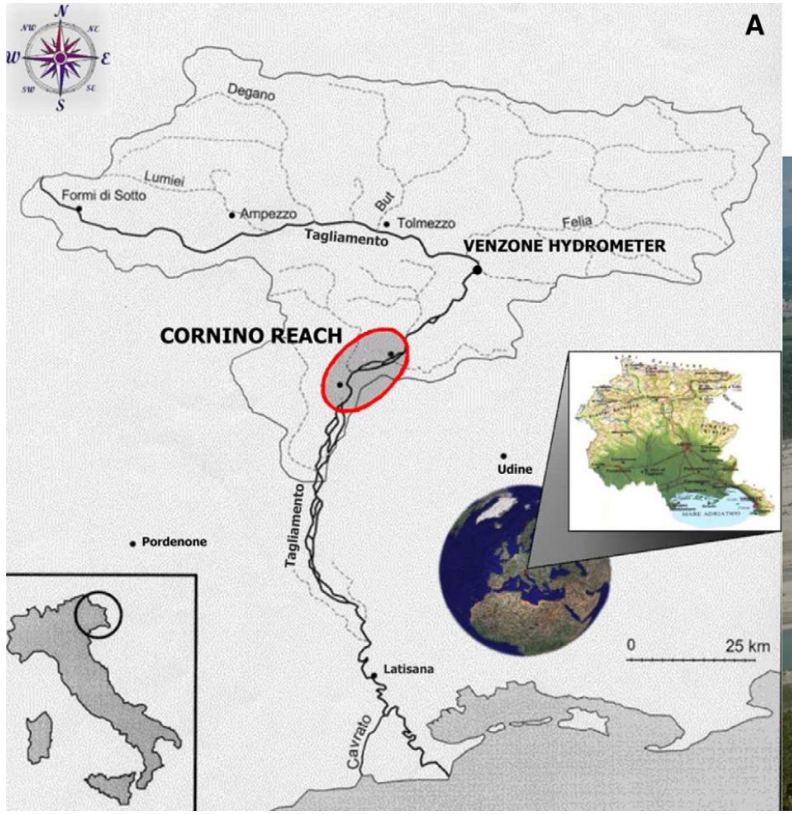




Laghetto G, 2019, unpub MSc thesis

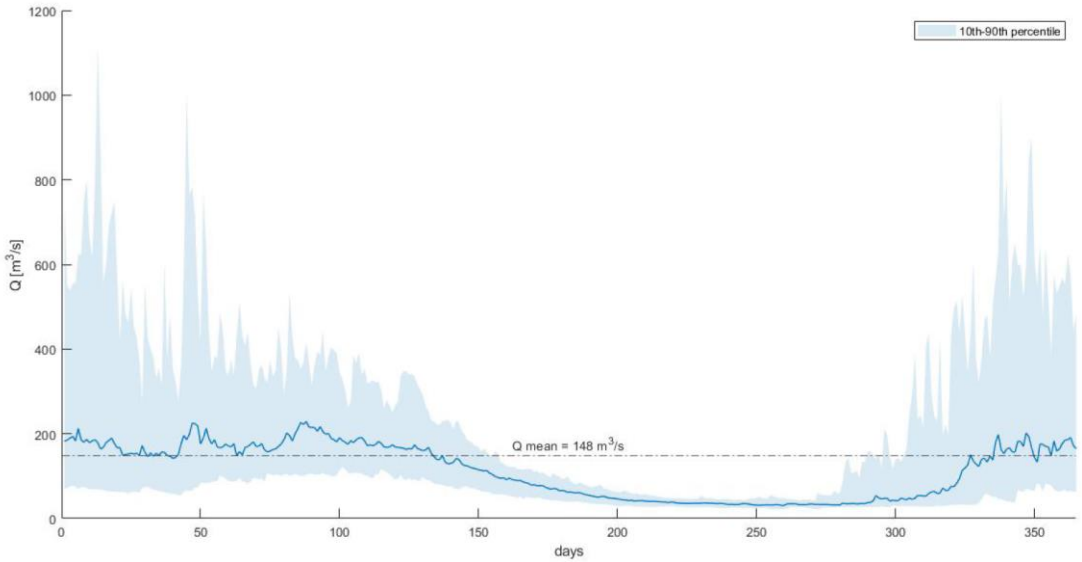
Figure 5.27: Floodplain erosion and riverbed encroachment by the vegetation in the Kuta reach

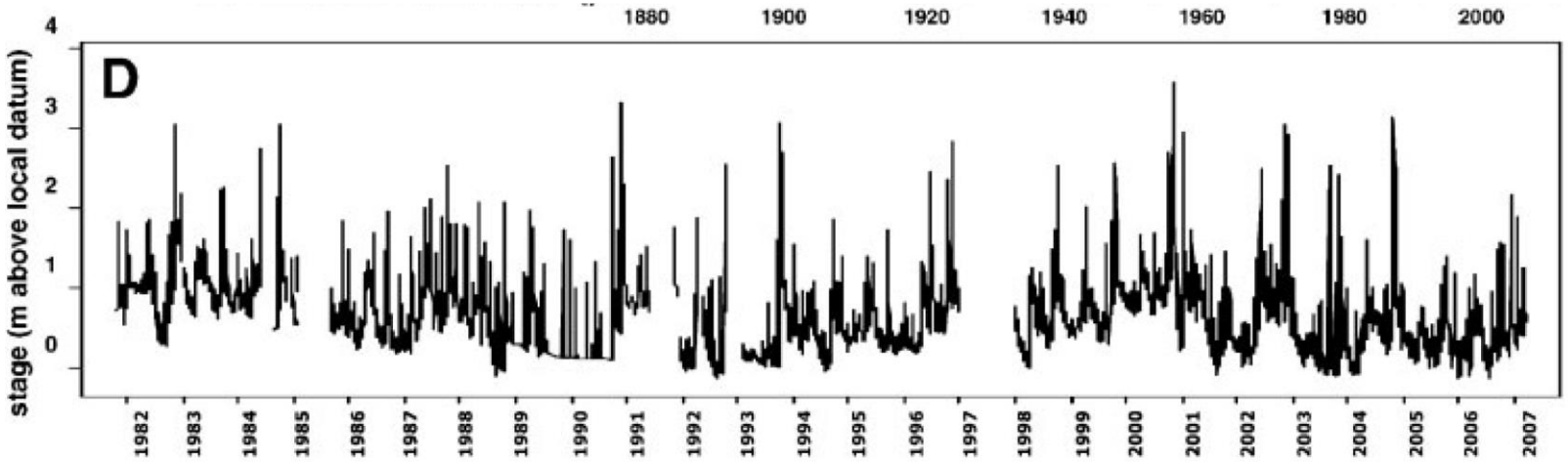
Wild (large, braided) rivers:
Tagliamento River (Alps) and Vjosa river (Balkans)



Welber et al, 2012 ESPL

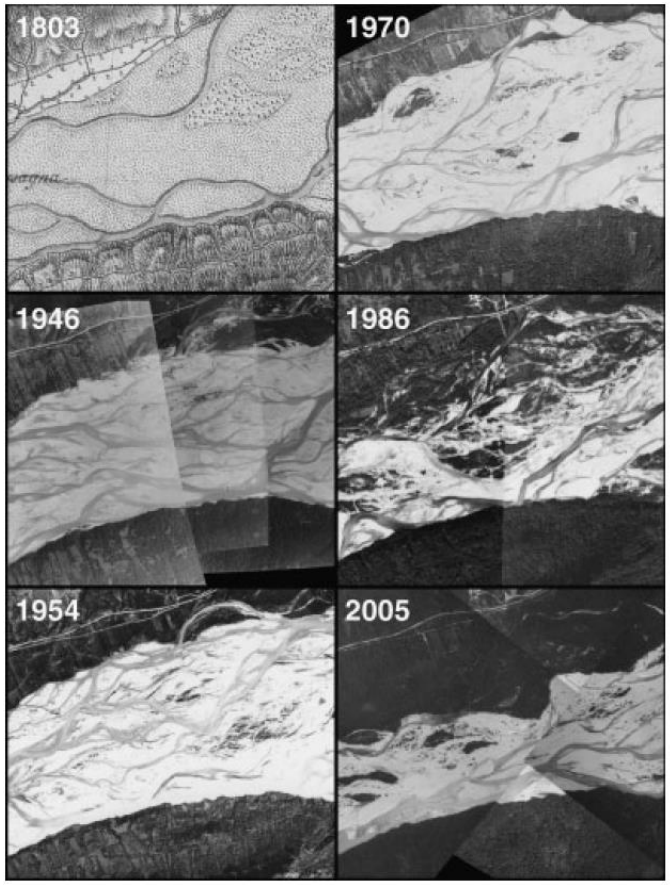
Tagliamento vs. Vjosa
Different climate, biogeography and flow regime





Bertoldi et al, 2009 RRA

Tagliamento also followed trajectories, but established as a «reference system», because it retains «reference processes» or «wild eco-morphodynamic processes»



RIVER RESEARCH AND APPLICATIONS

River. Res. Applic. (2009)

Published online in Wiley InterScience
(www.interscience.wiley.com) DOI: 10.1002/rra.1233

UNDERSTANDING REFERENCE PROCESSES: LINKAGES BETWEEN RIVER FLOWS, SEDIMENT DYNAMICS AND VEGETATED LANDFORMS ALONG THE TAGLIAMENTO RIVER, ITALY†

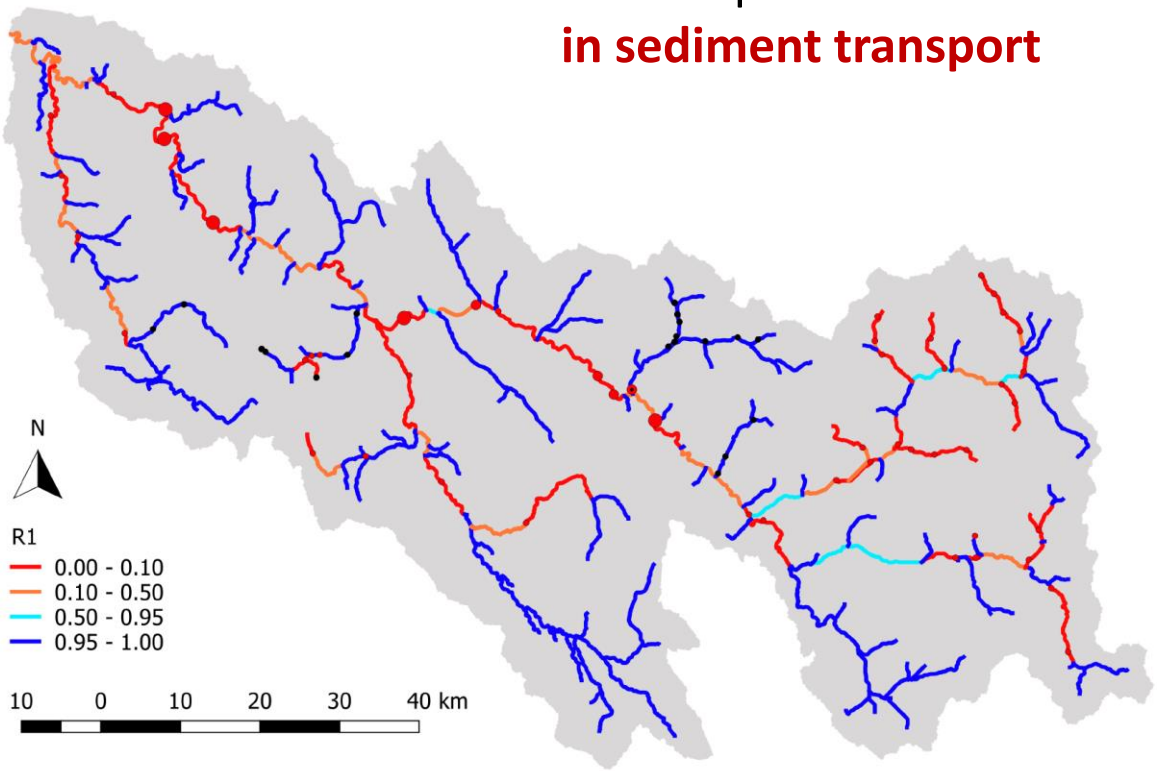
WALTER BERTOLDI,[a] ANGELA GURNELL,[a,b]* NICOLA SURIAN,[c] KLEMENT TOCKNER,[d] LUCA ZANONI,[a] LUCA ZILIANI[c] and GUIDO ZOLEZZI[a]

Future of wild rivers?

Modelling sediment transport at the catchment scale

- CASCADE model (Schmitt et al., 2016)

Reaches with predicted **reduction in sediment transport**



Map of river network with **planned reservoirs**

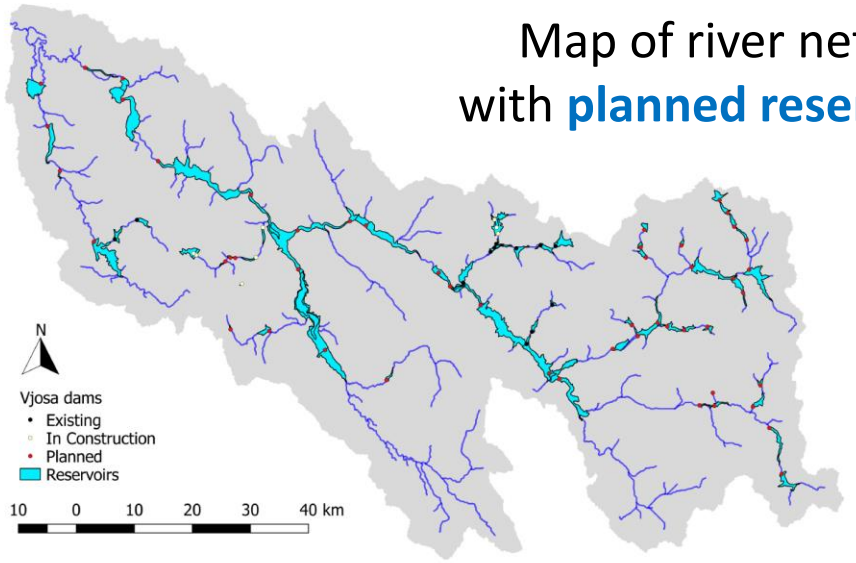


Figure 4.37: Dams and reservoirs in Vjosa catchment. Source: *Berlekamp J. pers. com.*

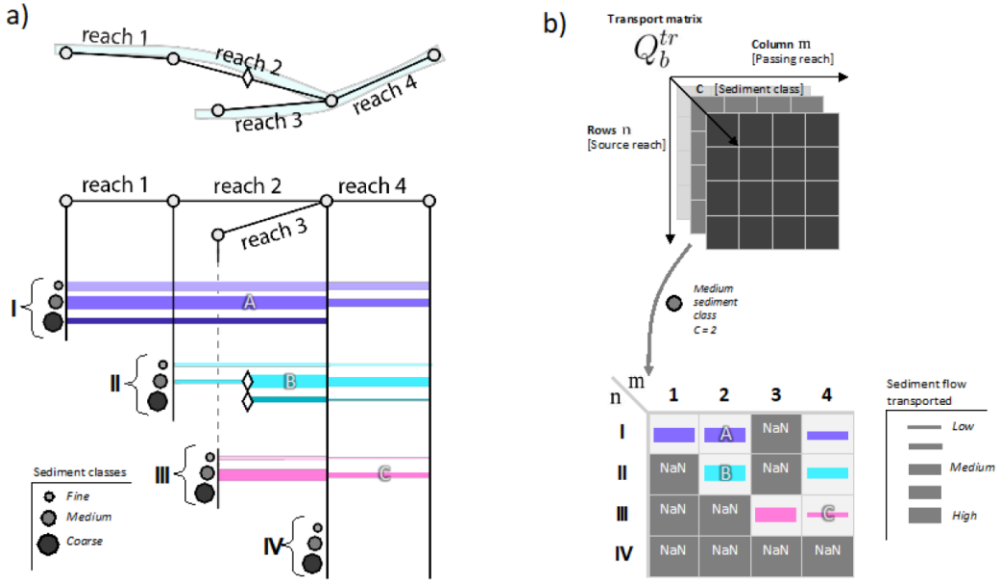
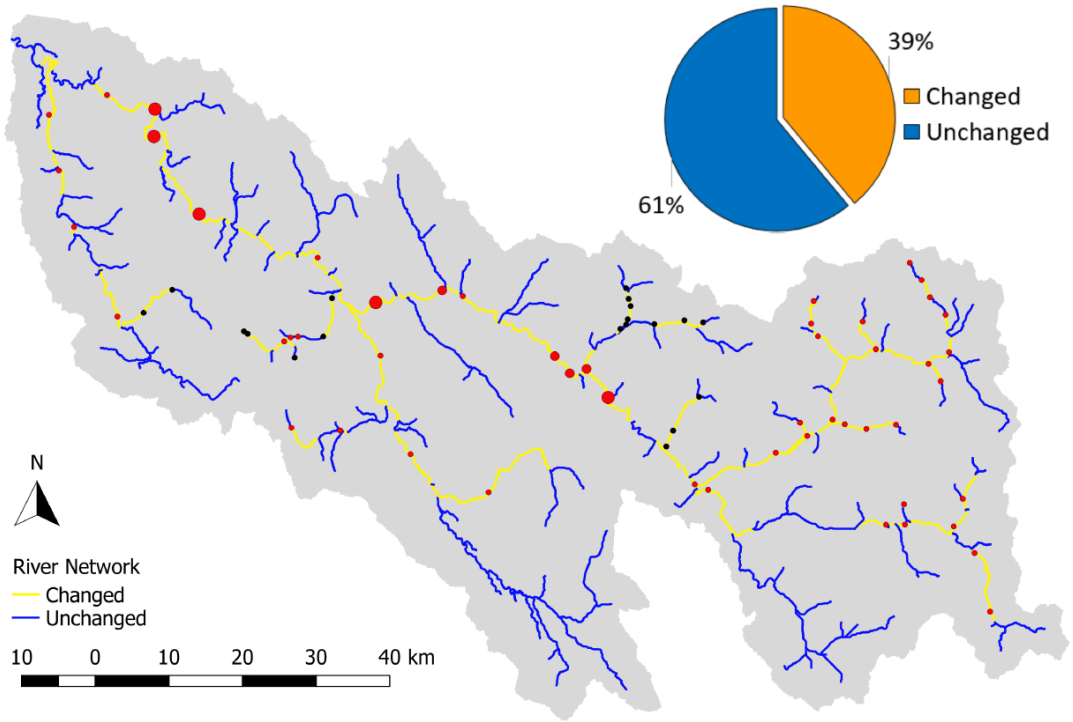


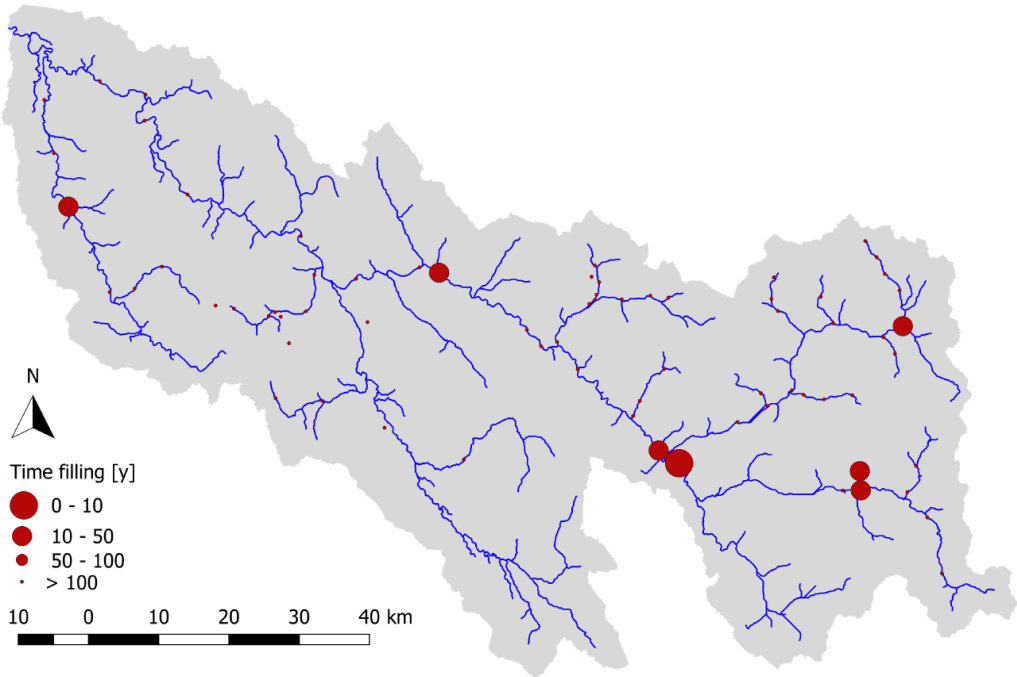
Figure 3.7: Basic structure of multiple grain size (a) and model outputs (b). Source: *Marco Tangi et al. 2019*

Predicted effect of hydropower development at the catchment scale

Predicted reaches with **channel adjustments** because of **reduced sediment transport** due to planned dams (orange)



Reservoirs for which **80% of volume is predicted to be filled** in less than 50 years



Stefani V, 2019, unpub MSc thesis

Synthesis «Wild» rivers (Albania)

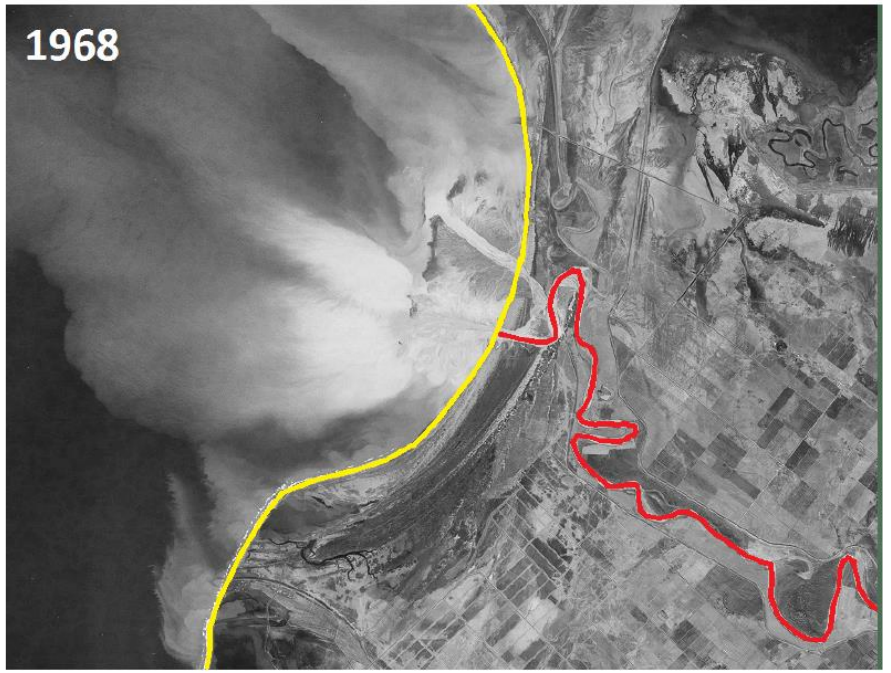
- Highly dynamic river systems
  - Short distance from mountains to sea
  - High gradient ➔ high energy
  - Large sediment transport (gravel and fines)
- Accelerated human stressors on rivers
  - Water abstractions
  - Sediment abstractions
  - Changes in land use (ex. Forrest cutting)
  - Hydropower

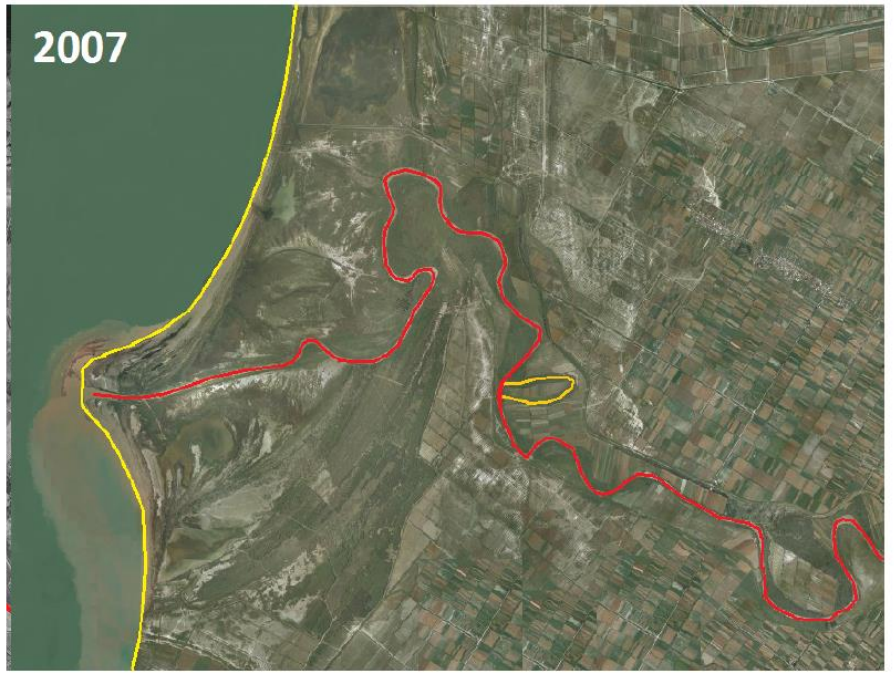
These «wild» rivers can react very rapidly to anthropic changes (hydropower, sediment mining, etc…)

➔coastal dynamics

➔Reduced safety of structures and of human activities

➔Completely altered ecosystem dynamics





Some take home messages

- «Wild rivers» rivers that retain «wild» processes
  - High scientific value: allow understanding and predicting river response to global changes
  - They catalize research interests ➔ relevant knowledge and datasets are rapidly developed
- Several rivers in Albania and in the Balkan area have already been subject to strong hydro-morphological alteration
  - Sediment mining and land-use changes as multiple stressors together with hydropower
- Morphodynamic modelling integrated with remote sensing and field observations offer great opportunities to support river management in conditions of data scarcity
- Eco-morphodynamic trajectories and
- Capacity building: interdisciplinary river scientists and manager

THANKS !!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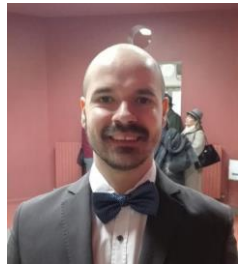
Michele Paderno


Livia Serrao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Vittoria Stefani


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Francesca Benci


Bestar Cekrezi


Francesco Deleo

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Martin Pusch
Marco Tangi
Paolo Molinari

Universities and research centers

United Nations Educational, Scientific and Cultural Organization

UNESCO Chair in Engineering for Human and Sustainable Development

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Eramsus Mundus Joint Doctorate Programme
SMART
Science for MAnagement of Rivers and their Tidal systems

IdroTK
Trentino - Kosovo cooperation for sustainable development

Partners - NGOs

TRENTINO con i BALCANI
ATB Onlus

CELIM
ARTIGIANI DELLO SVILUPPO

CELIM
Impact to Change

VOLONTARIATO INTERNAZIONALE PER LO SVILUPPO
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ALBANIA