Water Scarcity & Drought:

Risk, Management & Mitigation Actions

An Integrated Water Resources Management Approach

Water Resources Planning and Management System in Basilicata Region (Italy)

Experiences and Tools for Drought and Water Crisis Risk Prevention and Environmental Impacts

Interregional River Basin Authority of Basilicata

Athens 24th September 2008

Seminar Topics

Water Resources Management and Planning Tools in Basilicata (Southern Italy)

Hydraulic Infrastructures to Mitigate Water Crisis Risk

Impacts of Climate Changes and Hydraulic infrastructures for water supply on Basilicata River Basins (the erosion of the Basilicata Tyrrhenian and Ionian Coasts)

Interregional River Basin Authority of Basilicata

Italian Public Body involved in water resources and soil defence planning and management in Basilicata and Puglia Regions – Southern Italy

The surface water resources of Basilicata are mainly located in the territory of the River Basin Authority

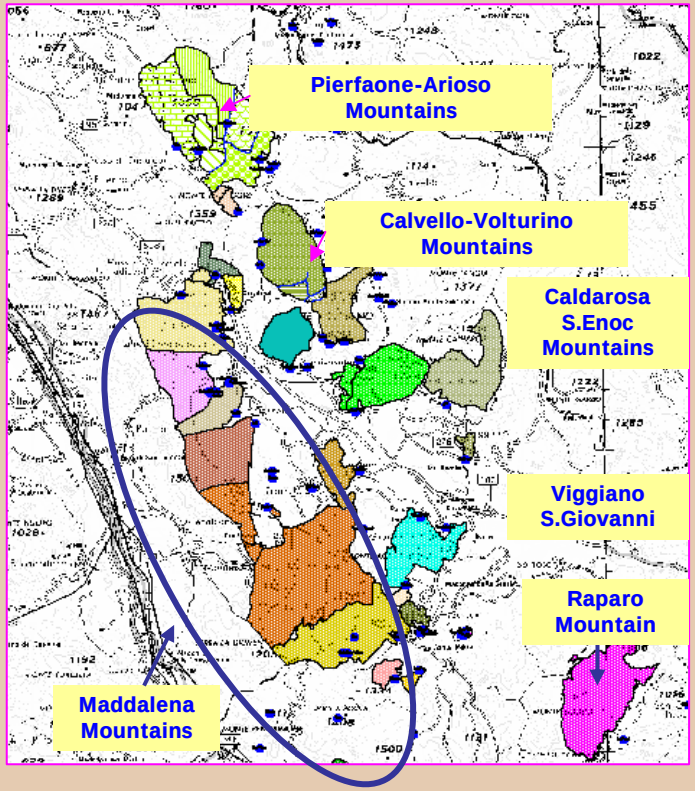
Interregional Basin

- Bradano Basin (Basilicata-Puglia)
- Sinni Basin (Basilicata-Calabria)
- Noce Basin (Basilicata-Calabria)

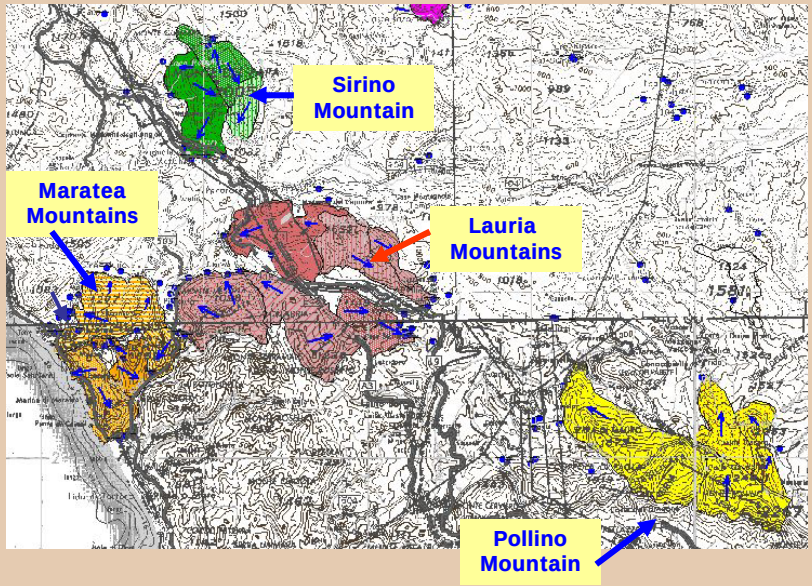
Basilicata Regional Basin

- Basento Basin
- Cavone Basin
- Agri Basin

Main Hydrogeological Structures in Basilicata



Also the Basilicata groundwater resources are mainly located in the territory of Interregional River Basin Authority of Basilicata



The natural distribution of the water resources in Basilicata and Puglia is not even

Water resources for supply of Basilicata and Puglia are mainly located in the western part of Basilicata, whilst high demands and uses of water resources are mainly in the central-eastern part of Basilicata and Puglia (intensive farming and drinking water uses)

Water resources for Basilicata and Puglia supply are mainly surface resources and their availability is due to rainfall

In Basilicata rainfall distribution is not constant in the year

Rainfalls are present mainly in autumn and springs, whilst the summer period is subject to drought

The risk of drought and desertification in Southern Italy and, therefore, in Basilicata is due to natural causes and to human activities

- **Reduction in precipitation (in the last years) mainly in autumn and winter limits surface and groundwater resources availability (this event caused the water crisis for water supplies in Basilicata and Puglia during the period 2001-2004)**
- **Complexity of the hydraulic infrastructures to supply water resources to Basilicata and Puglia due to the great distance between the areas where water is stored (Basilicata) and areas where water is used (Puglia)**
- **Strong development of human activities (mainly agriculture) in Basilicata and Puglia regions has caused a heavy rise in water demands**

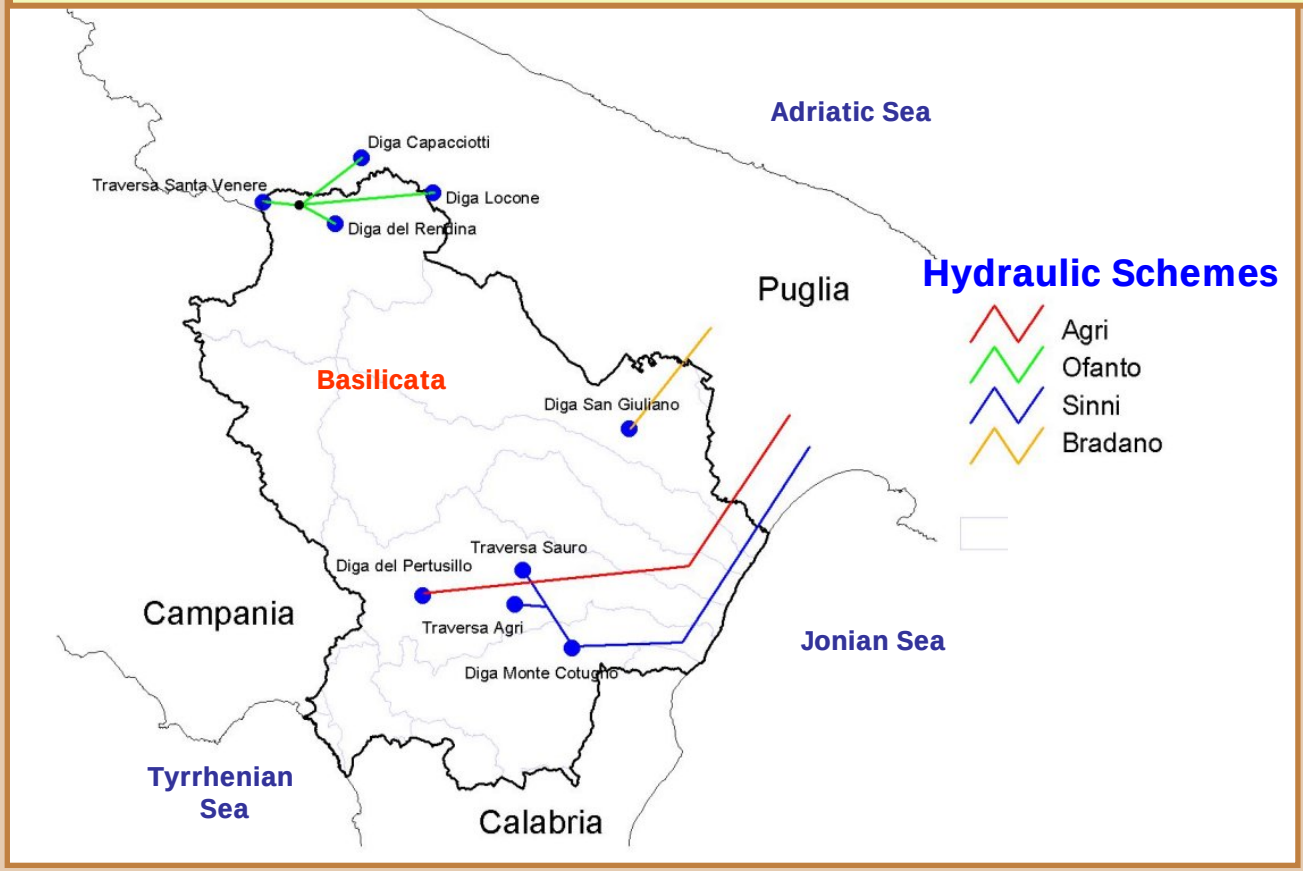
In Southern Italy Drought Events are more frequent in the last decades

In order to guarantee water supply in Basilicata and Puglia regions all over the year and to mitigate water crisis risk, starting from '50 year

Basilicata surface water resources are accumulated through an articulated complex system of hydraulic infrastructures (dams, wires, pipelines)

This system supplies water resources for drinking, industrial and irrigation uses to Basilicata Region but also to neighboring regions in Southern Italy, particularly to Puglia region, where water resources are hardly present

Main Hydraulic Schemes for Water Supply from Basilicata to Puglia



Yearly Supplied Volumes
590 Mmc/y

SINNI SCHEME
300 Mmc/y

AGRI SCHEME
170 Mmc/y

OFANTO SCHEME
80 Mmc/y

Bradano SCHEME
49 Mmc/y

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Main Hydraulic Infrastructures in the Interregional River Basin Authority of Basilicata Territory

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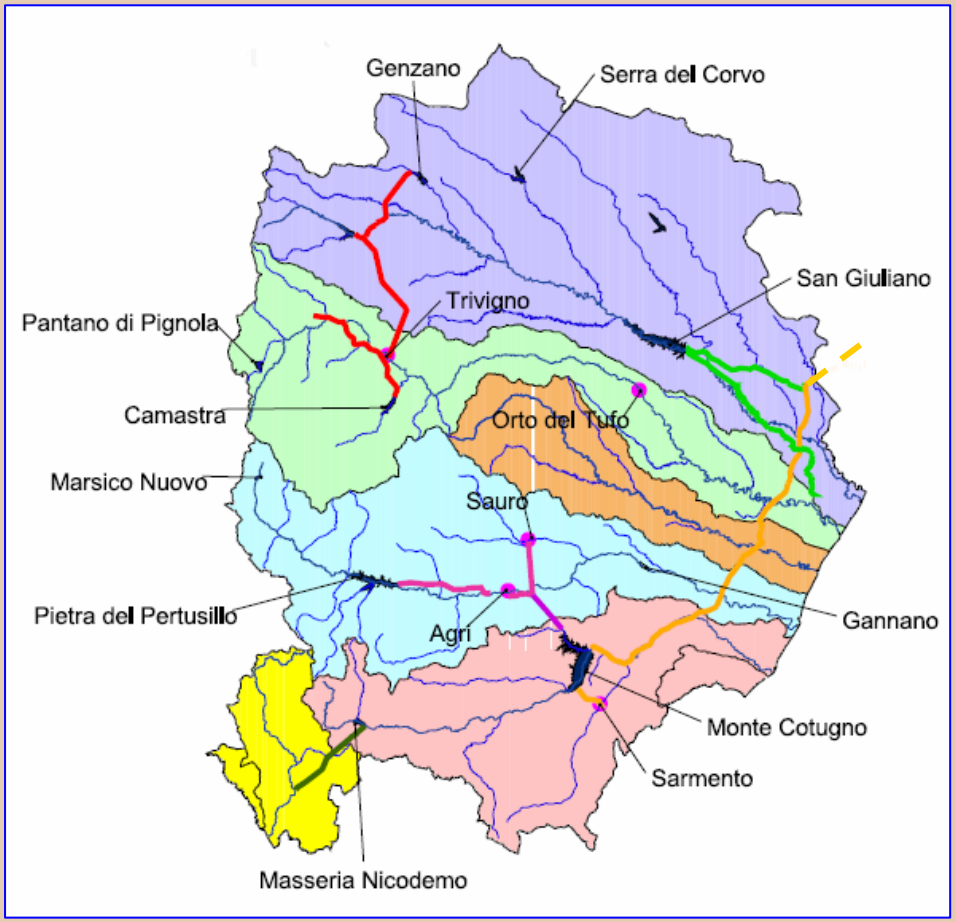


Dams

Weirs

Pipelines

Hydraulic Schemes for Multiple Uses Supplies

Basento-Bradano Scheme

Jonico-Sinni Scheme

Low Bradano Sub-Scheme

Sinni Sub-Scheme

Agri Sub-Scheme

Masseria Nicodemo - Castrocucco Hydroelectric Power Plant

Bradano Basin

Agri Basin

Noce Basin

Cavone Basin

Sinni Basin

Basento Basin

Basilicata Dams and Weirs Technical Data

	Completion year	Use	River	Cachemnt area (km^2)	Capacity (Mmc)	Regulation volume (Mmc)
		Bradano				
Acerenza Dam	1994	Irrigation	Bradano	142	47	38
Genzano Dam	1990	Irrigation	Fiumarella	37	57	52.95
Basentello Dam	1974	Irrigation	Basentello	267	41	28
San Giuliano Dam	1955	Irrigation	Bradano	1631	107	90.13
		Basento				
Pantano Dam	1981	Industrial	Tora		5.5	4.5
Trivigno Weir	1996	Irrigation	Basento			
Camastra Dam	1968	Multiple use	Camastra	350	32	23.6
		Agri				
Marsico Nuovo Dam	1996	Irrigation	Agri	26	7	5.31
Pertusillo Dam	1963	Multiple use	Agri	630	155	142
Agri Weir						
Gannano Weir	1959	Irrigation	Agri	1490		
		Sinni				
Monte Cotugno Dam	1983	Multiple use	Sinni	890	530	433
Sarmento Weir	1982	Multiple use	Sarmento	175.4		
Cogliandrino Dam	1975	Hydroelectric	Cogliandrino	120	12.4	10.1

Subjects Appointed to Water Resources Planning and Management in Basilicata

Regional Council of Basilicata	⇒	**Is responsible for the allocation of water resources among users**
Interregional River Basin Authority of Basilicata	⇒	**1- Is responsible for the evaluation of Water Budget** **2 - Plans water resources sharing between the users (Basilicata and Puglia Regions)**
Authority of Optimum Territorial Ambit of Basilicata	⇒	**Programs and manages Integrated Water Service at regional scale**
Acquedotto lucano	⇒	**Manages the Integrated Water Service at regional scale (water uptake, supply, distribution, wastewater collection and treatment plants)**
Acqua SpA	⇒	**Manages primary water supply and transfer**
Land-reclamation Syndicates	⇒	**Manage irrigation water distribution**

Scientific Support to Water Resources Planning

Basilicata University and Research Centres of Basilicata	⇒	**Characterize physical system and quality-quantity aspects of water resources**

Methodologies to mitigate the Water Crisis Risk in Southern Italy due to climate changes and to hydraulic infrastructures networks deficiencies

- Adoption of advanced processes of governance based on institutional forms of cooperation between local authorities involved in water resources planning and management
- Powerful mechanisms of interregional cooperation for shared water resources planning and management between Basilicata and Puglia Regions ratified by the “Program Agreement on Shared Water Resources”
- Careful evaluation of water resources availability
- Continuous monitoring of hydraulic infrastructures, meteoclimatic parameters and water bodies quali-quantitative characteristics

Water Resources Planning and Management Tools

River Basin Plan for Water Balance and Minimum Vital Outflow

Program Agreement between Basilicata Region, Puglia Region and Italian Government on Shared Water Resources

These Tools

- allow to plan and manage correctly the natural systems and the infrastructures for water distribution taking into account:
  - the water resources availability and the territory characteristics
  - the proper needs for social and economic development process of Basilicata and Puglia regions
- are aimed at ensuring a sustainable, solidarity based use of water resources between the different categories of users within Basilicata region and outside of it, thus settling the existing conflicts between neighbouring regions and different stakeholders

River Basin Plan for Water Balance and Minimum Vital Outflow

arranged by Interregional River Basin Authority of Basilicata at river basin and hydrogeological structures scale

Defines

- Surface and ground water resources availabilities
- Water resource uses, demands and distribution
- Hydraulic infrastructures assessment
- Water Budget (WB) and the its equilibrium conditions
- Rivers Minimum Vital Outflow
- Critical points with respect to the water resource availabilities
- Measures for: the maintenance on WB equilibrium conditions; improvement of hydraulic infrastructure; water saving and reuse of wastewater

Includes

in compliance with UE Directive 2000/60

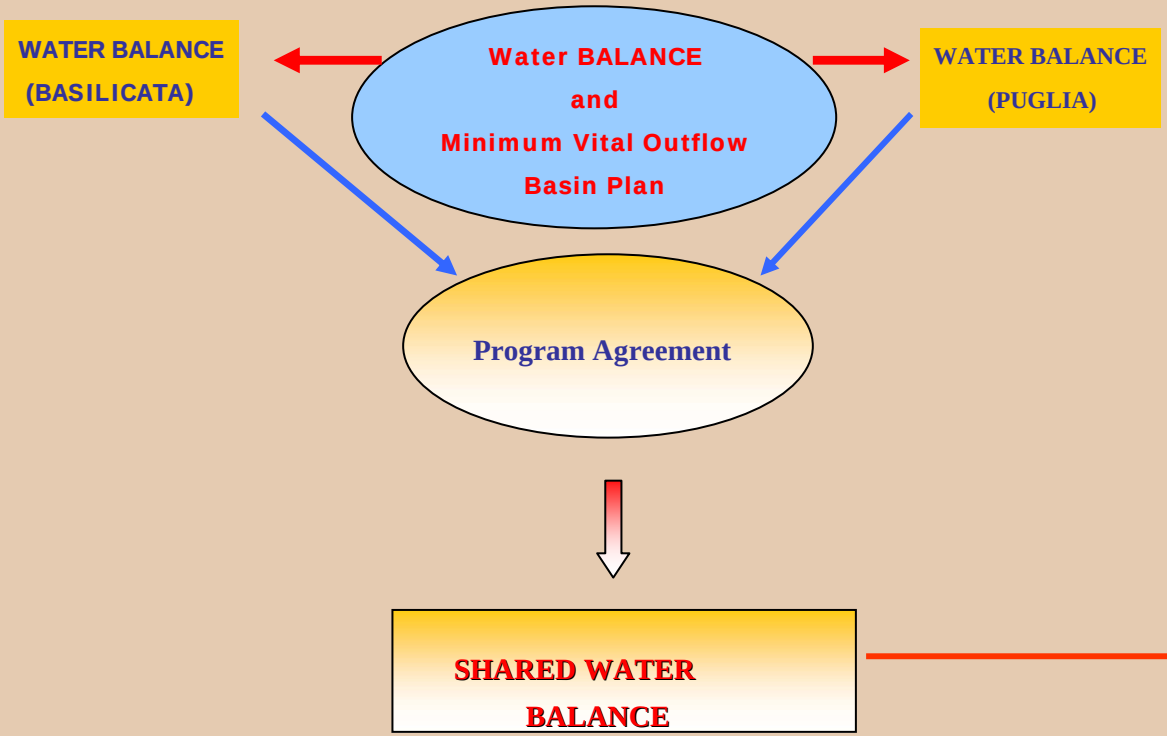
- Water Resources Uses Planning
- Measures for Regulation of Water Derivations
- Measures for Water Bodies Protection

Program Agreement between Basilicata Region, Puglia Region and Italian Government (1999)

Main Purposes

- Assessment of Shared Water Balance between Basilicata and Apulia Regions for planning water resources uses taking into account real availability and proper needs
- Definition of interconnetted hydraulic infrastructures, considered necessary by Basilicata and Puglia in order to ensure water supplies
- Enforcement of permanent coordination tools to develop shared water resources plans, hydraulic infrastructures programs and monitoring actions
- Definition of homogeneous criteria and guidelines for irrigation, industrial and drinking water demand evaluation
- Definition of raw water production costs
- Definition of recovery, recycling and water saving actions

Methodology for the Assessment of Shared Water Balance



Defined Actions

- Water Uses Yearly Programme
- Measures Planning
  - to mitigate water crisis
  - to complete the hydraulic infrastructures systems
- Yearly Raw Water production costs
- Yearly Programme for the utilization of water tariff income

Hydraulic Schemes and Water Balance

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Sinni – Agri Scheme

Uses	Volumes supplied [10^6 m^3/y]	Availability (T=5 y) [10^6 m^3/y]
Drinking	227.54	
Irrigation	246.50	
Industrial	12.60	
MVO	66.65	
Total	553.29	795

Camastra Scheme

Uses	Volumes supplied [10^6 m^3/y]	Availability (T=5 y) [10^6 m^3/y]
Drinking	15	
Irrigation	3	
Industrial	2	
MVO	31,5	
Total	51,5	65

Basento – Bradano Scheme

Total Water Demand 82.37 [$10^6 m^3/y$]

Future Availability (T=5 y) 86.4 [10^6 m^3/y]

Schemes	Hydrostructures	Average Supply (10^6mc/y)	Availability (10^6mc/y)
Basento Camastra	Maddalena M.	7.89	7.40
	Il Monte Marsico Nuovo	0.16	0.70
	Il Monte Peschiera del Pedale	0.59	4.96
	Calvello M. Vulturino M.	3.59	5.64
	Pierfaone M. Arioso M.	4.25	12.3
	Total	16.48	31.00
Agri	Maddalena M.	2.5	5.8
	Total	2.5	5.8
Torbido Maratea	Sirino M.	8.24	28.4
	Lauria M.	1.61	NA
	Maratea M.	16.7	17.47
	Total	26.55	45.87
Frida	Lauria M.	3.82	NA
	Pollino M.	12.82	21.88
	Caramola M.	0.53	NA
	Total	17.17	21.88

Water Resources Managed by Program Agreement between Basilicata and Puglia Regions

WATER SUPPLIES - BASILICATA and PUGLIA REGIONS

REGION	TOTAL (Mmc)	%
BASILICATA	259	43,3
PUGLIA	331	56,7
TOTAL	590	100

WATER SUPPLIES by USES	Mmc	%
DRINKING	311	52,71%
IRRIGATION	258	43,73%
INDUSTRIAL	20,65	3,50%

Example of Yearly Planning for water resources stored in Basilicata dams

Pertusillo Reservoir – Agri River

Capacity 155 Mcm

Water Uses 2007 Programme

Supplies

EROGAZIONI (mc/s)	aprile	maggio	giugno	luglio	agosto	settembre	ottobre	novembre	dicembre	TOTALE
AQP	3,50	3,50	3,75	3,75	3,75	3,75	3,50	3,50	3,50	85.795.200
C.B. Bradano- Metaponto			5,79	5,60	5,60	3,28				53.500.000
TOTALE (mc)	9.072.000	9.374.400	24.720.000	25.044.000	25.044.000	18.220.000	9.374.400	9.072.000	9.374.400	139.295.200

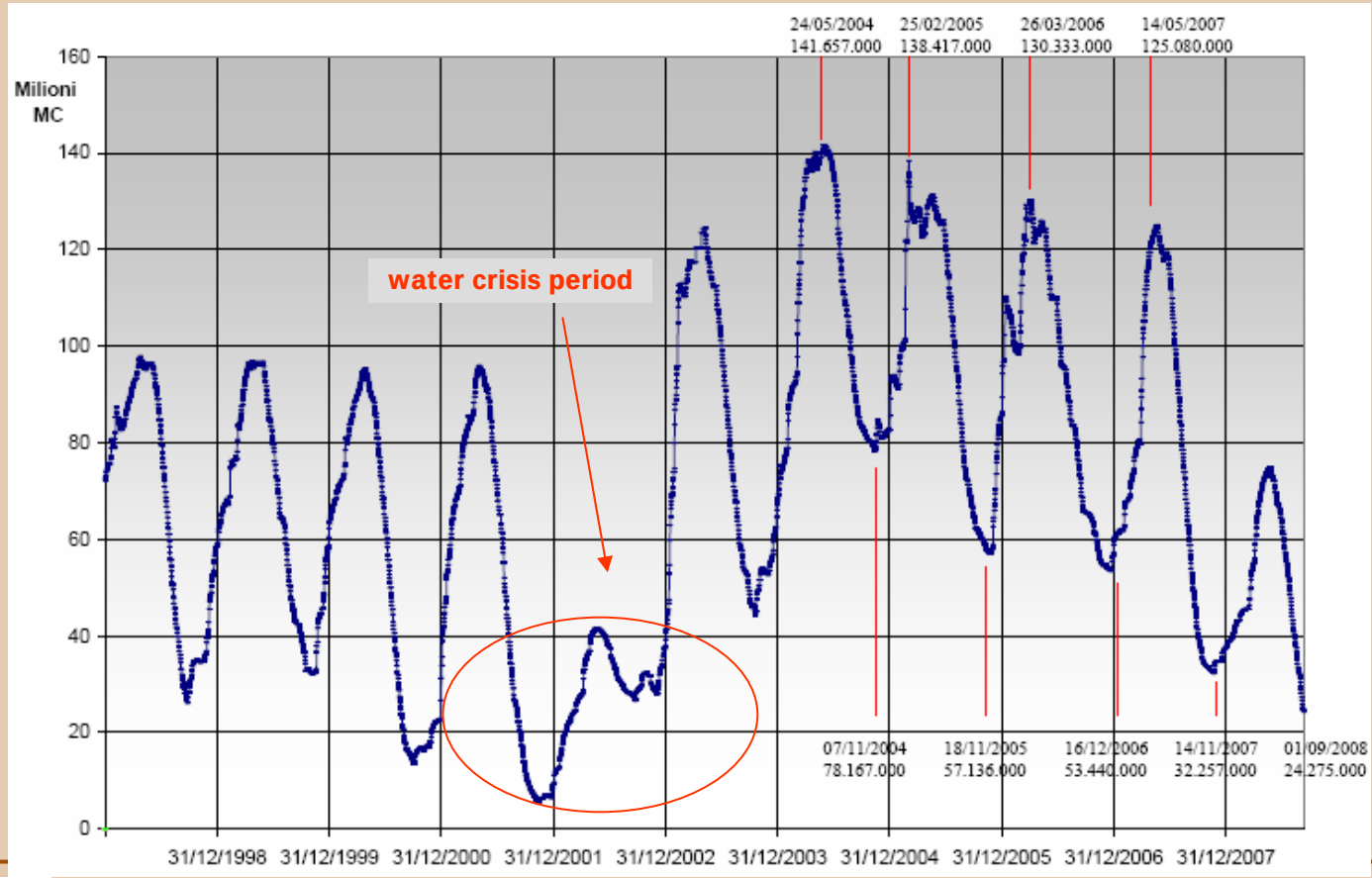
Flows – Forecast Standard Average in 1996-2006 period (the highest values are rejected)

AFFLUSSI	aprile (8,52 mc/s)	maggio (5,39 mc/s)	giugno (2,15 mc/s)	luglio (1,17 mc/s)	agosto (1,32 mc/s)	settembre (2,38 mc/s)	ottobre (4,09 mc/s)	Novembre (5,50 mc/s)	dicembre (9,90 mc/s)	TOTALE
AFFLUSSI MENSILI (mc)	22.082.000	14.449.000	5.561.000	3.129.000	3.547.000	6.174.000	10.949.000	14.255.000	26.766.000	106.912.000

Water Balance

BILANCIO IDRICO	1 aprile	1 maggio	1 giugno	1 luglio	1 agosto	1 settembre	1 ottobre	1 novembre	1 dicembre	1 gennaio
DISPONIBILITA' NETTA (mc)	106.440.000	119.165.049	123.847.049	104.213.130	81.709.231	59.525.182	47.099.247	48.673.847	53.856.847	71.248.447
EROGAZIONE MESE (mc)	-9.072.000	-9.374.400	-24.720.000	-25.044.000	-25.044.000	-18.220.000	-9.374.400	-9.072.000	-9.374.400	
AFFLUSSI MESE	22.082.000	14.449.000	5.561.000	3.129.000	3.547.000	6.174.000	10.949.000	14.255.000	26.766.000	
VOLUME EVAPOTRASPIRATO (ipotesi) (mc)	-284.951	-392.600	-474.919	-588.899	-687.049	-379.935				
DISPONIBILITA' NETTA A FINE MESE (mc)	119.165.049	123.847.049	104.213.130	81.709.231	59.525.182	47.099.247	48.673.847	53.856.847	71.248.447	

Variation of Water Resources Volumes Stored in the Pertusillo Reservoir in 1998 -2008



Hydrological Model - DREAM

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Distributed model for Runoff, Evapotranspiration and Antecedent Soil Moisture Simulation
(Manfreda 2005)

Purposes

- Evaluation of Noce Basin Water Balance
- Definition of the Flow Duration Curves
- Identification of Frequency and Duration of Drought

Aim

Water Resources Management

Model Input

Hydrological Data

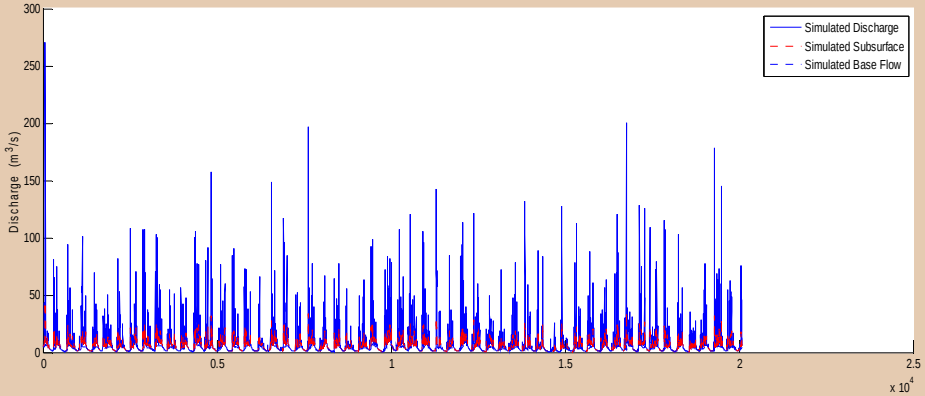
- Raingauges data
- Temperatures
- Water level

River Basin Characteristics

- DEM
- Land use
- Soil texture
- Lithology

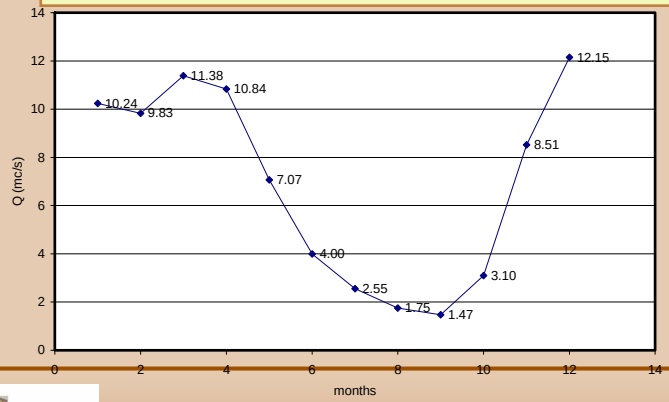
DREAM Model Application
Period 1951-2005

Simulated streamflow at “Le Fornaci” section along Noce river

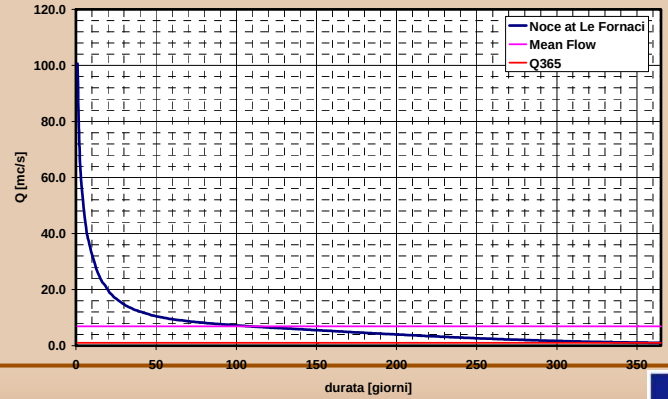


DREAM simulates the surface runoff, the subsurface runoff and the ground water contribution to streamflow

Simulated Average monthly streamflow



Average Duration Curve



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DREAM Model Application
Period 1951-2005

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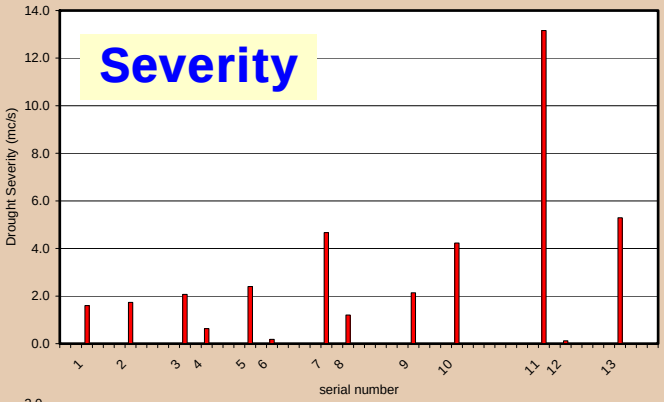
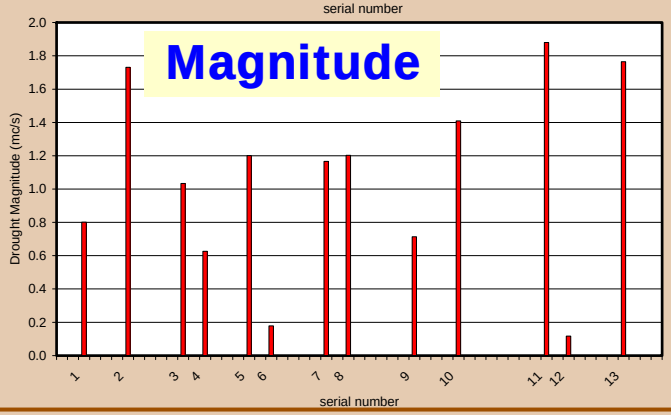
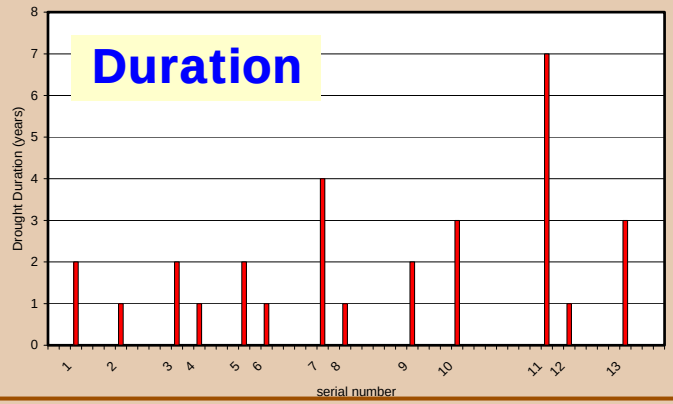
Drought Events derived from the simulated streamflow series at Le Fornaci section along the Noce river



In the Noce river basin the duration of droughts is about 2.6-2.8 years The duration of wet periods is approximately 2.2-2.6 years

The duration and the severity of droughts was observed to increase with time





Meteoclimatic and Quali – Quantitative Water Resources Monitoring Networks

Technical Instruments of Early Warning for Water Crisis in Basilicata

Monitoring system of the civil, industrial and agricultural water uses:

- devices for measuring the capacity of 198 agricultural reservoirs, 100 water pumping stations and 70 water intakes in the Irrigation and Land Reclamation Consortium;
- telemetry of water volumes for irrigation supplied to 59.079 agricultural users;
- telemetry of volumes and discharges of 202 reservoirs and 28 split flows, and of 25 water pumping stations from wells and springs;
- telemetry of 30 water systems for the Potenza and Matera Industrial Areas;
- discharge measuring devices for 17 derivations along the main Sinni pipeline;
- devices for measuring the discharges supplied to Puglia and Calabria Regions by Sinni, Pertusillo and Ofanto pipelines;
- telemetry of water consumptions of 3.816 users and 40 check points in Potenza

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Meteoclimatic and Hydrometric Monitoring Networks

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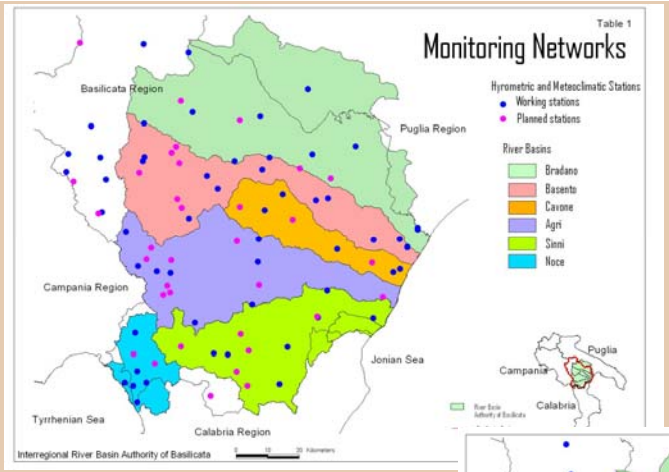
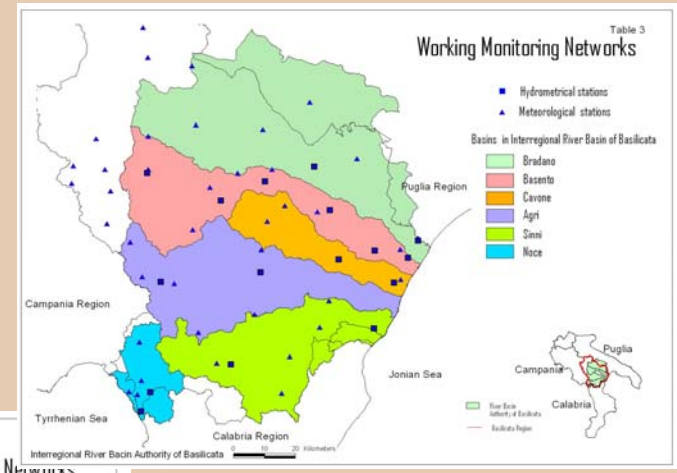
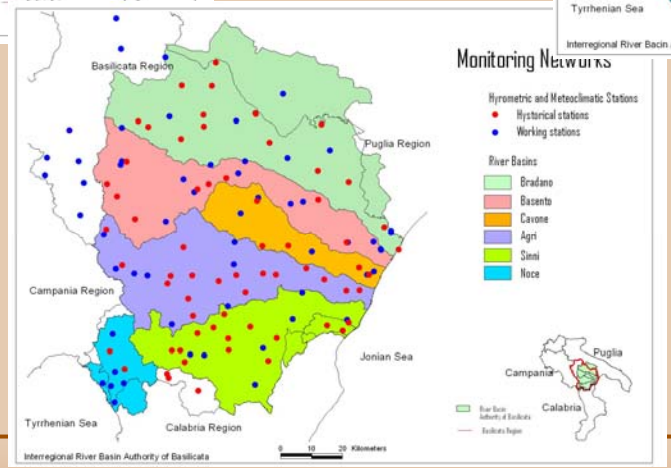
Working and Planned Stations



Working Stations

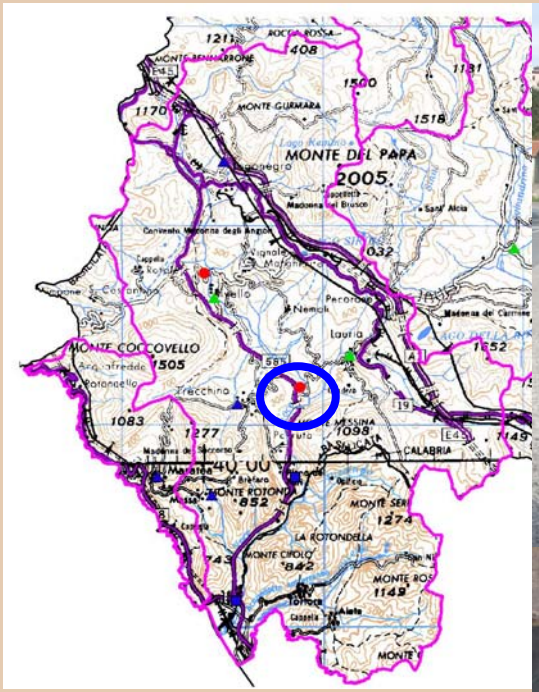




Hystorical and working Stations

Interregional River Basin Authority of Basilicata

Reactivation of the Monitoring Station on the Noce River – Le Fornaci section



Hydrometer

Solar panel

Thermometer

Data acquisition system

Pluviometer

Thermometer

The works for the improvement and management of monitoring networks, hydraulic infrastructures and the measures to mitigate their impacts on river basins are funded by the Italian Government, by Regional Government and by the income of Raw Water Tariff

The Cost Components of Raw Water Tariff

Cost Components of Raw Water Tariff	Incidence
Industrial Costs	25%
Environmental costs	37%
Costs for environmental rebalance	19%
Energetic costs for water pumping stations	19%

1. Industrial costs for management and extraordinary maintenance, due to IWS management;
2. Environmental costs, related to public interest requirements:
   - ➢ costs directed to the realization of:
     - interventions for hydrogeological risk mitigation or prevention;
     - wastewater treatment plants;
     - water bodies and meteo-climatic parameters monitoring networks; hydraulic intervention down to dams;
     - interventions for costal shore protection in order to mitigate the erosion process due to sediment transport reduction;
   - ➢ costs for re-balance between water production and utilization areas
3. energetic costs due to water pumping stations

Repercussions on Environmental Conditions due to rainfall reduction

Causes of the Tyrrhenian Coast Erosion of Basilicata at the Noce river mouth

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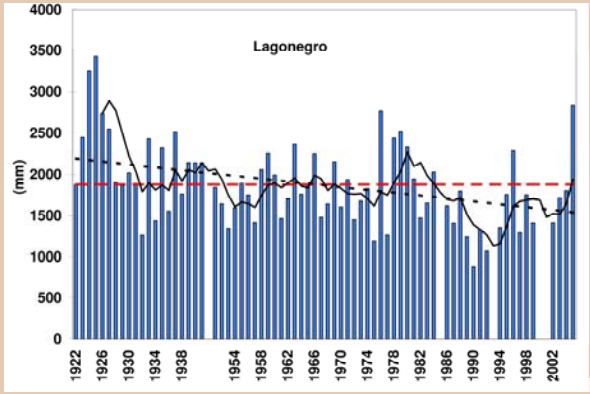
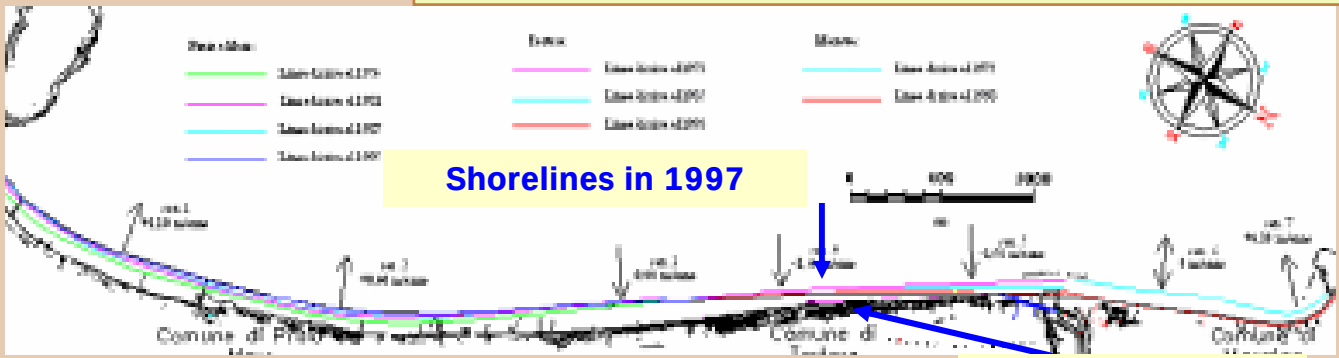
Annual rainfall variations in the period 1921-2007 in the Noce River Basin



long term average
trend line
moving average over 5 years

- River Sediment Transport Reduction
  - Changes in the rainfall amount, beginning from '90, has caused a decrease in the average streamflow of the Noce river (about 13%-15%) and in the sediment transport capacity
  - Protective structure realization in areas under hydrogeological risk (landslides and flooding) in the Noce Basin
  - Sediment extraction in Noce river bed and alluvial strips
- Coast erosion due to sea wave motion and currents



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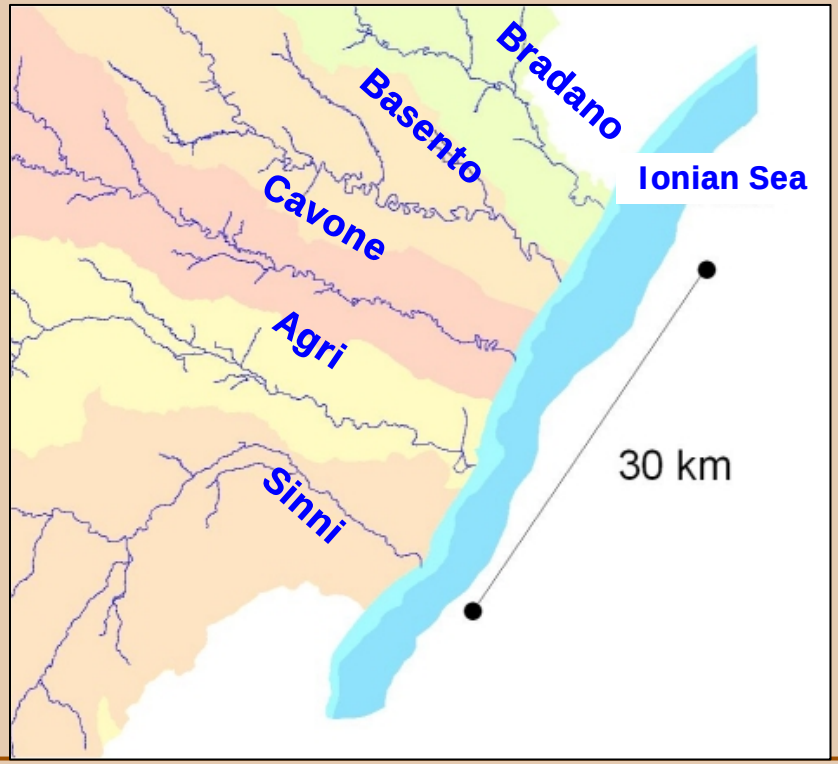
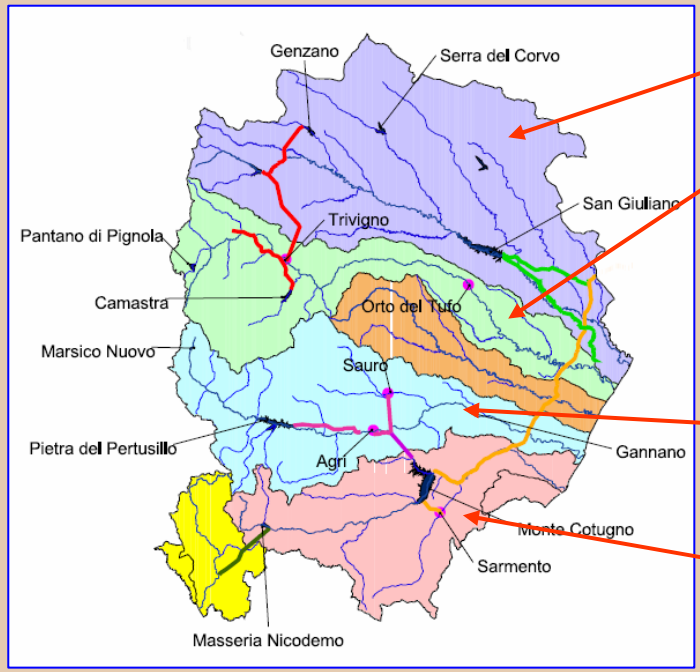
Repercussions on Environmental Conditions of Basilicata River Basin due to Water Resources Uses and to the presence of Hydraulic Infrastructures (dams and weir) on main Basilicata Rivers



The Lucanian Ionian Coast Erosion



Bradano Basin
4 dams

Basento Basin
2 dams
1 weir

Sinni Basin
2 dams
1 weir

Agri Basin
2 dams
1 weir

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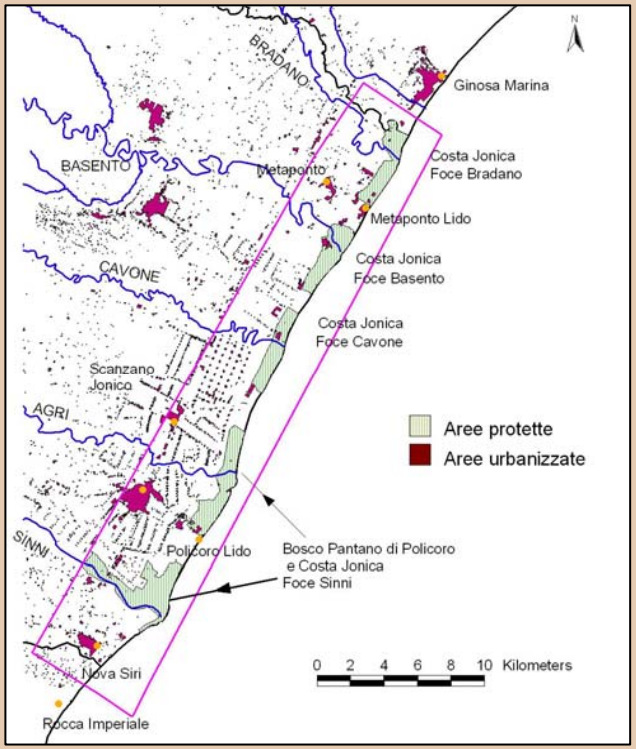
Metaponto Coastal Plain



The Lucanian Ionian Shore is bounded by the Metaponto Plain, an alluvial plain grown on the deltaic systems of the main Basilicata Rivers flowing in the Jonian Sea

Ionian Lucanian Coast Erosion Causes

- **River Sediment Transport Reduction**
  - **Dams and weirs built on river flowing into the Ionian Sea**
  - **Sediment extraction in Basilicata river bed and alluvial strips**
  - **Protective structure realization in areas under hydrogeological risk (landslides and flooding) in Basilicata river basin**
- **Coast erosion due to sea wave motion and currents**

Study Methodology of the Ionian Lucanian Shore Dynamics

Shoreline Reconstruction by maps, aerial photos and satellite images

1949 – IGMI Maps 1:25000
1961 – Images Satellite Corona P - 12/09/61
1984 – Images satellitelLandsat-5 - 19/05/84
1994 – Images Satellite Landsat-5 - 18/07/94
1997 – Aerial Photos Italia
1998 – Images Satellite Spot 4 Xi - 19/02/98, Images Satellite Landsat 5 - 13/07/98
1999 – Images Satellite Landsat 7 ETM - 26/09/99
2000 – Aerial Photos flight 16/11/2000
2001 – Aerial Photos flight 04/04/2001, 15/06/2001, 30/09/2001
2001 – Images Satellite Landsat 7 ETM - 30/08/01
2006 – Aerial Photos flight 14/04/2006
2007 - Laser Scanner Survey

Aerial Photo (2005)

Bradano Mouth

Digital Terrain Model Reconstruction by Laser-Scanner Survey (TOPEYE MKII System)

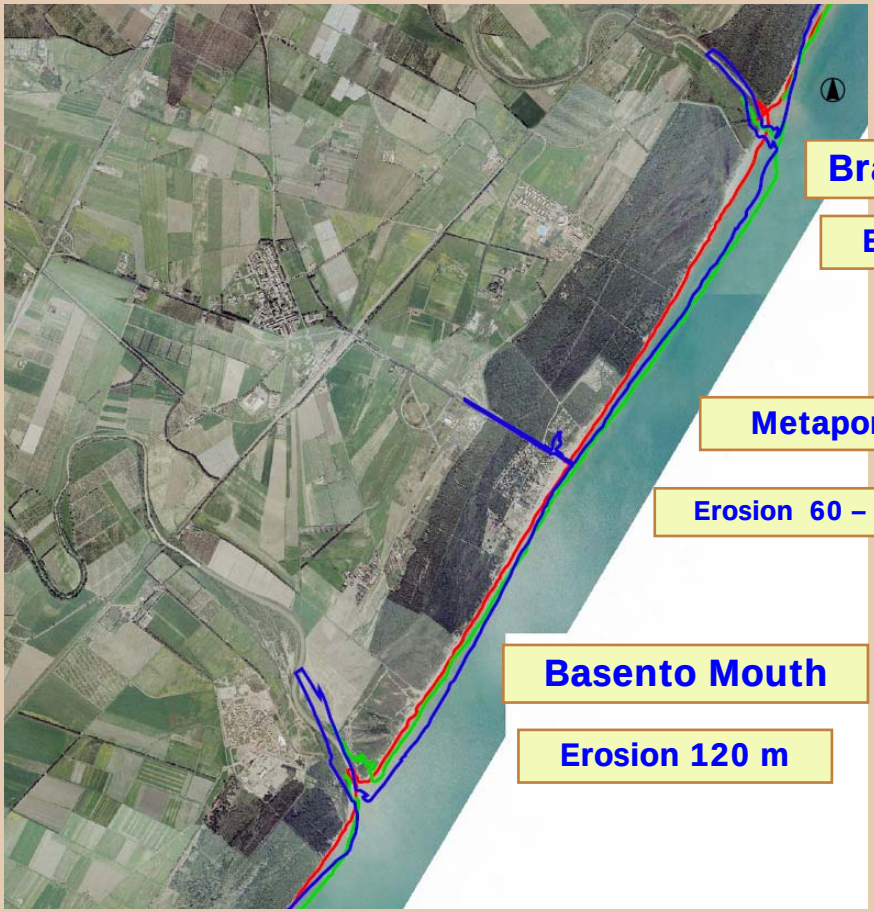
Targets → Analysis of Metaponto Coastal Plain Morphology

Reconstruction of Fluvial and Sea Dynamics

Coast Erosion

1949 - 2006

(after dams and weirs building)



Shoreline

- 2006
- 1961
- 1949

Bradano river: 4 dams

Basento river: 2 dams + 1 weir

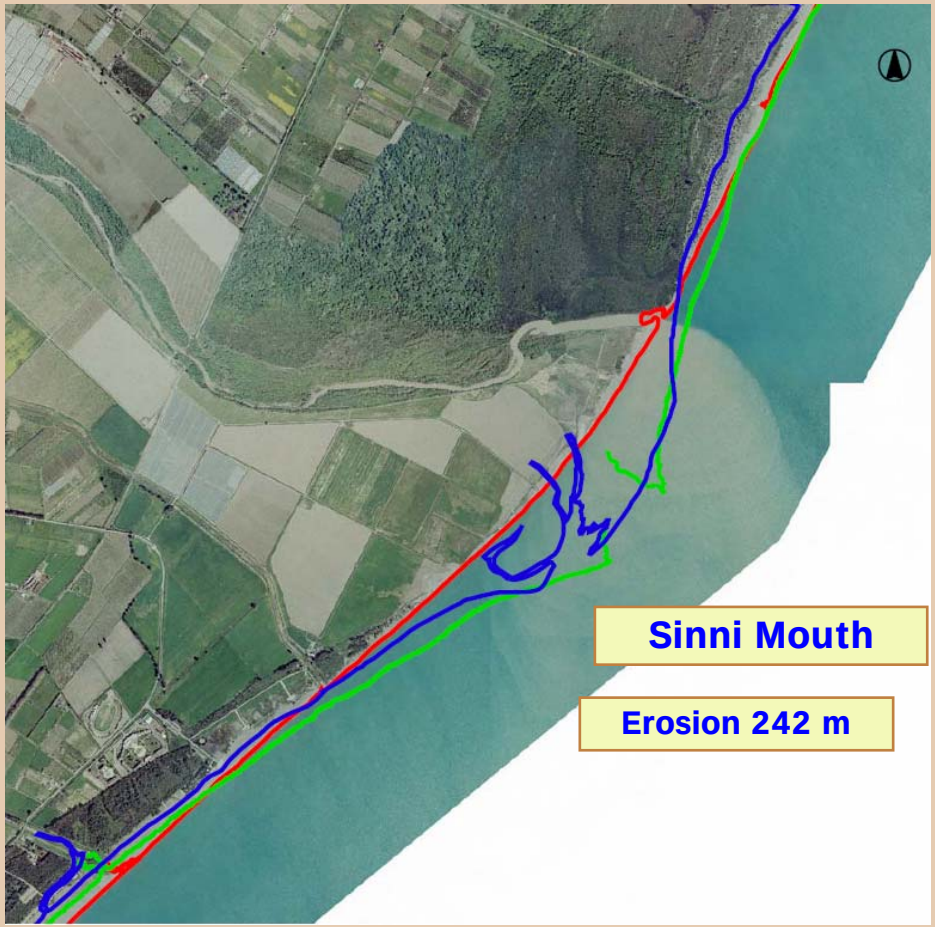
meddman

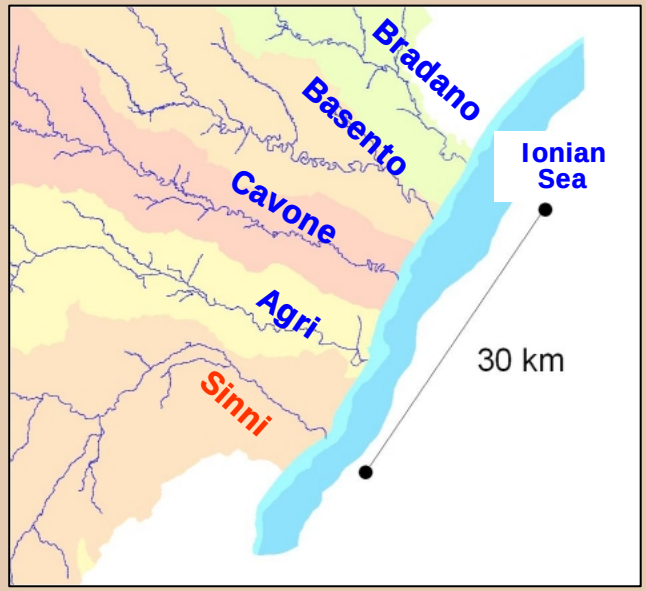
Programme Interreg IIIB
MEDOCC
Pour la cohésion des territoires de l'Europe du Sud
FEDER

Coast Erosion

1949 - 2006

(after dams and weirs building)





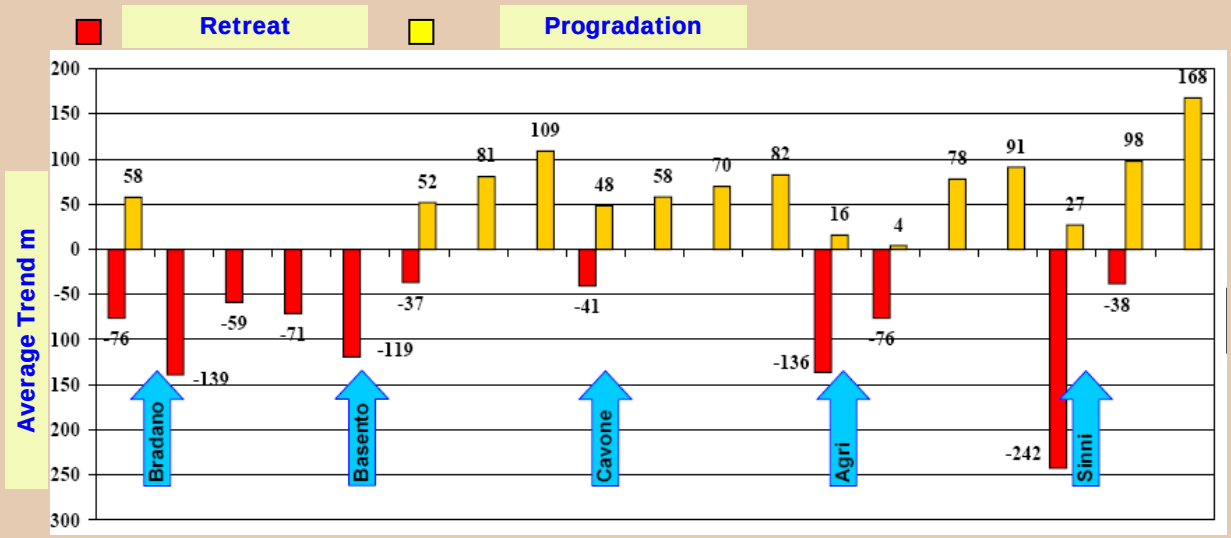
Shoreline

- 2006
- 1961
- 1949

Sinni river: 2 dams + 1 weir

Lucanian Ionian Shoreline Evolution

1949 - 2006



Great shoreline retreat in the river mouth systems after dams and weirs building on the Basilicata rivers flowing into the Ionian Sea

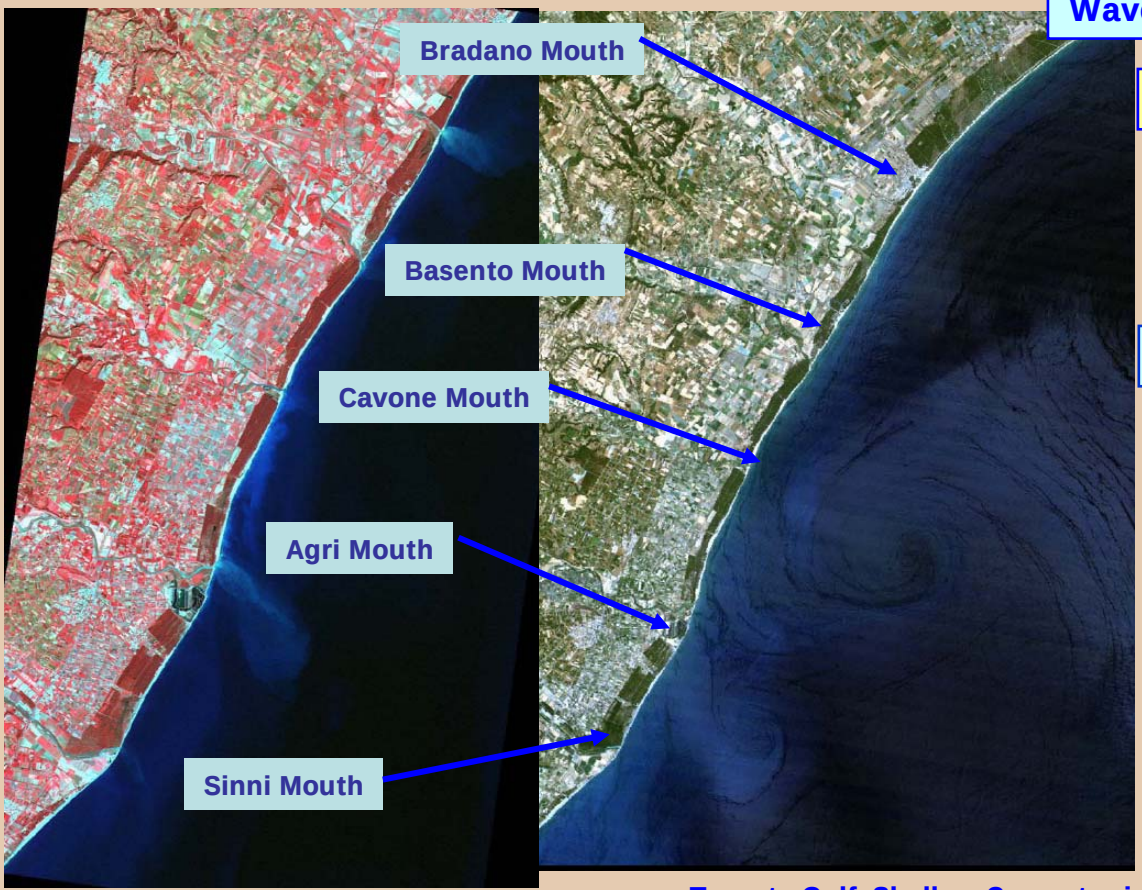
1961-1997

Erosion Peak

→ **Concomitant Causes**

Dams and weirs became operative

Maximum alluvial sediment extraction



Waves motion action + **Long shore currents action**

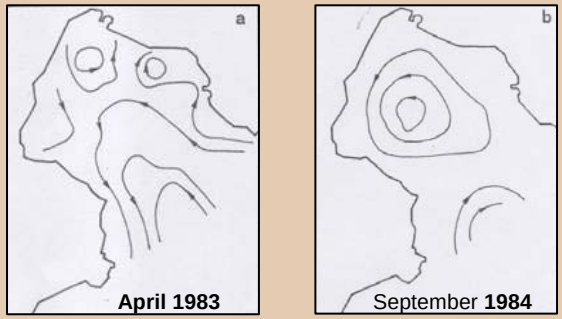
Beach erosion

Sediment Transport long shore
SW – NE Direction

Offshore currents action

Sediment Transport from platform to slope

Sediment capture in Taranto Gulf canyons and transport towards basin



Taranto Gulf Shallow Currents circulation
da Gasparini (1986)

Shore Protective Structures Planning

Priority Survey Activities

- Soil erosion characteristics in the Basilicata River Basins
- River sediment transport and its changes caused by natural phenomena and water uses
- Dams sedimentation
- Sea currents and wave motion action

Monitoring Systems Activation

Sediment Transport – Dams Sedimentation

Wave Motion and Sea Current – Shorelines Evolution

Necessary condition:
Coordination between Regions overlooking the Upper Ionian Shores

- Puglia
- Basilicata
- Calabria

Structural Measures to Mitigate Lucanian Ionian Shores Erosion

Shore Defense Works

- **Structural Works**
- **Maintenance Works**

Works for Dams Desilting → **Targets**

- ➢ Restoration of dams capacity
- ➢ Reactivation of sediment transport down dams

Problems

- ➢ Reduction of water volumes stored in dams
- ➢ Landslides activation

To Sum up

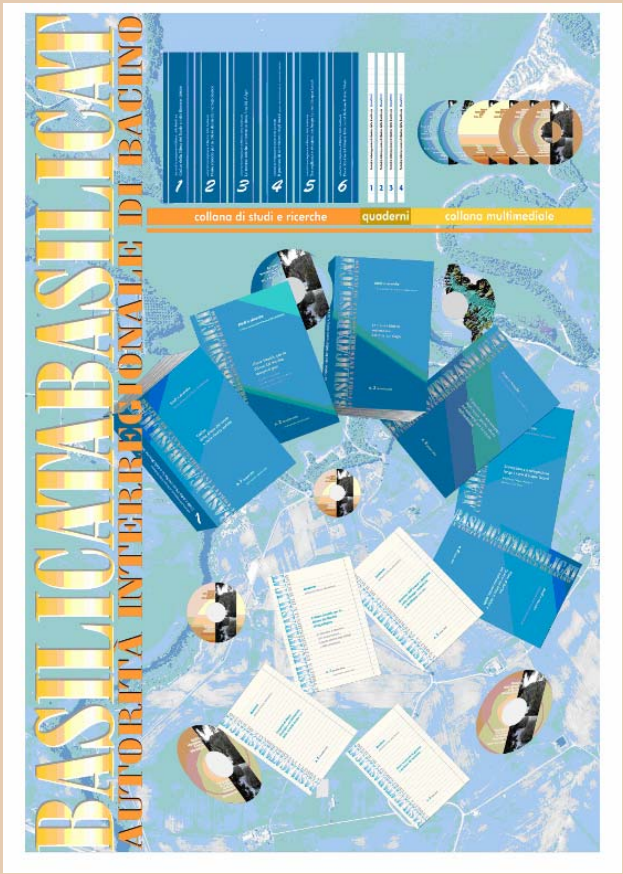
In front of global phenomena, such as changes in climate and desertification, advanced process of governance may limit the water crises

The whole management of water resources will be to respond to new criteria:

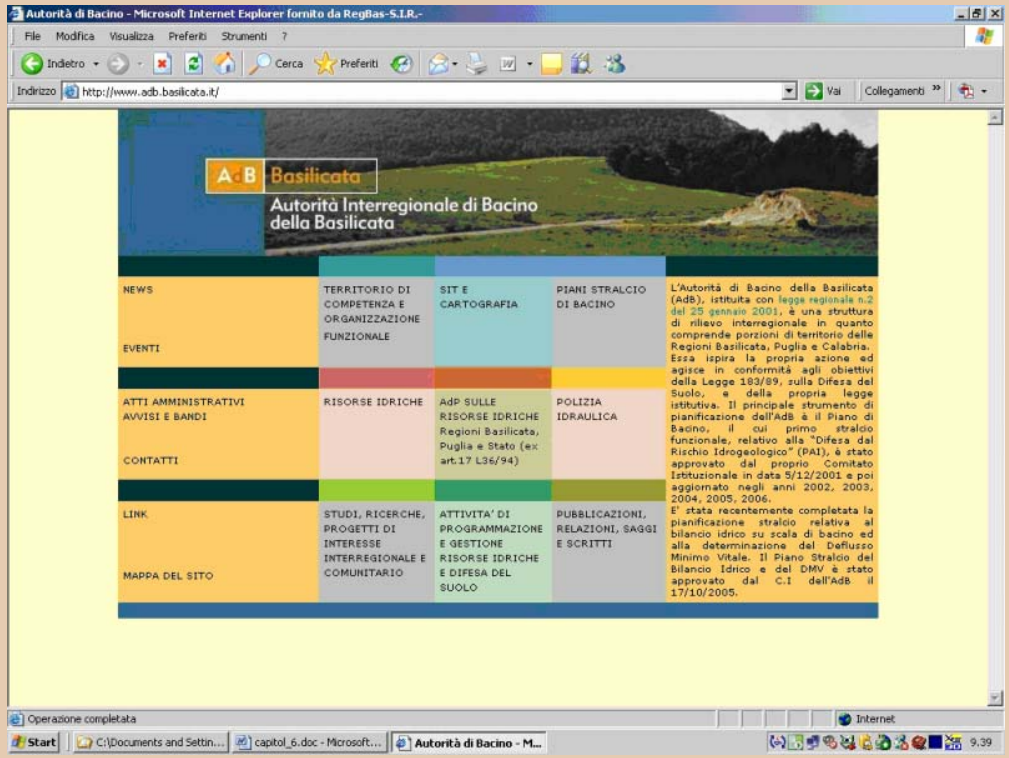
- **Powerful mechanism of cooperation at national, interregional or even international scale in order to share and plan water resources**
- **Monitoring of water resources quality and availability**
- **Monitoring and regulation of water uses (civil, agriculture, industry)**
- **Construction and maintenance of a system of modern infrastructure network and artificial water reservoirs**

The impacts of the climate changes and of the hydraulic infrastructures can be mitigated by structural works and non structural measures funded by national and regional goverments and by the private financing bodies

Interregional River Basin Authority of Basilicata
Communication and Diffusion Tools



Pubblications



Web Site: www.adb.basilicata.it

Thank you for your attention