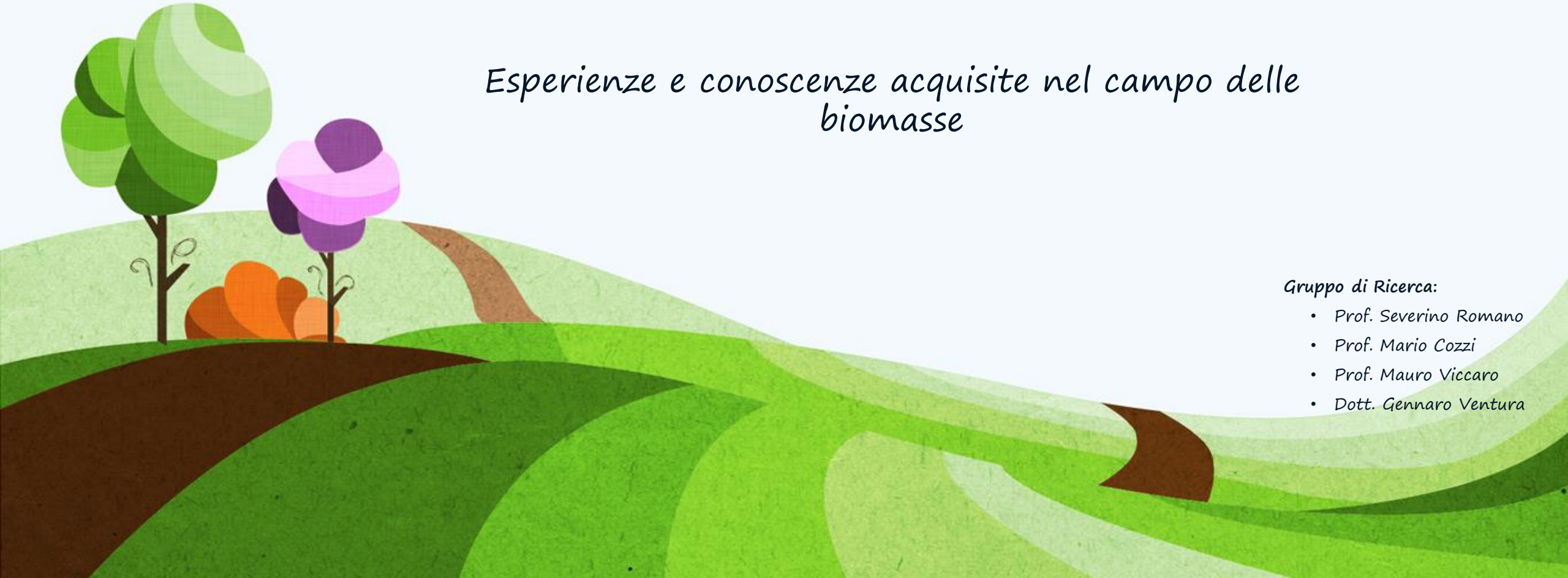
Università degli Studi della Basilicata

Scuola di Scienze Agrarie, Forestali, Alimentari e Ambientali SAFE



Esperienze e conoscenze acquisite nel campo delle biomasse

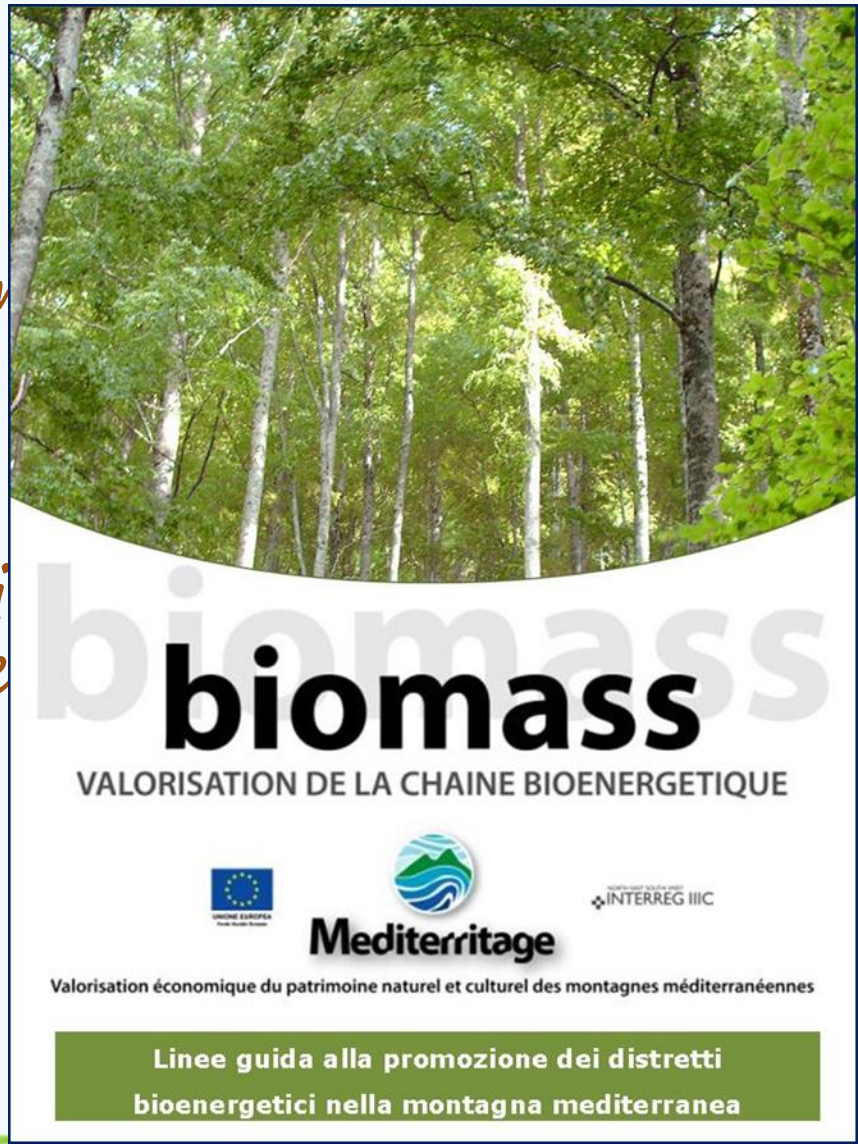
Gruppo di Ricerca:

- Prof. Severino Romano
- Prof. Mario Cozzi
- Prof. Mauro Viccaro
- Dott. Gennaro Ventura

Ricerche e Progetti

Pubblico e Privato

- PROBIO: Le potenzialità di sviluppo delle filiere bioen
  un'area interna della Basilicata
- RAMSES: I Distretti Agroenergetici: Linee Gui
  loro Modellizzazione e Analisi degli Impatti ne
  Rurali
- INTERREG IIIC SUD MEDITERRITAGE:



Ricerche e Progetti

- PROBIO: Le potenzialità di sviluppo delle filiere bioenergetiche in un'area interna della Basilicata

OBIETTIVO

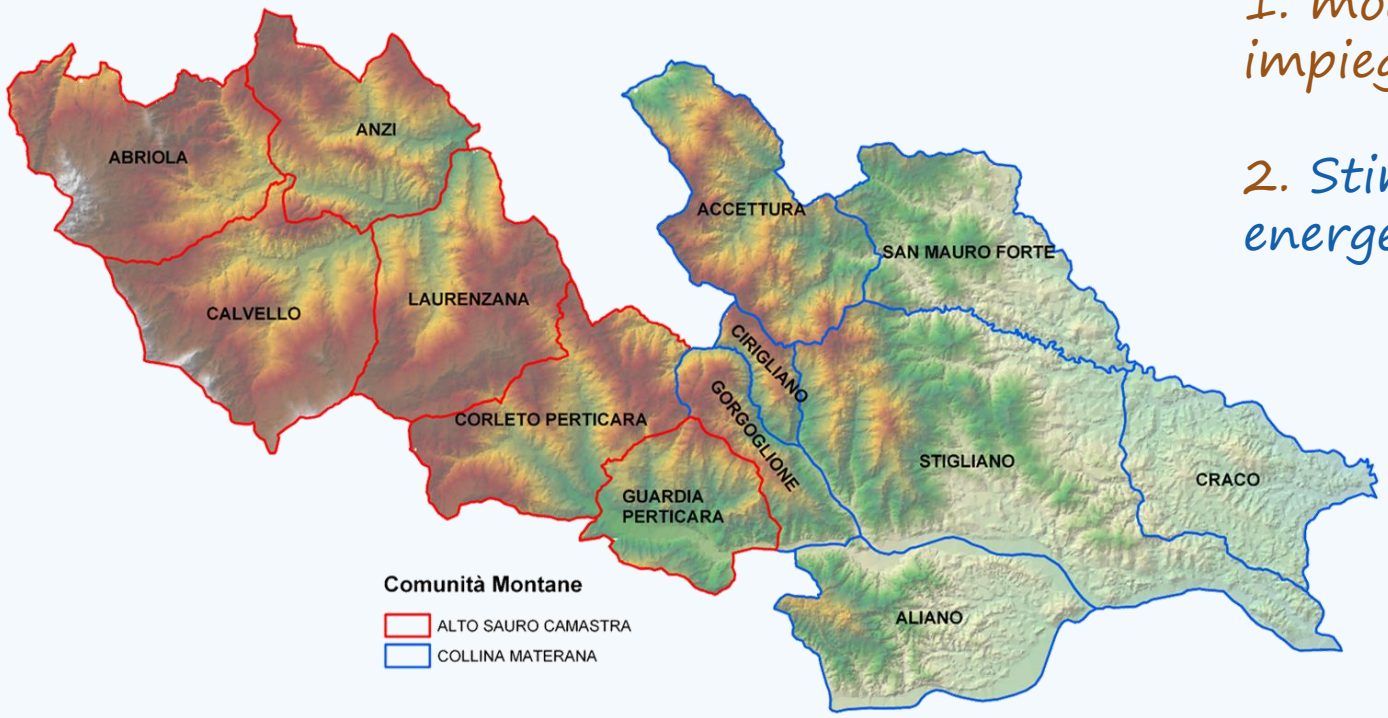
1. promozione di risorse rinnovabili e spazialmente distribuite
2. decentralizzazione delle produzioni energetiche sul territorio

A. Verifica le potenzialità intrinseche di un'area interna della Basilicata

B. Attivazione di reti di imprese locali in grado di produrre bio-combustibili per l'alimentazione di impianti termici ed elettrici

Ricerche e Progetti

- PROBIO: Le potenzialità di sviluppo delle filiere bioenergetiche in un'area interna della Basilicata



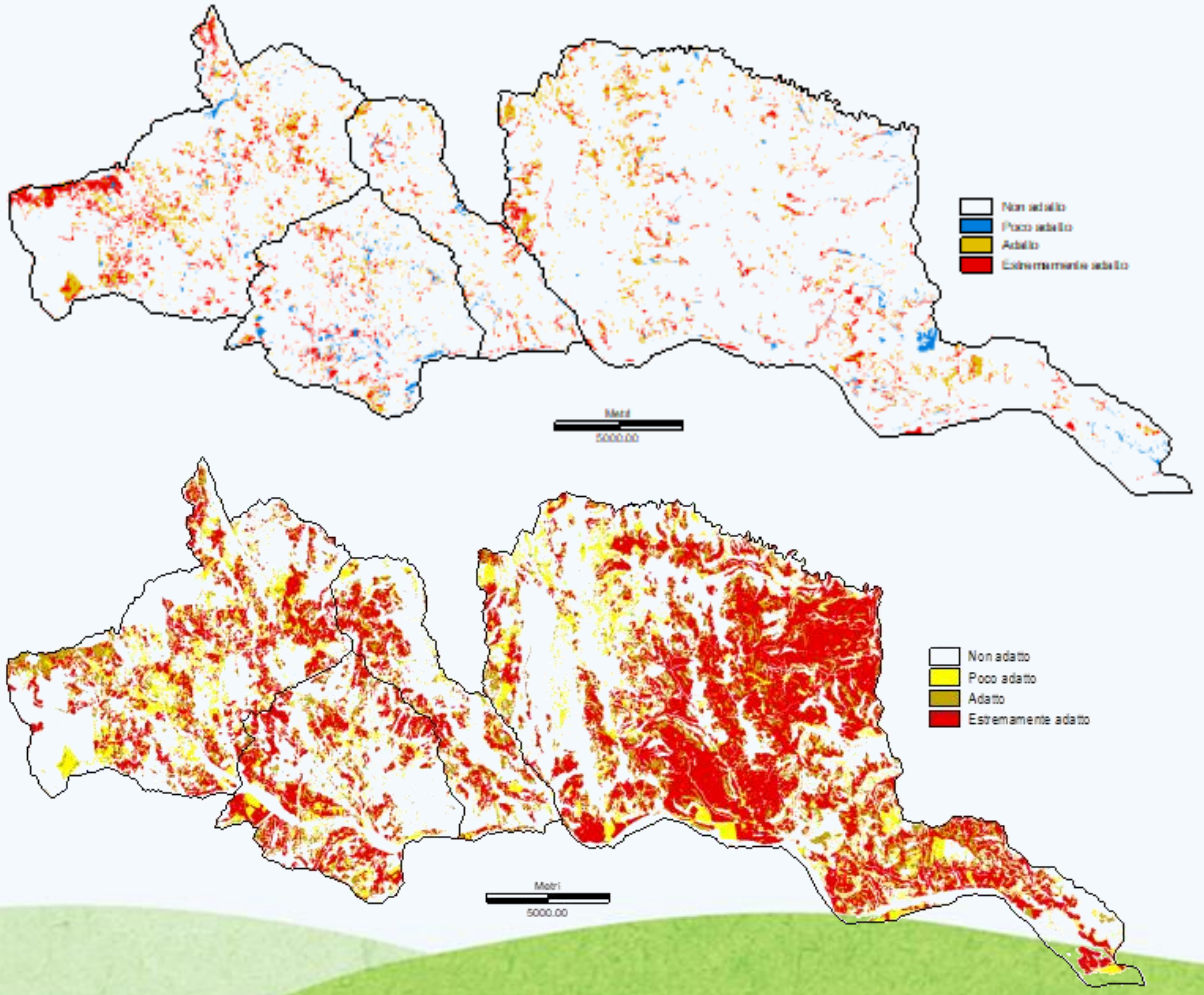
1. modello di Analisi Multicriteriale (AMC) impiegato per la definizione delle aree vocate;

2. Stima della disponibilità di biomasse a fini energetici

   a. Aree agricole;
   b. Aree forestali;
   c. Industrie di trasformazione del legno

Ricerche e Progetti

- PROBIO: Le potenzialità di sviluppo delle filiere bioenergetiche in un'area interna della Basilicata



1. modello di Analisi Multicriteriale (AMC) impiegato per la definizione delle aree vocate alla SRF;

2. Stima della disponibilità di biomasse a fini energetici
   a. Aree agricole;
   b. Aree forestali;
   c. Industrie di trasformazione del legno

Ricerche e Progetti

- PROBIO: Le potenzialità di sviluppo delle filiere bioenergetiche in un'area interna della Basilicata

Stima della disponibilità di biomasse a fini energetici

a. Aree agricole;
b. **Aree forestali;**
c. Industrie di trasformazione del legno

Ricerche e Progetti

- RAMSES: I Distretti Agroenergetici: Linee Guida per la loro Modellizzazione e Analisi degli Impatti nei Territori Rurali

Stima della disponibilità di biomasse a fini energetici

a. Aree agricole;
b. Comparto zootecnico;
c. Aree forestali;
d. Industrie di trasformazione del legno

L'UR ha condotto un'analisi specifica nella valutazione delle disponibilità di tali biomasse, individuando e caratterizzando le seguenti variabili:

1. Le superfici investite;
2. Le produzioni unitarie;
3. I principali impieghi del prodotto.

Ricerche e Progetti

- RAMSES: I Distretti Agroenergetici: Linee Guida per la loro Modellizzazione e Analisi degli Impatti nei Territori Rurali

a) boschi comunali assestati

b) boschi regionali assestati

Specie	Prezzo medio all'ingrosso (Euro/q.le)	
	Legna da ardere	Legname da opera
Boschi di faggio	7,00 – 8,00	9,00 – 9,50
Boschi di quercine	8,00 – 8,50	8,00 – 8,50
Boschi di castagno	-	7,50 – 8,50 (*)
Ostrio carpineti	8,00 – 8,50	-
Boschi igrofili	5,50 – 6,50	10,00 – 11,00
Macchia a leccio	9,00 – 10,00	
Pinete montane	0,50 - 1,00	5,00 – 5,50 (**)
Pinete mediterranee		5,00 – 5,50 (**)

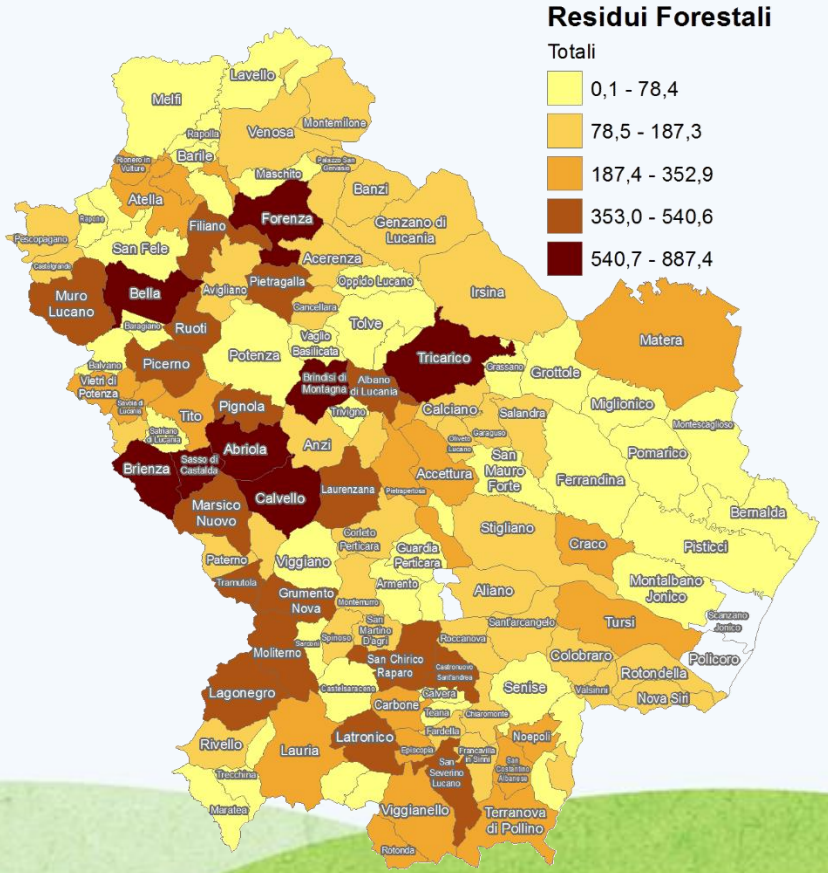
(*) Prezzo medio riferito ad assortimenti per la produzione di paleria.

(**) Prezzo medio riferito a legname da triturazione.

Ricerche e Progetti

- RAMSES: I Distretti Agroenergetici: Linee Guida per la loro Modellizzazione e Analisi degli Impatti nei Territori Rurali

Stima reale utilizzazione



Ricerche e Progetti

- RAMSES: I Distretti Agroenergetici: Linee Guida per la loro Modellizzazione e Analisi degli Impatti nei Territori Rurali

La realizzazione del Sistema Informativo territoriale

1. **La localizzazione geografica delle biomasse disponibili** sia per la componente agricola sia per quella forestale, realizzati attraverso rilievi effettuati in campo, uniti a numerose ricerche bibliografiche;
2. **La localizzazione geografica dei centri di trasformazione della biomassa;**
3. **L'andamento plano altimetrico** (quota e pendenza), ottenute dall'interpolazione del modello digitale del terreno;
4. **La viabilità**, distinta nelle diverse categorie (autostrada, strada statale, strada provinciale, comunale, sentieri, tratturi e mulattiere), al fine di poter attribuire alle tipologie di strada le classi di velocità;
5. **Rilevazioni di campo e confronti con la principale bibliografia nazionale** per la valutazione dei tempi necessari ai mezzi forestali (trattori) ed ai camion, relativamente alle fasi di carico/scarico e trasporto del materiale legnoso;
6. **Individuazione del percorso a minimo costo**.

Ricerche e Progetti

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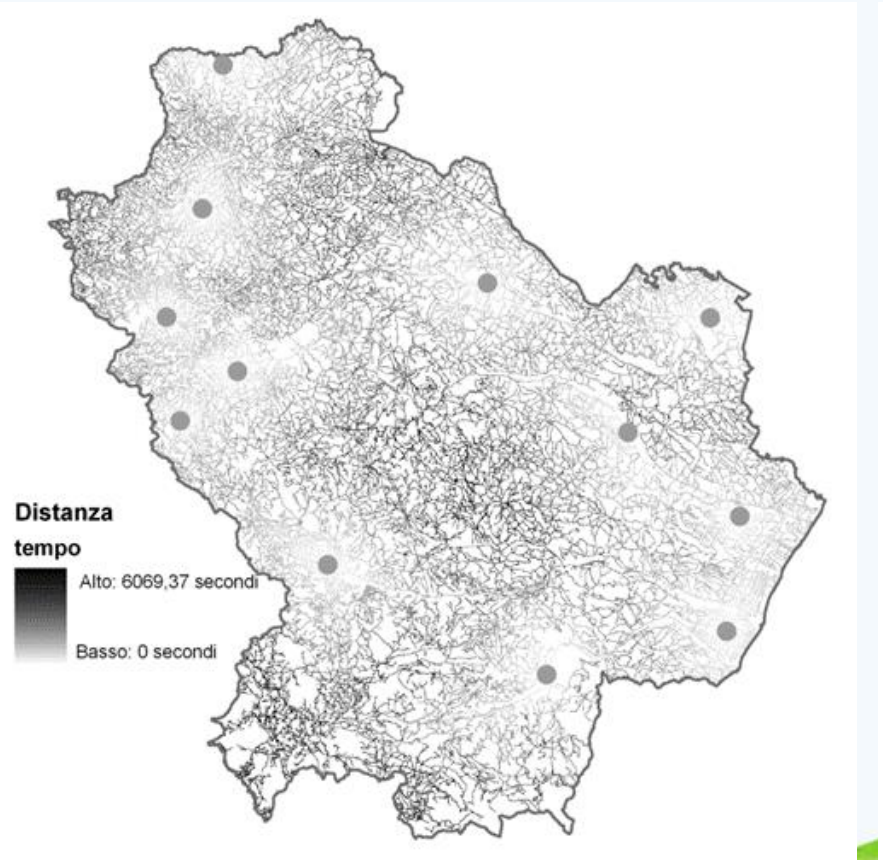
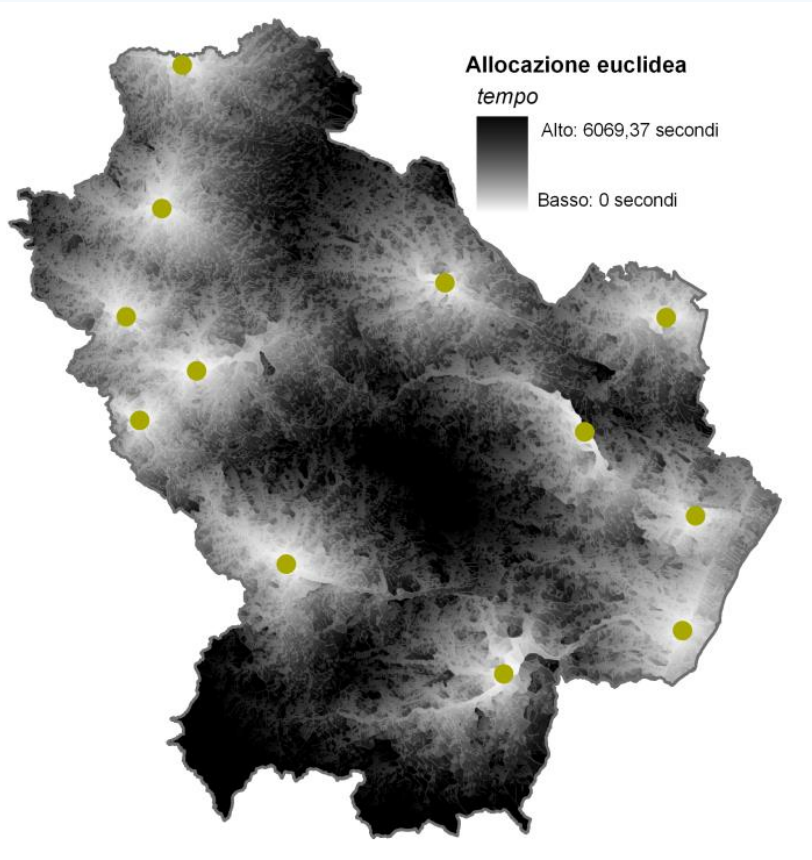
La realizzazione del Sistema Informativo territoriale

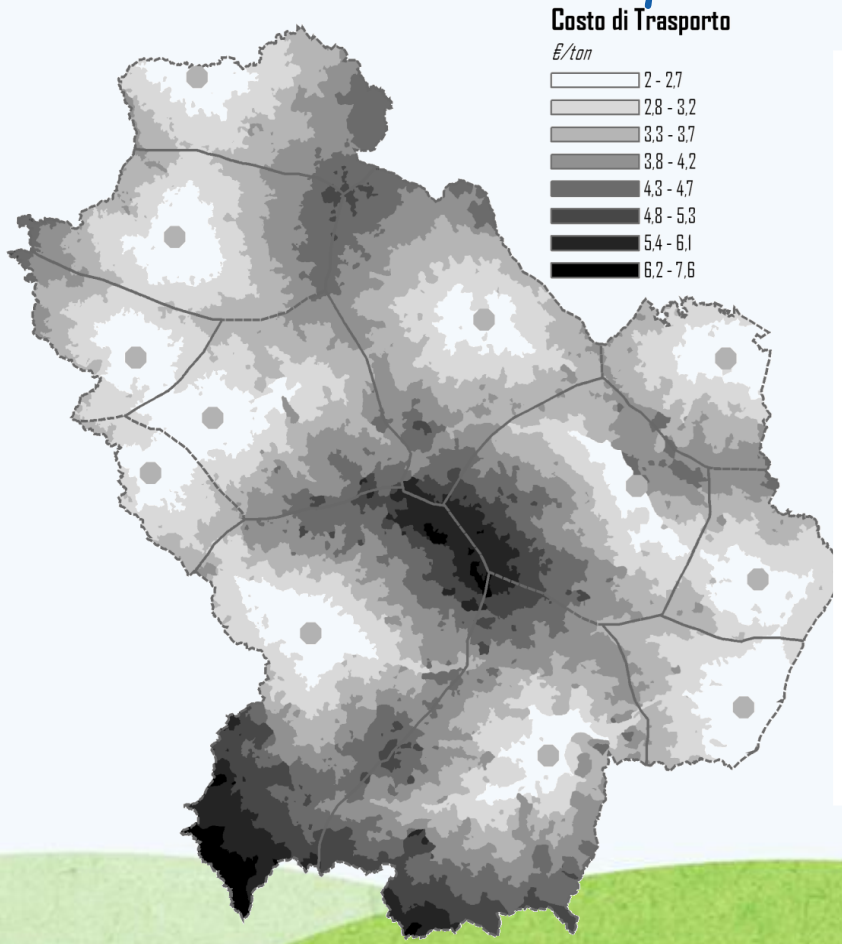


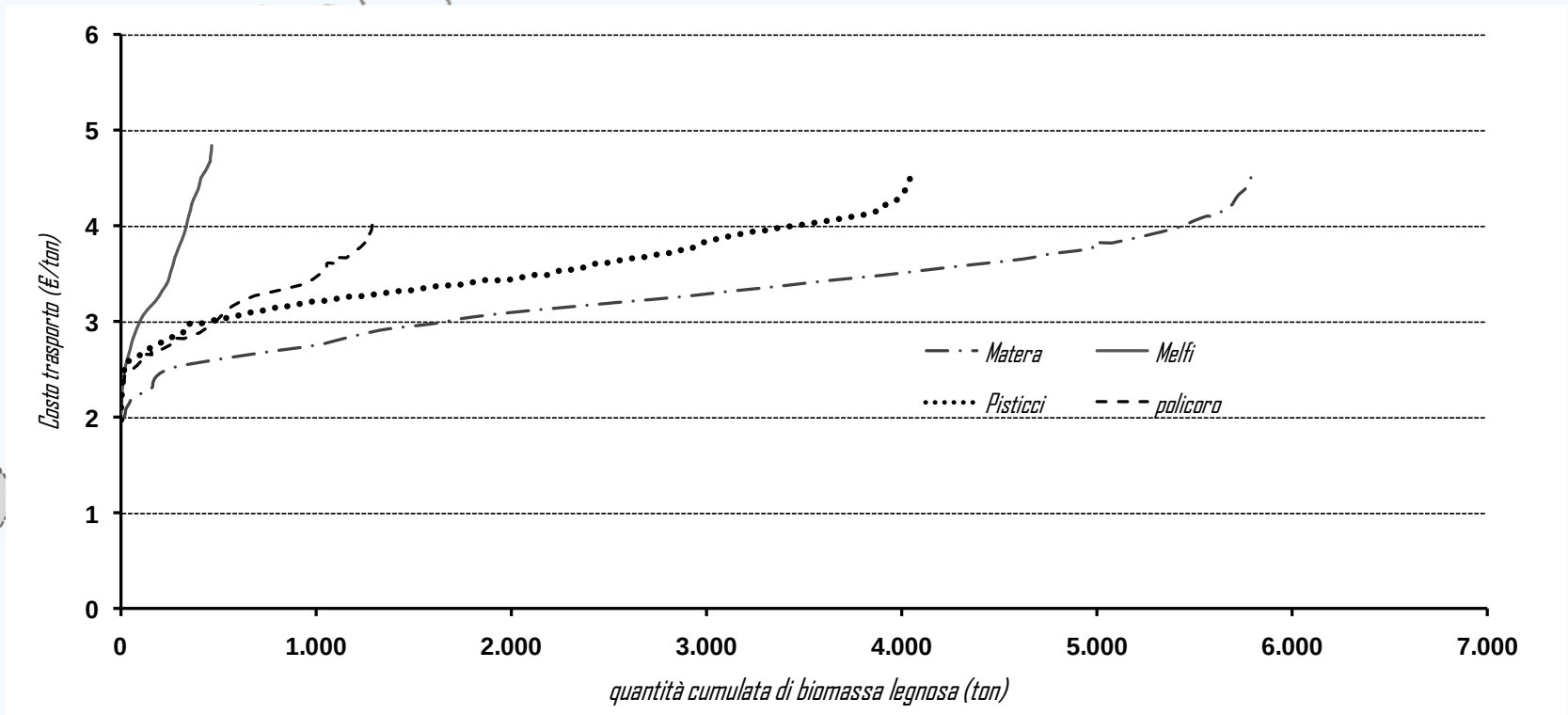


Ricerche e Progetti

- RAMSES: I Distretti Agroenergetici: Linee Guida per la loro Modellizzazione e Analisi degli Impatti nei Territori Rurali

L'analisi dei costi di trasporto della biomassa





Ricerche e Progetti

- RAMSES: I Distretti Agroenergetici: Linee Guida per la loro Modellizzazione e Analisi degli Impatti nei Territori Rurali

L'analisi dei costi di trasporto della biomassa

Bacino di approvvigionamento	Disponibilità totale di biomassa	Disponibilità di biomassa sotto i 5€	Variazione	Costo medio di trasporto
	ton	*ton*	*ton*	*€/ton*
Atella	13.615,87	13.615,87	-	3,611
Baragiano	6.847,97	6.847,97	-	2,821
Ferrandina	16.838,33	13.215,00	-3.623,33	4,008
Irsina	25.185,78	24.307,00	-878,78	3,761
Matera	5.798,91	5.798,91	-	3,303
Melfi	461,96	461,96	-	3,562
Pisticci	4.045,4	4.045,4	-	3,523
Policoro	1.290,62	1.290,62	-	3,185
Satriano	10.107,91	10.107,91	-	3,060
Senise	30.810,98	28.725,00	-2.085,98	3,884
Tito	12.636,58	12.636,58	-	3,399
Viggiano	84.802,51	70.193,00	-14.609,51	3,685

Ricerche e Progetti

Fattibilità economica per la produzione di biogas derivante dalla trasformazione dei residui agroforestali

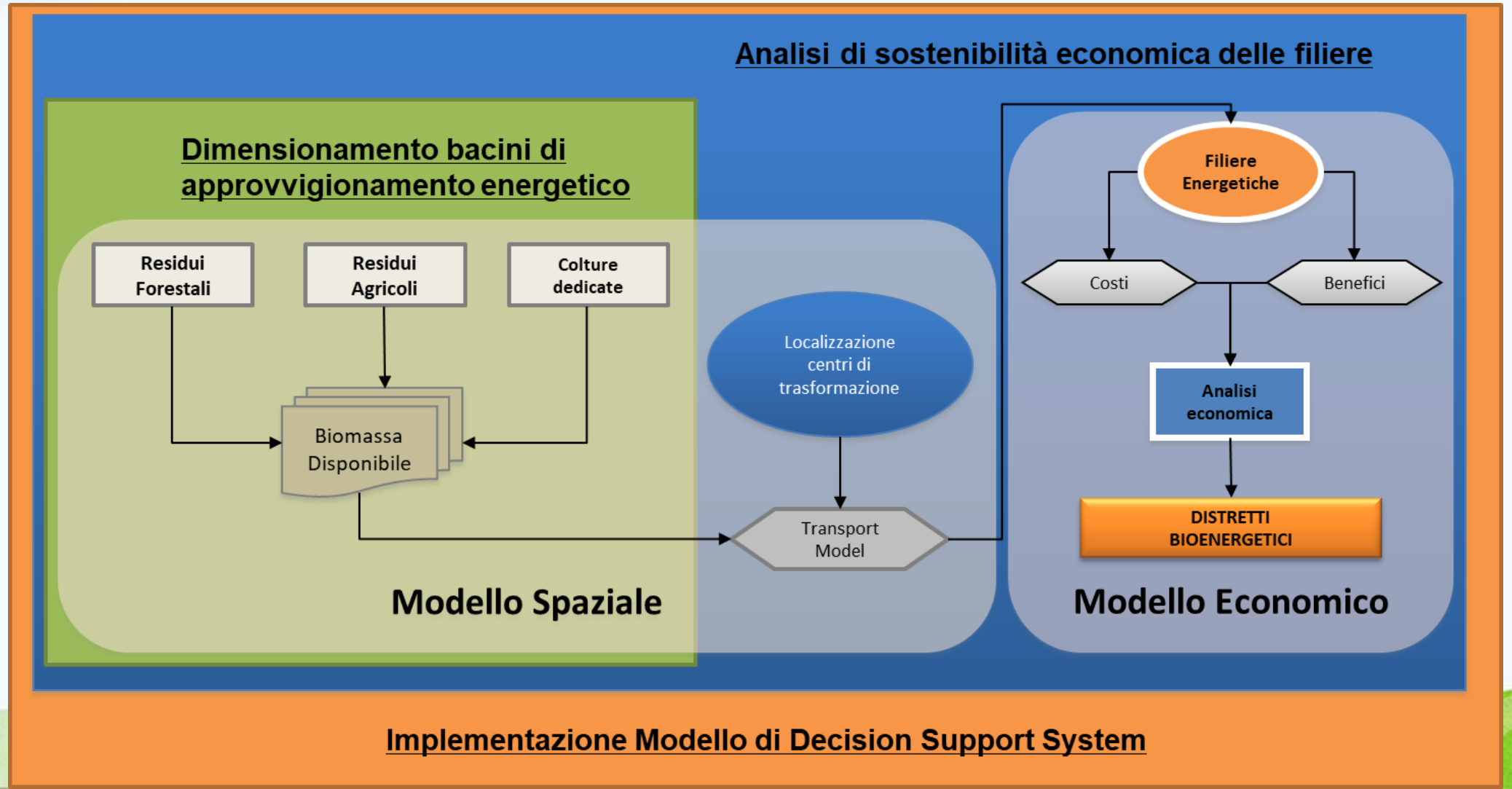
SMART BASILICATA:
OR2.1 – Sub-attività 9

Analisi costi benefici della realizzazione dei distretti energetici

Gruppo di ricerca:
Prof. Mario Cozzi
Prof. Severino Romano
Dott. Mauro Viccaro

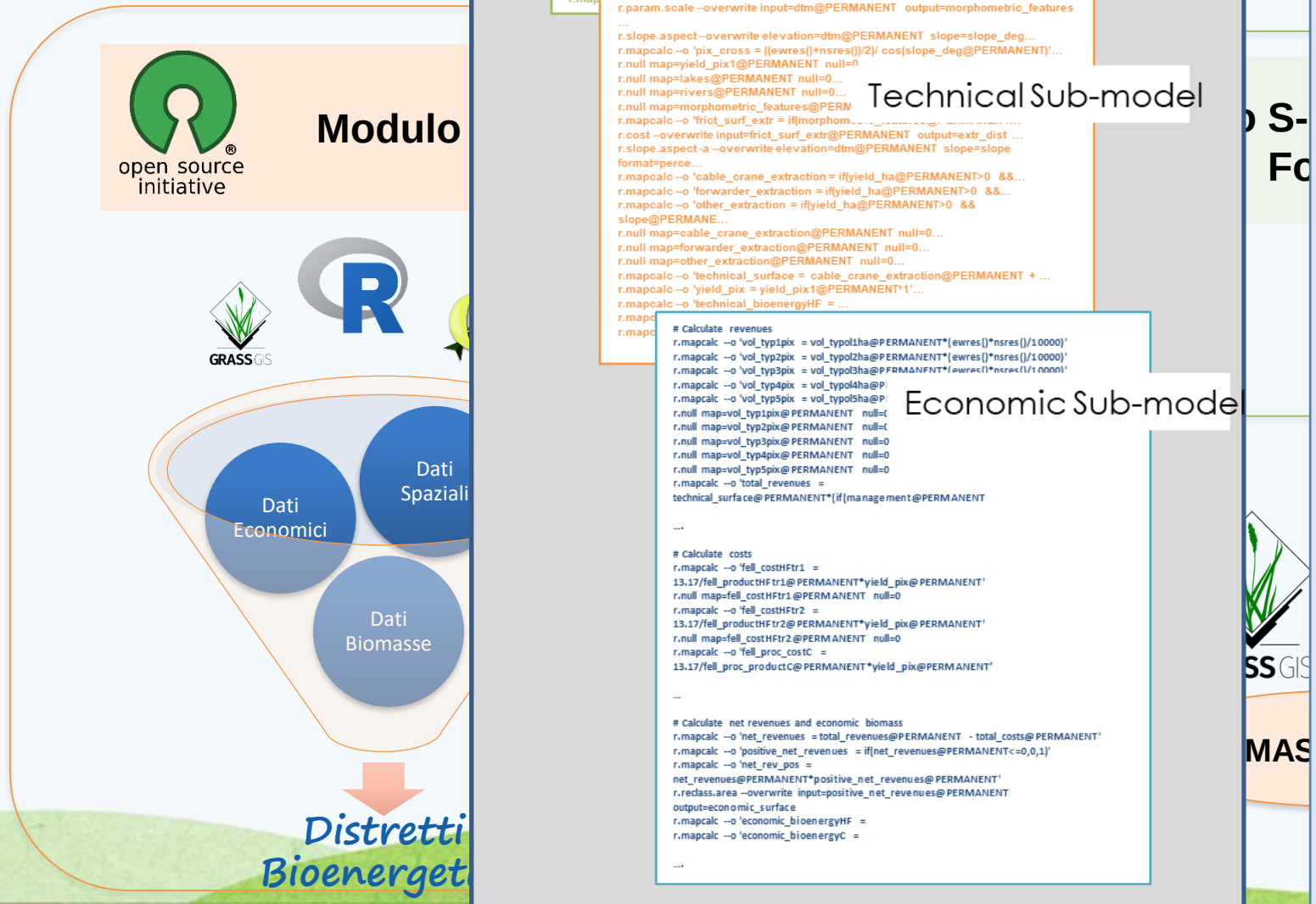
Ricerche e Progetti

SMART BASILICATA:
Analisi costi benefici della realizzazione dei distretti energetici



Ricerche e Progetti

SMART BASILICATA:
Analisi costi benefici della



Biomassfor Model

Ecological Sub-model

```
r.mapcalc --o 'yield_pix1 = yield_ha@PE
r.mapcalc --o 'ecological_bioenergyHF = if(management@PERMANENT == 1 && ...
r.mapcalc --o 'ecological_bioenergyC = if(management@PERMANENT == 2, ...
```

Technical Sub-model

```
r.param.scale --overwrite input=dtm@PERMANENT output=morphometric_features
...
r.slope.aspect --overwrite elevation=dtm@PERMANENT slope=slope_deg...
r.mapcalc --o 'pix_cross = ((ewres()+nsres())/2)/ cos(slope_deg@PERMANENT)'...
r.null map=yield_pix1@PERMANENT null=0
r.null map=lakes@PERMANENT null=0...
r.null map=rivers@PERMANENT null=0...
r.null map=morphometric_features@PERM
r.mapcalc --o 'frict_surf_extr = if(morphom...
r.cost --overwrite input=frict_surf_extr@PERMANENT output=extr_dist ...
r.slope.aspect -a --overwrite elevation=dtm@PERMANENT slope=slope
format=perce...
r.mapcalc --o 'cable_crane_extraction = if(yield_ha@PERMANENT>0 &&...
r.mapcalc --o 'forwarder_extraction = if(yield_ha@PERMANENT>0 &&...
r.mapcalc --o 'other_extraction = if(yield_ha@PERMANENT>0 &&
slope@PERMANE...
r.null map=cable_crane_extraction@PERMANENT null=0...
r.null map=forwarder_extraction@PERMANENT null=0...
r.null map=other_extraction@PERMANENT null=0...
r.mapcalc --o 'technical_surface = cable_crane_extraction@PERMANENT + ...
r.mapcalc --o 'yield_pix = yield_pix1@PERMANENT*1'...
r.mapcalc --o 'technical_bioenergyHF = ...
```

Economic Sub-model

```
# Calculate revenues
r.mapcalc --o 'vol_typ1pix = vol_typol1ha@PERMANENT*(ewres()*nsres()/10000)'
r.mapcalc --o 'vol_typ2pix = vol_typol2ha@PERMANENT*(ewres()*nsres()/10000)'
r.mapcalc --o 'vol_typ3pix = vol_typol3ha@PERMANENT*(ewres()*nsres()/10000)'
r.mapcalc --o 'vol_typ4pix = vol_typol4ha@P
r.mapcalc --o 'vol_typ5pix = vol_typol5ha@P
r.null map=vol_typ1pix@PERMANENT null=(
r.null map=vol_typ2pix@PERMANENT null=(
r.null map=vol_typ3pix@PERMANENT null=0
r.null map=vol_typ4pix@PERMANENT null=0
r.null map=vol_typ5pix@PERMANENT null=0
r.mapcalc --o 'total_revenues =
technical_surface@PERMANENT*(if(management@PERMANENT

....

# Calculate costs
r.mapcalc --o 'fell_costHFtr1 =
13.17/fell_productHFtr1@PERMANENT*yield_pix@PERMANENT'
r.null map=fell_costHFtr1@PERMANENT null=0
r.mapcalc --o 'fell_costHFtr2 =
13.17/fell_productHFtr2@PERMANENT*yield_pix@PERMANENT'
r.null map=fell_costHFtr2@PERMANENT null=0
r.mapcalc --o 'fell_proc_costC =
13.17/fell_proc_productC@PERMANENT*yield_pix@PERMANENT'

...

# Calculate net revenues and economic biomass
r.mapcalc --o 'net_revenues = total_revenues@PERMANENT - total_costs@PERMANENT'
r.mapcalc --o 'positive_net_revenues = if(net_revenues@PERMANENT<=0,0,1)'
r.mapcalc --o 'net_rev_pos =
net_revenues@PERMANENT*positive_net_revenues@PERMANENT'
r.reclass.area --overwrite input=positive_net_revenues@PERMANENT
output=economic_surface
r.mapcalc --o 'economic_bioenergyHF =
r.mapcalc --o 'economic_bioenergyC =

....
```

Input

Mandatory

1. DTM – Digital Terrein Model (ASCII –grid)
2. Main roads
3. Forest roads
4. **Total yield**
5. **Yield of forest typology *n***
6. Forest management (M)
7. Woodchip collection point(s)
   e.g., District Heating Plants (DHP)

Optional

1. Landing site
2. Forest treatment
3. Compartments
4. Roughness
5. Lakes
6. Rivers
7. Mean tree diameter
8. Mean tree volume
9. Boundary
10. Energy demand
11. Soil productivity
12. Soil texture
13. Soil depth
14. Soil compaction risk
15. Fire risk index
16. Potected areas
17. Touristic value (O)

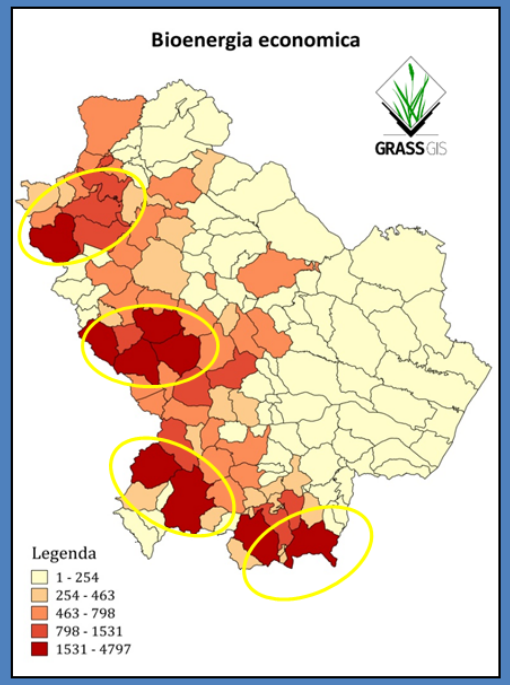
Ricerche e Progetti

SMART BASILICATA:
Analisi costi benefici della realizzazione dei distretti energetici

COMPONENTI DEL SSD

COMPONENTE SPAZIALE

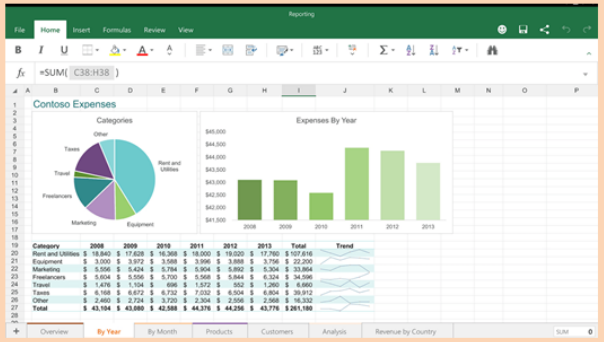
MODELLO BIOMASSFORBAS



- ✓ CIRCA 17.013 TONNELLATE DI RESIDUI
- ✓ 57.843,6 MWH ANNUI DI ENERGIA
- ✓ 3.111.040 €/ANNO DI RICAVI NETTI

COMPONENTE COMPUTAZIONALE

SOFTWARE DI CALCOLO



1. DIMENSIONAMENTO BACINI ENERGETICI DA PARTE DELL'UTENTE
   - ✓ INDIVIDUAZIONE AREA D'INTERESSE
   - ✓ SCELTA DELLA TIPOLOGIA IMPIANTISTICA
2. ANALISI DI FATTIBILITÀ ECONOMICA

CONVENIENZA ECONOMICA DELLA REALIZZAZIONE DEL DISTRETTO

Ricerche e Progetti

PON BIOFEEDSTOCK
Titolo: Sviluppo di piattaforme tecnologiche integrate per la valorizzazione di biomasse residuali

- Università degli Studi di Napoli Federico II (Soggetto Capofila)
- Consorzio IPASS -Ingegneria per l'Ambiente e lo Sviluppo Sostenibile
- CRdC Tecnologie Scarl
- Eni S.p.A.
- GORI S.p.A. Gestione Ottimale Risorse Idriche
- Graded Spa
- Hydrolab
- Qohelet Solar Italia
- Syndial Servizi Ambientali
- Università degli Studi della Basilicata
- Università degli Studi della Tuscia
- Università degli Studi di Palermo

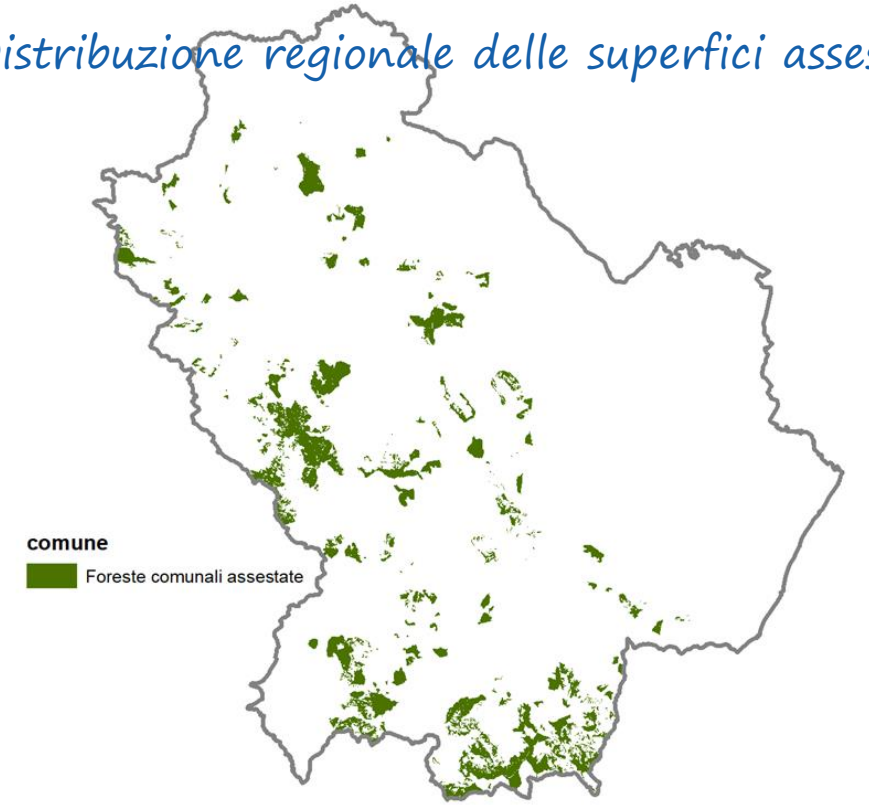
Ricerche e Progetti

PON BIOFEEDSTOCK
Titolo: Sviluppo di piattaforme tecnologiche integrate per la valorizzazione di biomasse residuali

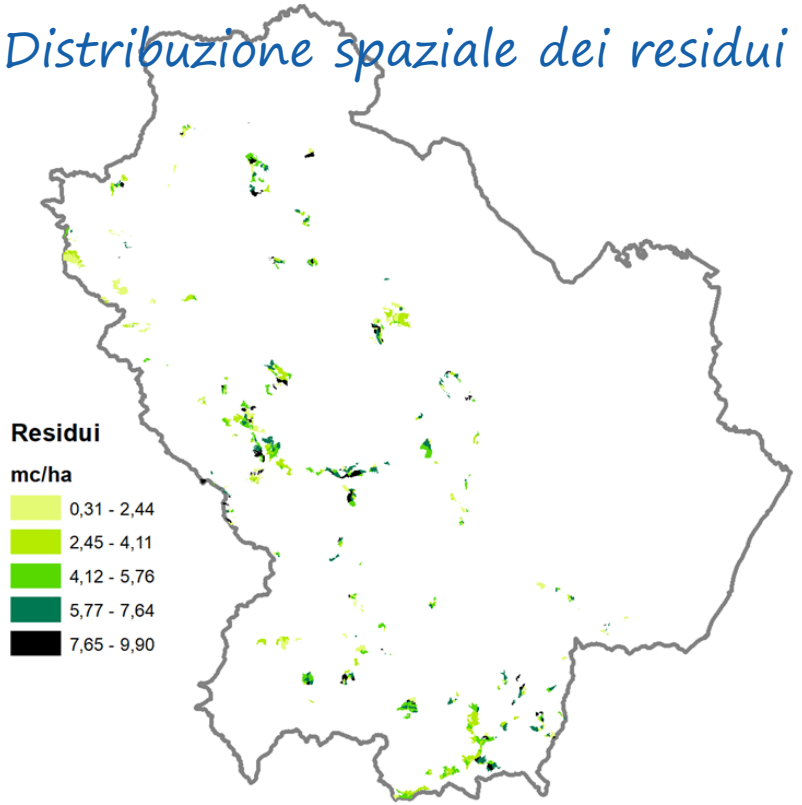
OR1 – Valutazione dei bacini di potenziale approvvigionamento di biomasse residuali
AR 1.1 – Analisi della disponibilità quali/quantitativa dei materiali biogenici di scarto e delle opzioni tecnologiche di trattamento/valorizzazione di interesse nelle Regioni sedi del progetto

SCARTO

Distribuzione regionale delle superfici assestate



Distribuzione spaziale dei residui



Ricerche e Progetti

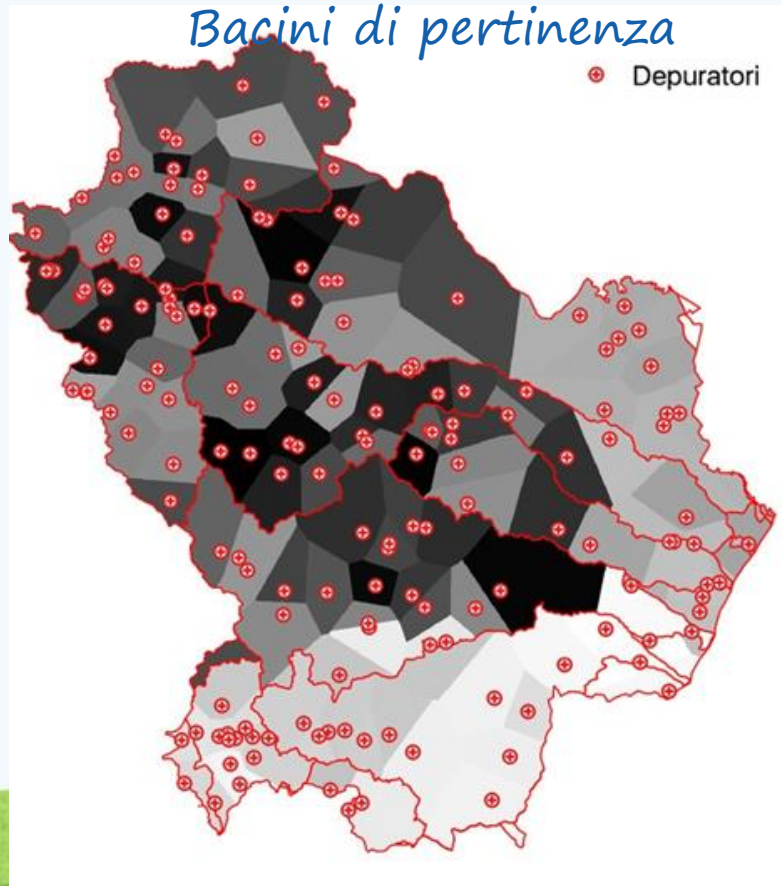
PON BIOFEEDSTOCK
Titolo: Sviluppo di piattaforme tecnologiche integrate per la valorizzazione di biomasse residuali

OR1 – Valutazione dei bacini di potenziale approvvigionamento di biomasse residuali
AR 1.1 – Analisi della disponibilità quali/quantitativa dei materiali biogenici di scarto e delle opzioni tecnologiche di trattamento/valorizzazione di interesse nelle Regioni sedi del progetto

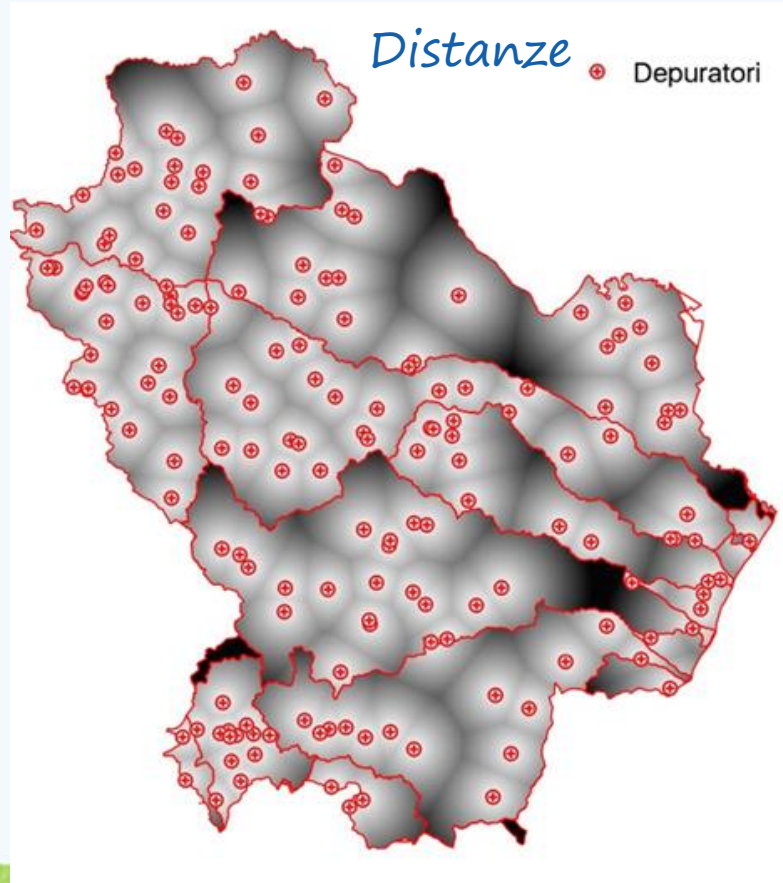
Acque reflue e coltivazioni dedicate

Solo 35 depuratori (21%) posseggono portate tali da poter irrigare più di 10 ettari. Tuttavia è da tener presente che la superficie complessiva irrigabile con tali depuratori ammonta a 1246 ettari, pari al 78% della superficie complessiva irrigabile con l'acqua derivante da tutti i depuratori, con una produzione annua di biomassa pari a 89525 tonnellate di sostanza secca (78% della produzione totale.

Bacini di pertinenza



Distanze



XLIII Incontro di Studio del Ce.S.E.T.: 147-164

Severino Romano,
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mauro.viccaro@gmail.com

Keywords: *fonti energetiche rinnovabili, gestione forestale, biomassa forestale, utilizzazioni forestali, aree di approvvigionamento, funzioni costo-offerta, analisi di sensitività, ESCO, Certificati Bianchi*

Le biomasse come opportunità per il territorio: analisi tecnico-economica per la Regione Basilicata

In Basilicata region there is a considerable amount of unused wood as well as the capacity to use it as feedstock for the production of bioenergy. Thus, the supply of renewable energy could be increased through greater utilization of forest biomass. However, for a better planning of the production and processing chain, the energy and forestry sectors require better estimates of the availability of unused roundwood and residues. The aim of the research was the development of a model for the spatial evaluation of biomass quantities obtainable from forestland. The results obtained point out a) significant amounts of biomass distributed on most of the territory; b) good opportunities related to white certificate trading and c) potential of business creation, entrepreneurship and local employment.

Energies **2013**, *6*, 5259-5282; doi:10.3390/en6105259

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Article

Building Agro-Energy Supply Chains in the Basilicata Region: Technical and Economic Evaluation of Interchangeability between Fossil and Renewable Energy Sources

Severino Romano, Mario Cozzi *, Francesco Di Napoli and Mauro Viccaro

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* Author to whom correspondence should be addressed; E-Mail: mario.cozzi@unibas.it; Tel./Fax: +39-0971-205409.

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Abstract: In this study, we present a model for the implementation of agro-energy chains based on the actual availability of forest biomass and the real demand for energy (heat) in the area of the Basilicata region, Italy. The demand for energy has been estimated by drawing on the database of the Ministry of Economic Development or by calculating the Annual Energy Requirement (AER) index, while for the estimate of the available forest biomass, reference was made to the public forest lands managed according to forestry management plans. The collected data were cross-checked with a view to detecting the technical and economic feasibility of district heating systems. The technical evaluation has mainly focused on the energetic and plant aspects, while the economic assessment was directed to defining the cost effectiveness criteria [Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period] that can measure the profitability of the investment. In the economic evaluation we also included the national public incentives, designed to encourage the production of energy from renewable sources in compliance with the international agreements signed by Italy for the reduction of greenhouse gases (GHGs).

Keywords: biomass; agro-energetic chain; district heating systems; cost-effective use of biomass; green economy

Forests **2013**, *4*, 1121-1140; doi:10.3390/f4041121

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Article

Use of Forest Residues for Building Forest Biomass Supply Chains: Technical and Economic Analysis of the Production Process

Mario Cozzi *, Francesco Di Napoli, Mauro Viccaro and Severino Romano

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Abstract: In the field of biomass and bio-energy production, an analysis was performed of the whole production process from biomass supply to bio-energy production. The available biomass, harvesting and transportation costs and the distribution of supply area were quantified. The assessment of volumes was based on forest type and its relative increment. The transportation costs, influenced by different species-specific and site-specific factors, were calculated by integrating data in a geographic information system (GIS). The economic values calculated were the main economic indicators (net present value (NPV), internal rate of return (IRR) and Payback Period). The results show that: (a) there is a good supply of forest biomass across most of the territory of Basilicata region, Italy; (b) the harvesting and transportation costs are dependent on biomass density and distances; (c) there are strong margins for economic profits at the level of each single supply basin; and (d) the endogenous value added was estimated to about 150 seasonal workers.

Keywords: biomass; forest energy chain; geographic information systems; cost-effective use of biomass

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The green economy for sustainable development: a spatial multi-criteria analysis - ordered weighted averaging approach in the siting process for short rotation forestry in the Basilicata Region, Italy

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Abstract

Optimising bioenergy chains and the creation of a bio-energy district can make a positive contribution to territorial development, land use planning and employment, while reducing environmental pollution. Energy planning issues are complex problems with multiple decision makers and criteria. Given the spatial nature of the problem, the present paper proposes a spatial multi-criteria analysis approach for supporting decision makers in the site selection process for short rotation forestry planting in the Basilicata Region, southern Italy. The methodology applied in the decision-support system is ordered weighted averaging, extended by means of fuzzy linguistic quantifiers. The purpose of the research is to formulate a systematic procedure to analyse complex decision problems, while supplying decision makers with a flexible tool to decide on possible agro-energy policies. The outcomes of the analysis may support decision makers in defining targeted agro-energy policies and help the private sector to identify the most appropriate cropping plan.

Introduction

Man's production and consumption of energy are among the factors responsible for global climate change. The major contributors to climate changes include the greenhouse gases (GHGs), of which CO_2 is the primary element. There has been a big increase in its concentration levels, reaching 390 ppm in 2010, and rising by 39% as compared to pre-industrial levels (IPCC, 2011) (Data up-dated to January 2013 report that the concentration of CO_2 has reached 395 ppm; available from: http://www.esrl.noaa.gov/gmd/ccgg/trends/global.html). This has caused a trend for rising global mean temperatures. The World Bank report of November 2012 *Turn Down the Heat: Why a 4°C Warmer World Must be Avoided* (World Bank, 2012) highlights how the impact of a 4% increase in mean temperature (expected in 2060 given the current GHGs emission levels) may be catastrophic for mankind and for the ecosystems.

Several options have been identified to limit and reduce the climate change emissions in the atmosphere, including decarbonisation policies in production and consumption, and investment in the *green economy*. The United Nations Environment Programme (UNEP) defines a green economy as one that results *in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities* (UNEP, 2011).

This approach to development suggests economic, legislative, technological and public education measures aimed at reducing the consumption of energy and natural resources, by promoting the increase in energy and production efficiency, the decrease in greenhouse emission gases, and the reduction in local and global pollution, through the promotion of a genuinely sustainable and lasting global economy. These measures mainly use renewable resources (such as biomasses, wind energy, solar energy, hydraulic energy) and focus on preventing as much waste as possible.

Bioenergy has a significant potential to mitigate GHG provided sustainable strategies are adopted to develop resources and efficient bioenergy systems are used (IPCC, 2011). Biomass is a primary source of food, fodder and fibres, and as a renewable energy source, in 2008, it provided approximately 10.2% (50.3 EJ) of global total primary energy supply (IPCC, 2011). Several studies confirm that there is still room for further development of the bio-energy sector (Berndes *et al.*, 2003; Hoogwijk *et al.*, 2005; de Vries *et al.*, 2007; Hoogwijk *et al.*, 2009), notably for short-rotation crops grown on farmland (Dornburg *et al.*, 2008, 2010). Actually, following the IPCC report on renewable energies (IPCC, 2011) it would also be possible to obtain 700 EJ/year from dedicated biomass productions if used on abandoned lands and/or on soils not used for food crops.

In the Basilicata Region, southern Italy, marginal farmland areas

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Key words: green economy, fuzzy analysis, multi-criteria spatial analysis, ordered weighted averaging, short rotation forestry.

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CONNESSIONI TRA ACQUE REFLUE E BIOENERGIE: UN'ANALISI EMPIRICA

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Le colture energetiche irrigate con le risorse idriche non convenzionali su larga scala potrebbero diminuire gli impatti negativi derivanti dall'uso dei combustibili fossili, e allo stesso tempo salvaguardare le risorse idriche potabili e ridurre l'inquinamento nelle acque superficiali, in particolare in ambienti caratterizzati da carenza idrica come il bacino del Mediterraneo. *Short Rotation Forestry* (SRF) con pioppi e salici irrigati con acque reflue, noti come "*vegetation filter system*", sono una valida alternativa ai sistemi forestali e di depurazione delle acque convenzionali per il raggiungimento degli obiettivi ambientali ed energetici fissati dall'Unione europea e per aumentare il reddito degli agricoltori. Problemi di pianificazione energetica sono problemi complessi con più decisori e criteri. Data la natura territoriale del problema, la ricerca propone un sistema spaziale di supporto alle decisioni in GIS (*Geographic Information System*) per valutare la fattibilità agronomica ed economica dei v*egetation filter system* nella regione Basilicata. I risultati mostrano che le distanze tra le aree di SRF e i depuratori sono il fattore chiave. Da 163 impianti di depurazione attivi, solo 25 sono economicamente convenienti e in grado di irrigare 864 ettari di SRF. Questo dimostra che c'è un grande potenziale nella regione per lo sviluppo delle bioenergie, con vantaggi economici, mettendo in evidenza l'ampia disponibilità di siti con benefici netti fino a 46,000 €/ha e periodo di ammortamento tra i 3 ei 10 anni.

Parole chiave: bioenergia, short-rotation forestry, acque reflue, analisi geografica multicriteriale, analisi degli investimenti.
Keywords: bioenergy, short-rotation forestry, wastewater, geographical multicriteria analysis, cost-effective evaluation.

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1. Introduzione

La realizzazione di impianti di *short rotation forestry* (SRF) multifunzionali, quali i "*vegetation filter system*", è diventata una valida alternativa alle SRF convenzionali. Quanto affermato è determinato dai notevoli benefici economici e ambientali che ne derivano (Rosenqvist e Dawson, 2005b; Berndes *et al.*, 2008; Ericsson *et al.*, 2009; Dimitriou e Rosenqvist, 2011). Tali impianti, irrigati con acque reflue e realizzati con specie quali salici (*Salix spp.*) e pioppi (*Populus spp.*), sono destinati alla produzione di biomasse energetiche e alla fitodepurazione (Guidi *et al.*, 2008), in quanto le acque reflue forniscono alle piante acqua e sostanze nutritive (specialmente azoto e fosforo), favorendone la crescita e l'aumento della traspirazione, purificano le acque attraverso l'assorbimento degli elementi presenti in esse (BIOPROS, 2008). Nonostante però i numerosi vantaggi economici e ambientali mostrati dalle sperimentazioni effettuate in diversi paesi del centro-nord Europa (Rosenqvist e

spaziale in ambiente GIS (*Geographic Information System)* volto ad individuare aree potenzialmente idonee alla realizzazione di *vegetation filter systems*. Ponendo come base di partenza informativa gli impianti di trattamento delle acque reflue (WWTP, *wastewater treatment plant*) presenti, risulta praticabile l'impiego di un modello di analisi territoriale al fine di valutare la fattibilità di eventuali investimenti nel settore bio-energetico (Cozzi *et al.*, 2013). Il modello realizzato è stato applicato alla regione Basilicata, caratterizzata da un clima prettamente mediterraneo e interessato da fenomeni di carenze idriche, specialmente nel periodo estivo, che giustificano l'adozione di acque non convenzionali per l'irrigazione in agricoltura, al fine di non intaccare le disponibilità d'acqua potabile ad uso urbano. L'intero modello è stato costruito tenendo presente non solo della sostenibilità ambientale (corretto uso delle acque reflue, esclusione di aree vulnerabili a nitrati) ma anche della convenienza economica derivante dalla realizzazione di SRF fertirrigate con acque reflue urbane, elementi che sono alla base della reale

Ordered weight averaging multicriteria procedure and cost-effectiveness analysis for short rotation forestry in the Basilicata region, Italy

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Abstract: Optimisation of bio-energy chains and the establishment of a bioenergy district can make a positive contribution to territorial development, while reducing environmental pollution. The Ordered Weighted Averaging (OWA) multi-criteria analysis was applied to Basilicata Region in southern Italy to identify suitable areas for Short Rotation Forestry: 4659 ha, 8847 ha and 4742 ha could be planted with eucalyptus, poplar and black locust, respectively. Based on the results, financial analysis compared different management and production scenarios and explored the possibility of accessing national incentives. Economic results are positive above certain yield thresholds (> 15 t.d.m/ha) that can be ensured only with irrigation in summer: the NPV/ha ranged from €111 for black locust to €1360 for poplar. Further economic benefits could be generated by the access to the white certificate market and to the voluntary carbon credit market. Lastly, the results obtained have been confirmed by a sensitivity analysis.

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A spatial analysis model to assess the feasibility of short rotation forestry fertigated with urban wastewater: Basilicata region case study

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ABSTRACT

The large-scale cultivation of energy crops irrigated with non-conventional water resources could reduce the negative impacts of fossil fuel use, while still saving potable supplies and decreasing pollution in surface water, particularly in water-deficient environments, like the Mediterranean region. Energy planning is a complex process involving multiple decision makers and criteria. Given the spatial nature of the problem, the research proposes a spatial analysis model to assess the agronomic and economic feasibility of vegetation filter systems in Basilicata region, southern Italy. The model chosen for land suitability analysis is the ordered weighted averaging (OWA) with the use of linguistic quantifiers. The suitability map obtained from the OWA model was used as input in the spatial analysis functions to quantify the productivity and irrigation needs of the species, the potential irrigable service area of the wastewater treatment plants (WWTPs), as well as the distances between them and SRF, which are all key elements in the economic evaluation. The results show that the distance is the main element that influences the feasibility: only 25 out of 163 WWTPs are cost-effective and can actually irrigate 864 ha of SRF. The research demonstrates that there is a great potential for bio-energy development in the region with significant economic advantages; in fact, there is a large number of sites with positive NPV up to 50,876.43 €/ha and payback period between 3 and 10 years. The implementation of vegetation filter systems could create chains with a high number of local actors (farmers, intermediaries, forest nurseries, etc.) and contribute to promoting territorial development and employment.

1. Introduction

Bioenergy has a significant potential to mitigate greenhouse gases (GHGs), provided that sustainable strategies are adopted to develop resources, and efficient bioenergy systems are used (Styles and Jones, 2007; IPCC, 2011). Considered as the most promising renewable resource in the short and medium term (Hoogwijk et al., 2003), bioenergy is expected to play an increasing role in Europe, in view of achieving the targets recently established by the European Union on energy supply security and in compliance with international agreements on emission reductions. Within this context the biomass produced on agricultural soils will play an important role (Bernetti et al., 2004; EEA, 2013), related in particular to short-rotation forestry (SRF) (Dornburg et al., 2008, 2010; Romano et al., 2013a,b). Actually, following the IPCC report on renewable energies (IPCC, 2011), it would be possible to obtain up to 700 EJ/year from dedicated biomass crops grown on abandoned lands and/or on soils not planted with food crops. In the Basilicata Region, southern Italy, marginal farmland areas are being increasingly abandoned due to their low productivity in terms of output and product type, and as a result of the major reforms of the EU Common Agricultural Policy (Romano and Cozzi, 2008). It follows that there is a large availabil-

SWOT-AHP Dynamic Approach to Define Medium Term Strategies to Develop Forest Quality Chain and Forest Energy Chain in Tuscany

by *Claudio Fagarazzi*[*], *Francesco Riccioli*[*], *Mario Cozzi*[**], *Severino Romano*[**], *Mauro Viccaro*[**], *Toufic El Asmar*[***], *Jean Pierre El Asmar*[****], *Roberto Fratini*[*]

1. Introduction

The Tuscan forest-wood chain is characterized by the lack of a physical connection between the internal forest resources and the processing wood companies (furniture and woodworking firms, etc.). This discontinuity is mainly due to the low quality of the regional forest productions, which are mainly focused on firewood from coppice (turkey-oak and pubescent-oak – 75÷85% of the production); on chestnut for lumber, tannin and post; on conifers, as Douglas fir and silver fir, for lumber and pulp wood; on pine forest for wood packaging (Casini, 2008). This situation determined a strong dependence of the local wood processing enterprise on the foreign lumber (Marinelli et al., 1993). The low quality of the productions, the structural weakness of the wood harvesting enterprises are also to be considered too in this context. Finally, the lack of professionalism of the forest chain en-

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Wastewater Reuse: An Economic Perspective to Identify Suitable Areas for Poplar Vegetation Filter Systems for Energy Production

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Abstract: The increasing interest towards climate change, water and energy saving, and soil protection has led the research community to consider non-conventional water as a sustainable source for irrigation of energy crops. Vegetation filter systems are considered a reliable technique for sustainable biomass cultivation, enabling the use of reclaimed wastewater as water and nutrients sources during irrigation periods. In this study, a geographic information system (GIS)-based spatial model was developed to identify areas potentially suitable for creating vegetation filter systems with poplars to size the plants of energy production. An economic assessment allowed us to identify the cost-effectiveness areas for biomass production that can be fertigated by reclaimed wastewater. Considering the Basilicata region as the test region, a surface area of 258,512 ha was investigated, identifying 73,331 ha of SRF soils sited downstream of 45 wastewater treatment plants (WWTPs). However, considering only areas that have positive net present value and are economically attractive, results indicate 1606 ha of SRF falling within the areas of influence of 39 WWTPs. The results show that the sector of dedicated crops, adjacent and linked with WWTPs, expresses a total capacity of 50.56 MW for thermal, 8.25 MW for electricity, and 31 MW for cogeneration (25.07 MWt and 5.94 MWe) plants.

Keywords: energy crops; green economy; short rotation forestry; vegetation filter; wastewater reuse

1. Introduction

Energy is the driving force for economic development. Most of the advances in livelihoods and life quality that we enjoy today can be traced back to the abundant and cheap supply of fossil fuels that humanity has been enjoying over the past century. However, owing to the rising crude oil price and stricter emission standards, the demand for alternative energy sources is growing.

The European Union has committed itself to comply with the Kyoto Protocol on Climate Change and greenhouse gas emission reduction by 2020 through adopting a series of Directives aiming at promoting the use of renewable energy sources (RESs) [1]. Among the available alternative energy sources that would help to respond to such challenges, biomass crops have many advantages over conventional energy and over some other RESs (e.g., wind and photovoltaic), in particular because of the reduced dependence on short-term weather changes, the promotion of regional economic structures, and the provision of alternative sources of employment in rural areas [2].

Promoting Small-Scale Biofuel Production: A Qualitative GIS-OWA Methodology for Land Suitability Analysis of Winter Rapeseed

Mauro Viccaro, Mario Cozzi, Antonella Vastola, and Severino Romano

Abstract Biofuels could be a possible solution to promote agricultural development in rural areas by increasing farm income. Different studies suggest that all problems linked to large-scale biofuel production can be overcome by promoting small-scale production, particularly of rapeseed straight vegetable oil (SVO) used as self-supply agricultural biofuel, specially if the rapeseed is cultivated in crop rotation systems with minimum tillage practices. However, an ex-ante analysis would be very important to explore the feasibility of rapeseed production, via the evaluation of land use suitability.

As land planning issues are complex problems with multiple decision makers and criteria, we propose a spatial multi-criteria analysis model for supporting decision makers in the site selection process for winter rapeseed production. The methodology applied is the Ordered Weighted Averaging (OWA) extended by means of fuzzy linguistic quantifiers. The results have shown as the proposed methodology is more flexible compared to the other MCA methods, in particular for the possibility to make the choice in qualitative rather than quantitative terms, enabling the decision-maker to explore different decision strategies or scenarios, thus facilitating a better understanding of alternative land use suitability models.

Keywords Biofuel · SVO · Land suitability · GIS · Ordered Weighted Averaging · Linguistic quantifiers

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Conservation agriculture to promote inland biofuel production in Italy: An economic assessment of rapeseed straight vegetable oil as a self-supply agricultural biofuel

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ABSTRACT

In order to reach the national target in the use of renewable energy in the transport sector, about 55% of the biodiesel consumed in Italy is imported. However, imported biofuel is currently debated since large-scale production has entailed different environmental and socioeconomic problems. Sustainability in biofuel production is a priority for the European Union and with the new Common Agricultural Policy 2014–2020 (CAP) this priority could become an opportunity through access to aids for the adoption of sustainable agricultural practices.

Considering the importance to promote small-scale biofuel production, this study aimed to assess the economic feasibility of rapeseed straight vegetable oil (SVO) use as a self-supply agricultural biofuel in Italian context, assuming that rapeseed is cultivated by using practices of conservation agriculture. The financial support of the new CAP was considered, and alternative hypotheses were assumed to promote the SVO supply chains. The economic analysis shows that EU aids can help to promote inland biofuel production, ensuring positive profits for farmers (with a net present value up to 181 thousand €), thereby reducing the risk connected to investments, mainly due to the fluctuation of some key variables, like diesel price. Moreover, results highlight the importance of establishing farmers' associations: given the high cost of the initial investment, the absence of an agreement for the creation of an optimum-sized supply chains might make those investments non profitable. Agricultural policy is therefore helpful to promote sustainable biofuel production, making the supply chains independent and self-sufficient over time. In this context, to ensure a sustainable biofuel production, beside the provision of support to the initial investments, it is also important to consider in the future biofuel policy scenario the possibility to incentive energy crop cultivation by promoting conservation agricultural practices (e.g., crop diversification, crop rotation, minimum tillage).

1. Introduction

In recent years, energy from biomass has been increasingly promoted as an alternative to fossil energy sources. In the European Union (EU), the Renewable Energy Directive (RED) has set an overall binding target to source 20% of the EU energy needs from renewable sources by 2020 (European Union, 2009). EU policy-makers claim to pursue several objectives with this policy: greenhouse gas (GHG) emission reduction, positive contributions to energy security and income generation in rural areas (Demirbas, 2009). As part of the overall target, each member state has to achieve at least 10% of their transport fuel consumption from renewable sources, including biofuels. In Italy, due to tax credits and national requirements to blend a minimum biofuel share into conventional fuels, the share of renewable energy in the transport sector grew from 1% in 2006 to 6.4% in 2015 (Eurostat, 2017a). The main source of biofuel used in Italy is biodiesel (98% of total consumption): the inland production was 500.3 thousand *toe* in 2015,

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