AI and Sustainability: Territorial Monitoring and Waste Valorization

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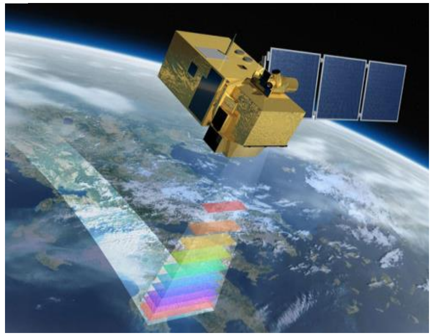
Workshop: AI per la Sostenibilità

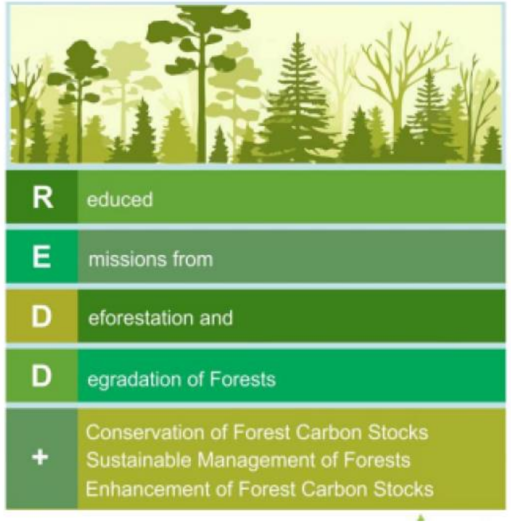
Artificial Intelligence for Sustainability

Artificial intelligence can be a tool to foster environmental sustainability and implement sustainable development goals :



- Support forest management by estimating above-ground biomass and carbon storage;
- Support researchers and policymakers in land management decisions;
- Bio-fuel production from biomass waste;
- Environmental crime detection.

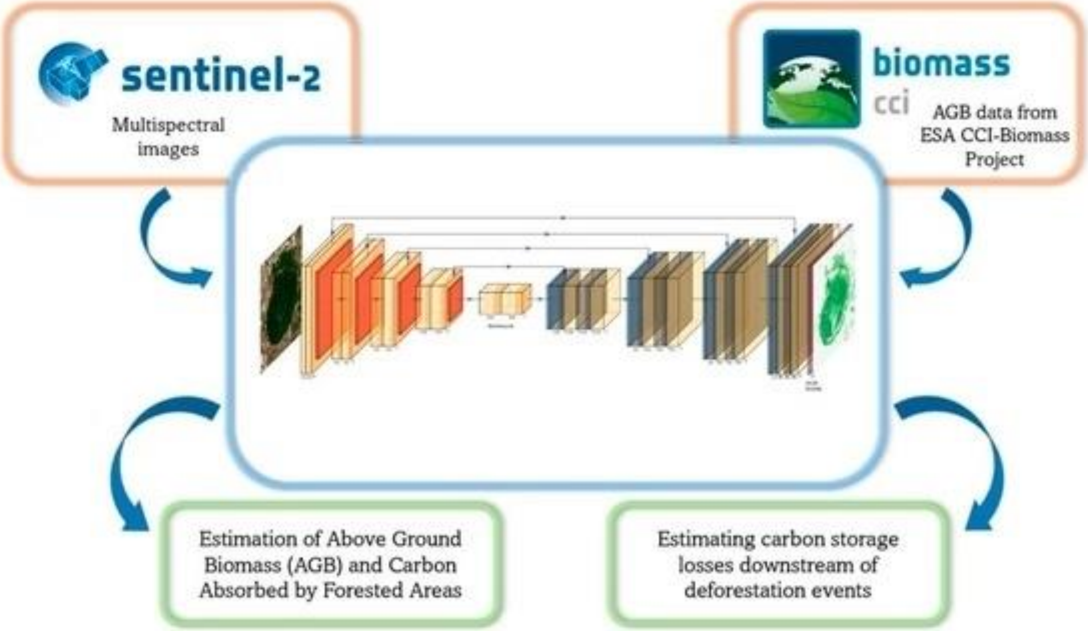
ReUse: REgressive Unet for Carbon Storage and Above-Ground Biomass Estimation



The United Nations Framework Conventions on Climate Change (UNFCCC) has endorsed programs for reducing emissions from deforestation and forest degradation (REDD+) and mandated that member countries periodically report forest carbon estimates via national greenhouse gas inventories (NGHGI).

Sustainable Development Goal 15 aims to “protect, restore and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss”

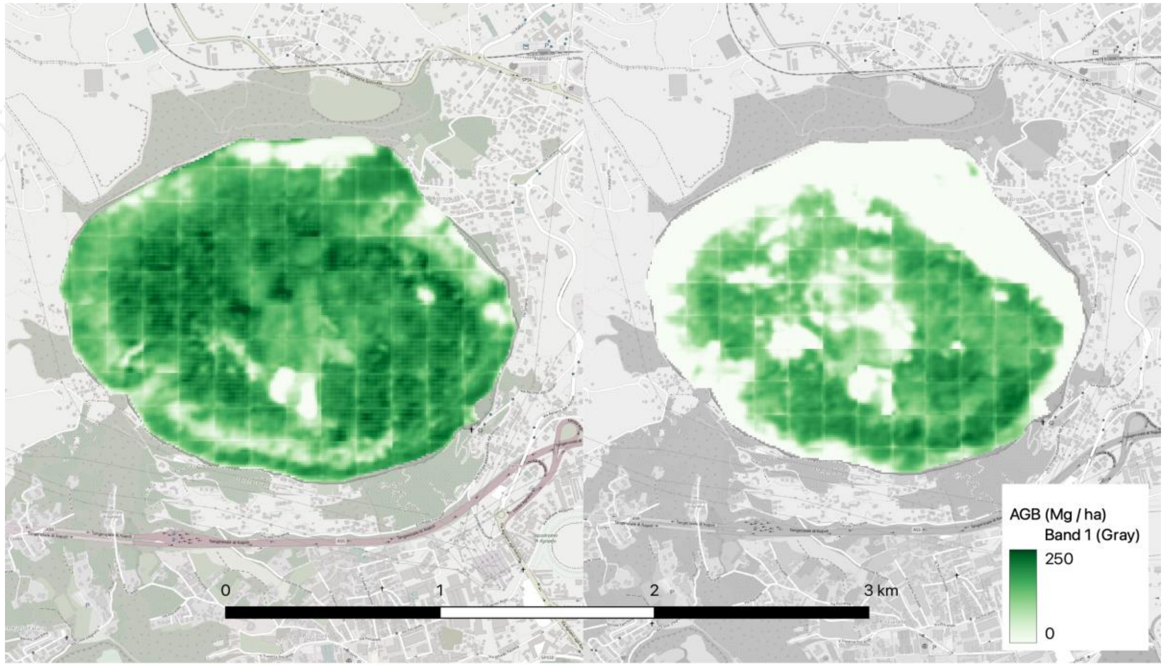
ReUse: REgressive Unet for Carbon Storage and Above-Ground Biomass Estimation



Area	Model	MAE	RMSE	R^2
Vietnam	ReUse with raw bands	**42.0 ± 6.6**	**57.7 ± 7.3**	**0.4 ± 0.2**
	ReUse with feature extraction	44.4 ± 6.0	59.5 ± 4.7	**0.4 ± 0.2**
	Competitor 1 [10]	60.1 ± 8.3	73.0 ± 9.4	0.2 ± 0.2
	Competitor 2 [14]	58.9 ± 8.6	72.0 ± 9.7	0.2 ± 0.2
Myanmar	ReUse with raw bands	10.8 ± 2.0	15.0 ± 2.4	**0.7 ± 0.1**
	ReUse with feature extraction	**10.7 ± 2.2**	**14.9 ± 2.6**	**0.7 ± 0.1**
	Competitor 1 [10]	15.7 ± 1.9	20.2 ± 2.3	0.4 ± 0.1
	Competitor 2 [14]	15.5 ± 1.5	20.1 ± 1.8	0.4 ± 0.1
Europe	ReUse with raw bands	24.5 ± 3.3	**46.6 ± 5.2**	**0.6 ± 0.1**
	ReUse with feature extraction	**24.1 ± 3.4**	46.9 ± 4.2	**0.6 ± 0.1**
	Competitor 1 [10]	32.5 ± 3.1	48.0 ± 4.4	0.5 ± 0.5
	Competitor 2 [14]	34.8 ± 3.1	51.1 ± 3.9	0.5 ± 0.5

The combined use of Sentinel-2 data and ESA AGB data with a UNet approach could be suitable for estimating the carbon absorbed in forest areas and help monitor deforestation events without field measurements on a *global* scale and with a *temporal* resolution equal to Sentinel-2.

ReUse: REgressive Unet for Carbon Storage and Above-Ground Biomass Estimation

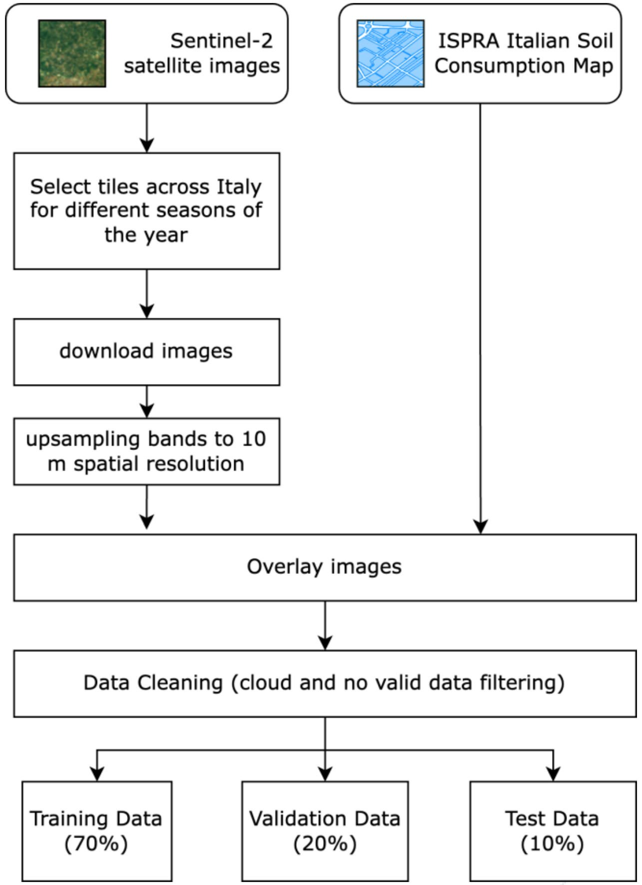


On the left is the predicted above-ground biomass(AGB) raster of the Astroni nature reserve before the July 2017 fire; on the right is the predicted AGB raster after a major fire event for the same area.

PICUSLab set up this system in collaboration with start-up **Latitudo-40.**

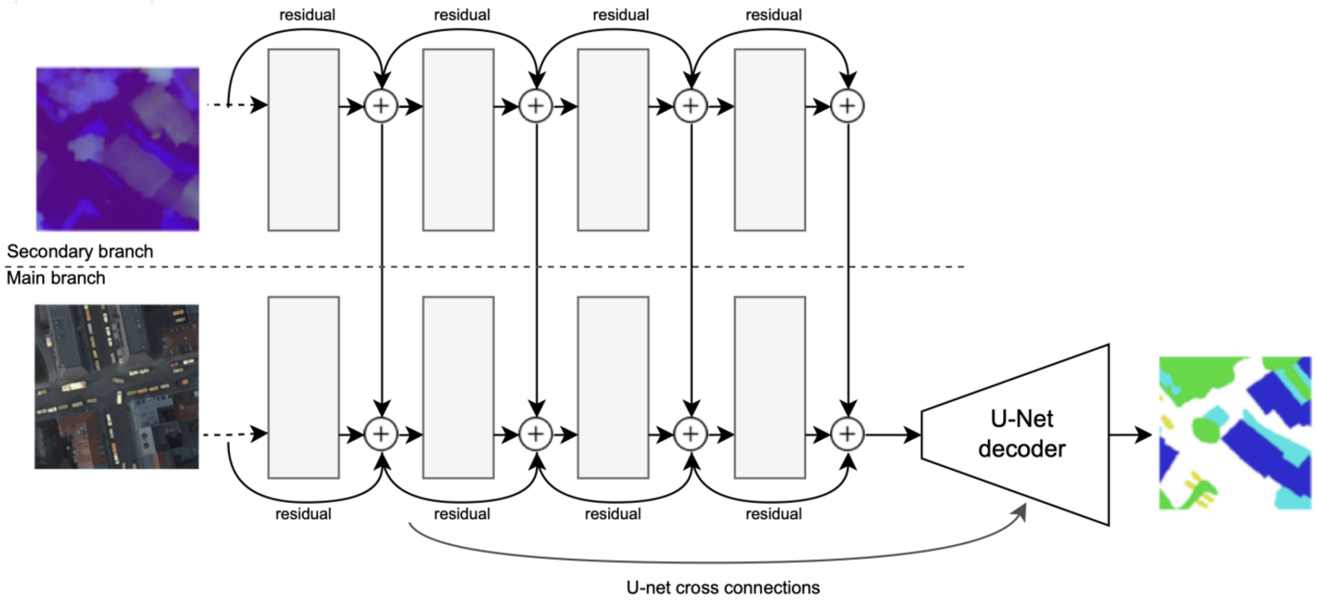
ReFuse: Generating Imperviousness Maps from Multi-Spectral Sentinel-2 Satellite Imagery

Sustainable Development Goal 11 aims to “Make cities and human settlements inclusive, safe, resilient and sustainable ”.

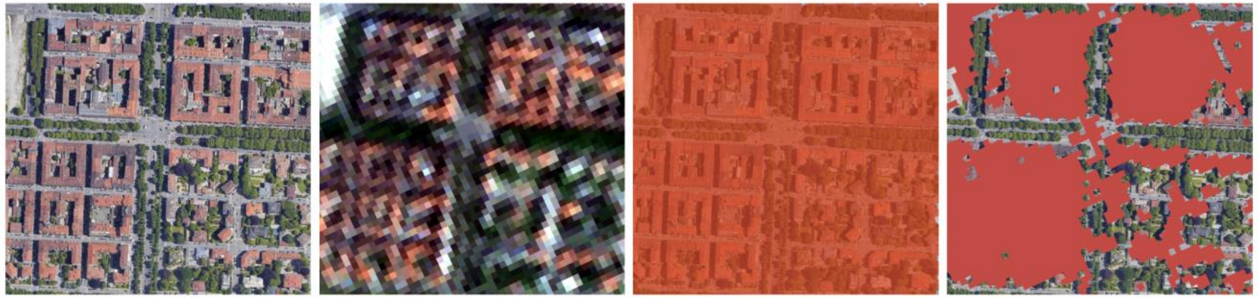


ReFuse: Generating Imperviousness Maps from Multi-Spectral Sentinel-2 Satellite Imagery

- **Proposed approach**: U-Net architecture with Resnet backbone and multispectral data fusion adapting the FuseNet approach with REsidual block (ReFuse).

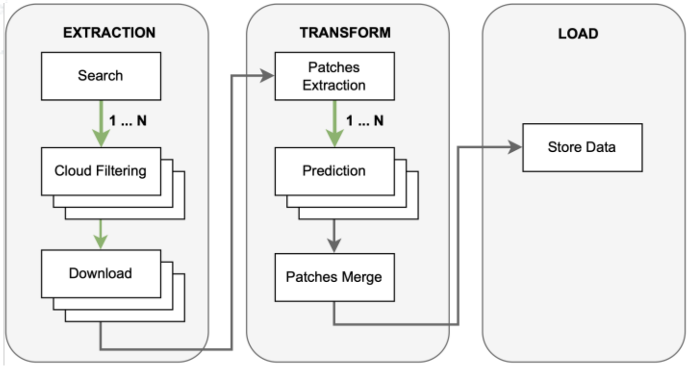


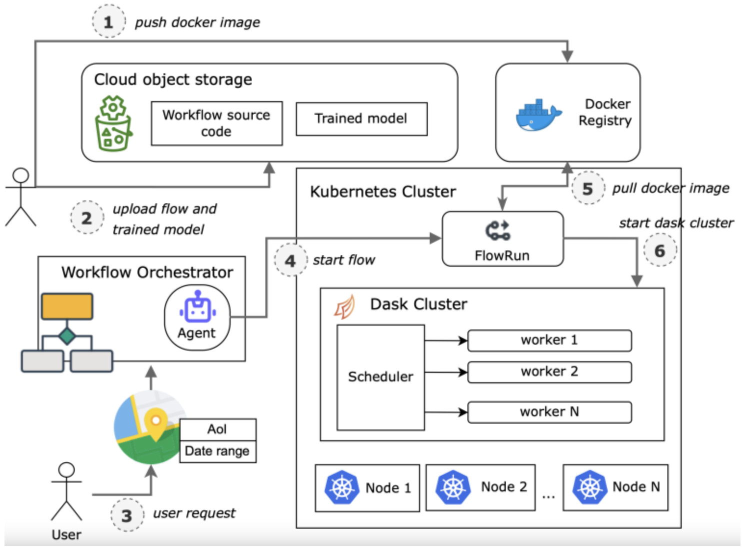
Network	Encoder	Bands	Accuracy	IoU
FCN-8s	-	R, G, B	89.54%	69.76%
FCN-8s	-	R, G, B, NIR	88.25%	69.55%
FCN-8s	-	All 13 bands	84.80%	60.35%
U-Net	VGG16	R, G, B	87.45%	70.03%
U-Net	ResNet-34	R, G, B	90.13%	70.54%
U-Net	ResNet-50	R, G, B	92.39%	73.50%
U-Net	ResNet-50	R, G, B, NIR	92.07%	71.37%
U-Net	ResNet-50	All 13 bands	89.37%	70.32%
U-Net	ResNet-101	R, G, B	90.39%	70.57%
U-Net	EfficientNetB7	R, G, B	94.48%	74.61%
DeepLabv3+	ResNet-50	R, G, B	92.19%	71.35%
DeepLabv3+	ResNet-50	R, G, B, NIR	91.32%	71.29%
DeepLabv3+	ResNet-50	All 13 bands	88.25%	68.50%
ReFuse	**ResNet-50**	**(R, G, B) + (B7, B8, B11)**	**95.72%**	**75.85%**

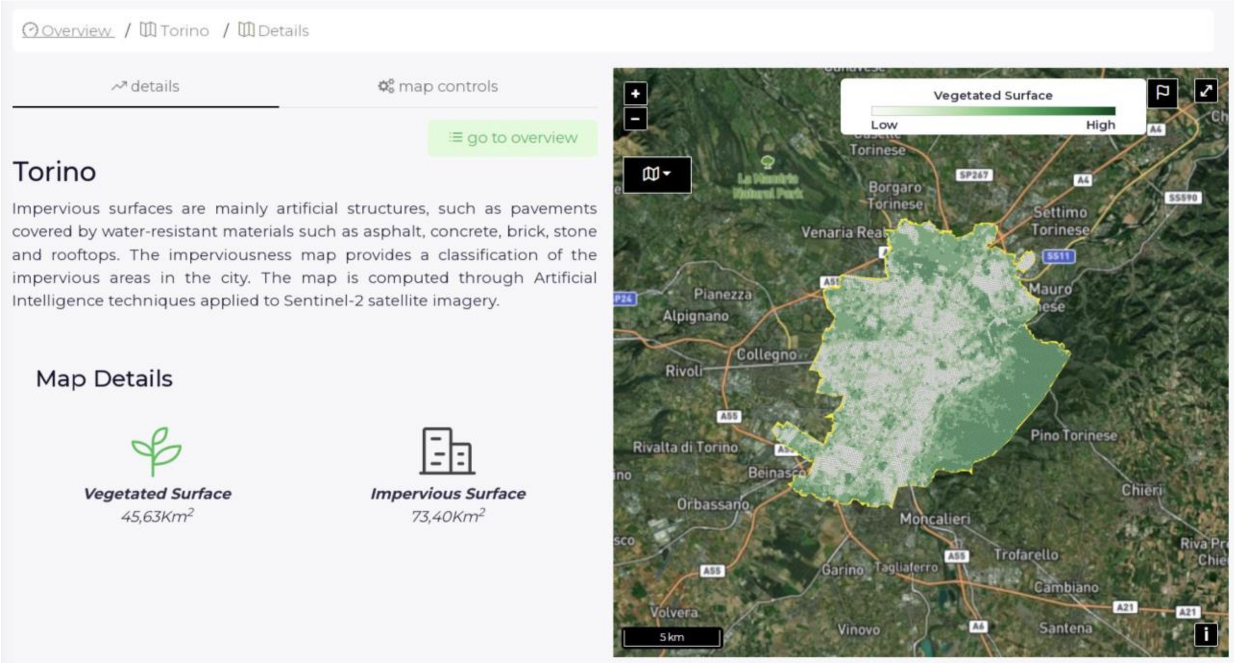


(a) Google Satellite **(b)** Sentinel-2 **(c)** Ground truth **(d)** ReFuse

ReFuse: Generating Imperviousness Maps from Multi-Spectral Sentinel-2 Satellite Imagery







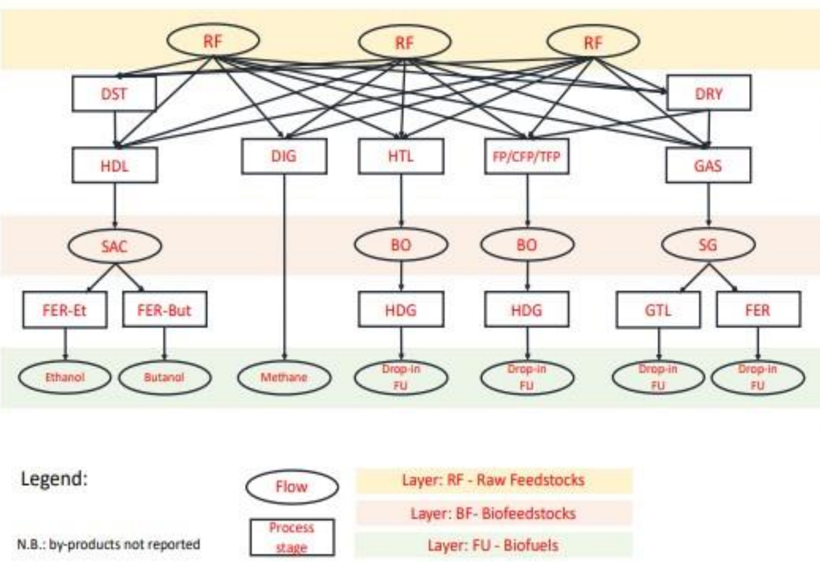
PICUSLab set up this system in collaboration with start-up **Latitudo-40.**

Enhancing Biomass-Waste Valorization with Machine Learning

Sustainable Development Goal 7 aims to “Ensure access to affordable, reliable, sustainable and modern energy for all”.

The 2015 ILUC Directive aimed to promote the development of biofuels produced from waste, residues, cellulosic materials of non-food origin and ligno-cellulosic materials.

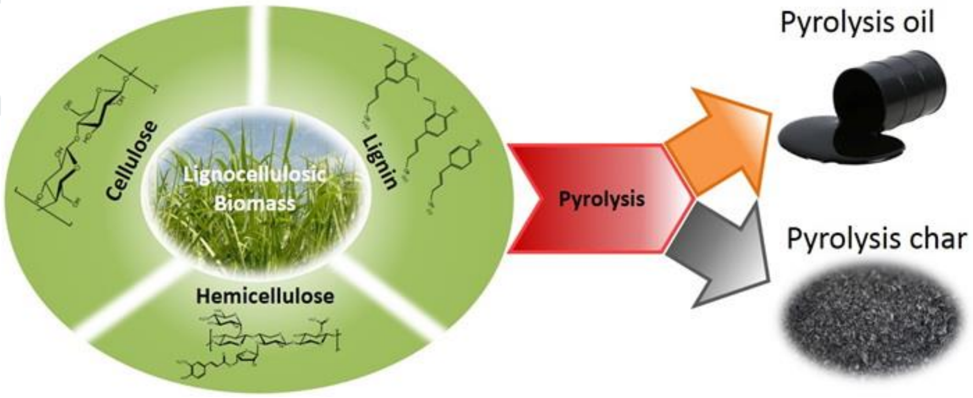
Integrated scheme for residual biomass exploitation



Legend – Flows	
RF	Raw feedstock
SAC	Sugars, oligomers
BO	Bio-oil
SG	SynGas

Legend – Process stages	
DRY	Drying
DST	Mech./Chem. Destr.
FP	Fast Pyrolysis
CFP	Catalytic Fast Pyrolysis
TFP	Torrefaction-> Fast Pyrolysis
HTL	Hydrothermal Liquefaction
HDL	Hydrolysis
GAS	Gasification
DIG	Anaerobic Digestion
HDG	Hydrogenation
FER	Fermentation
GTL	Gas-to-Liquid Stage

Enhancing Biomass-Waste Valorization with Machine Learning



This project, which is in development at **PICUSLab** in collaboration with **Eni**, aims to create a Decision Support System (DSS) based on machine learning models and fed by data carefully collected from the scientific literature. The objective is to use this DSS to identify the most effective processes for valorizing waste biomass in producing biofuels. At the moment, the focus is on pyrolysis.

Name	Ash (wt%)	Fixed Carbon (wt%)	Volatiles (wt%)	C (wt%)	H (wt%)	O (wt%)	N (wt%)	Cellulose (wt%)	Hemicellulose (wt%)	Lignin (wt%)	T (^C)	Heating Rate (^C/min)	Particle Size (mm)	Flow Rate-Nitrogen (ml/min)	O-Biooil (wt%)	Yield (wt%)	H-biooil (wt%)
cherry seed shell	0.78	17.02	76.12	48.86	6.32	41.62	3.09	27.19	31.93	36.9	500	5	2	25	26.35	44	7.89
cherry seed shell	0.78	17.02	76.12	48.86	6.32	41.62	3.09	27.19	31.93	36.9	600	5	2	25	27.79	42	7.79
Euphorbia rigida	6.5	11.6	78.9	49.1	5.7	44	1.2	21.1	19	50.4	500	7	0.55	100	13.45	41.97	9.27
Sesame stalk	6.63	9.87	74.8	52.43	6.09	40.86	0.62	28.5	32.5	32.6	500	7	0.47	100	27.28	45.91	8.02
wheat straw	6.9	13	74.2	52.9	6.3	40.4	0.4	31.2	45.2	18.1	300	7	0.5	200	22.9	37.04	7.3
wheat straw	6.9	13	74.2	52.9	6.3	40.4	0.4	31.2	45.2	18.1	400	7	0.5	200	21.6	39.83	7.6
wheat straw	6.9	13	74.2	52.9	6.3	40.4	0.4	31.2	45.2	18.1	500	7	0.5	200	19.6	43.92	8.3
wheat straw	6.9	13	74.2	52.9	6.3	40.4	0.4	31.2	45.2	18.1	600	7	0.5	200	19.8	43.45	8.5
wheat straw	6.9	13	74.2	52.9	6.3	40.4	0.4	31.2	45.2	18.1	700	7	0.5	200	19	38.81	8.5
wheat straw	6.9	13	74.2	52.9	6.3	40.4	0.4	31.2	45.2	18.1	800	7	0.5	200	17.5	37.32	9.1
oat straw	17.3	0.1	75.9	48.5	6	45.1	0.4	31.6	49.6	16.6	300	7	0.4	200	29	38.8	6.4
oat straw	17.3	0.1	75.9	48.5	6	45.1	0.4	31.6	49.6	16.6	400	7	0.4	200	28.6	40.79	6.7
oat straw	17.3	0.1	75.9	48.5	6	45.1	0.4	31.6	49.6	16.6	500	7	0.4	200	27.4	42.52	6.9
oat straw	17.3	0.1	75.9	48.5	6	45.1	0.4	31.6	49.6	16.6	600	7	0.4	200	26.9	43.39	6.9
oat straw	17.3	0.1	75.9	48.5	6	45.1	0.4	31.6	49.6	16.6	700	7	0.4	200	27.3	42.57	6.9
oat straw	17.3	0.1	75.9	48.5	6	45.1	0.4	31.6	49.6	16.6	800	7	0.4	200	23	41.41	7.3
linseed	5.6	10.7	77	61	8.5	28.2	2.3	14.1			550	300	1.2	100	13.8	61.59	10.26
Black cumin	4.8	19.18	70.85	51.17	7.95	35.11	5.32	37.14	10.44	26.73	450	35	0.85	200	10.54	48.21	10.35

Environmental Crime Detection

PEDESTRIAN ATTRIBUTE RECOGNITION (P.A.R)

- GENDER CLASSIFICATION
- HAT DETECTION
- BAG DETECTION
- COLOR-CLOTHES CLASSIFICATION

FIRE DETECTION
SMOKE DETECTION

GARBAGE CLASSIFICATION

Agenda

- SUBMISSION Deadline CAIP 2023: 30 JUNE 2023
- SUBMISSION Deadline ICIAP 2023: 21 JULY 2023
  - 11-15 SEPTEMBER 2023 – ICIAP 2023
  - 25-30 SEPTEMBER 2023 – CAIP 2023

https://mivia.unisa.it/onfire2023/

ONFIRE 2023

INTERNATIONAL CONTEST ON FIRE DETECTION

https://mivia.unisa.it/par2023/

PAR CONTEST 2023

INTERNATIONAL CONTEST ON PEDESTRIAN ATTRIBUTE RECOGNITION

Thank you for your attention!