

Omdena - Milan Chapter Agrifoods

AI for Sustainable agri-food systems: use of Satellite Imagery

Exploratory analysis of cereals production in Italy 2020-2022

Author: Mario Fisher

Here we have analysed the major areas and crop produced in Italy. Crop dataset used in this study was downloaded from the Italian National Institute of Statistics (Istat). The objective is to get some insights about crop production and its respective areas in Italy and how climate change have affected crop production in the last 3 years. Maps was created with dataset from Simone Rigoni, the address to the repository of the dataset is available in References.

	Territory	Data type	Type of crop	Select time	Value
0	Torino	total area - hectares	common wheat	2020	15362
1	Torino	total area - hectares	common wheat	2021	16831
2	Torino	total area - hectares	common wheat	2022	16735
3	Torino	total production - quintals	common wheat	2020	844910
4	Torino	total production - quintals	common wheat	2021	925705
...
12125	Pesaro e Urbino	total area - hectares	rye and winter cereal mixtures (maslin)	2022	3
12126	Roma	total area - hectares	rye and winter cereal mixtures (maslin)	2022	20
12127	Valle d'Aosta / Vallée d'Aoste	total area - hectares	winter barley	2022	1
12128	Torino	total area - hectares	spring barley	2022	220
12129	Valle d'Aosta / Vallée d'Aoste	total area - hectares	oats and spring cereal mixtures (mixed grain o...	2022	3

Pre-processing dataset

	Territory	Data type	Type of crop	Select time	Value
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12130 rows × 5 columns

DATASET SHAPE: (12130, 5)

```
FEATURE DATA TYPES:
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 12130 entries, 0 to 12129
Data columns (total 5 columns):
#   Column      Non-Null Count  Dtype
---  --
0   City         12130 non-null    object
1   Data_type    12130 non-null    object
2   Type_crop    12130 non-null    object
3   Year         12130 non-null    int64
4   Value        12130 non-null    int64
dtypes: int64(2), object(3)
memory usage: 474.0+ KB
None
```

NUMBER OF UNIQUE VALUES PER FEATURE:

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City          107
Data_type     3
Type_crop     24
Year          3
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dtype: int64
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```
NULL VALUES PER FEATURE:
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Data_type     0
Type_crop     0
Year          0
Value         0
dtype: int64
```

Cities in Italy producing cereals

```
array(['Torino', 'Vercelli', 'Biella', 'Verbanio-Cusio-Ossola', 'Novara', 'Cuneo', 'Asti', 'Alessandria', 'Valle d'Aosta / Vallée d'Aoste', 'Savona', 'Genova', 'La Spezia', 'Varese', 'Como', 'Lecco', 'Sondrio', 'Milano', 'Bergamo', 'Brescia', 'Pavia', 'Lodi', 'Cremona', 'Mantova', 'Trentino Alto Adige / Südtirol', 'Verona', 'Vicenza', 'Belluno', 'Treviso', 'Venezia', 'Padova', 'Rovigo', 'Pordenone', 'Udine', 'Gorizia', 'Piacenza', 'Parma', 'Reggio nell'Emilia', 'Modena', 'Bologna', 'Ferrara', 'Ravenna', 'Macerata', 'Ascoli Piceno', 'Viterbo', 'Rieti', 'Roma', 'Latina', 'Forlì-Cesena', 'Rimini', 'Massa-Carrara', 'Lucca', 'Pistoia', 'Firenze', 'Prato', 'Livorno', 'Pisa', 'Arezzo', 'Siena', 'Grosseto', 'Perugia', 'Terni', 'Pesaro e Urbino', 'Ancona', 'Salerno', 'Foggia', 'Bari', 'Taranto', 'Brindisi', 'Potenza', 'Matera', 'Cosenza', 'Crotone', 'Catanzaro', 'Vibo Valentia', 'Reggio di Calabria', 'Messina', 'Catania', 'Sassari', 'Nuoro', 'Cagliari', 'Oristano', 'Lecco', 'Trapani', 'Palermo', 'Agrigento', 'Caltanissetta', 'Siracusa', 'Ragusa', 'Napoli', 'Monza e della Brianza', 'Fermo', 'Barletta-Andria-Trani', 'Enna', 'Sud Sardegna', 'Bolzano / Bozen', 'Imperia'], dtype=object)
```

```
array(['total area - hectares', 'total production - quintals', 'harvested production - quintals'], dtype=object)
```

Select only Values for total production - quintals

In general crop production is reported in tonnes per hectare , however Istat (<http://dati.istat.it>) does not give variables definition, so we have assumed that the column 'Value' for rows containing data for 'harvested production - quintals', are values for total production of cereals.

City	Data_type	Type_crop	Year	Value
3	Torino	total production - quintals	common wheat	2020 844910
4	Torino	total production - quintals	common wheat	2021 925705
5	Torino	total production - quintals	common wheat	2022 836750
12	Vercelli	total production - quintals	common wheat	2020 64250
13	Vercelli	total production - quintals	common wheat	2021 74550

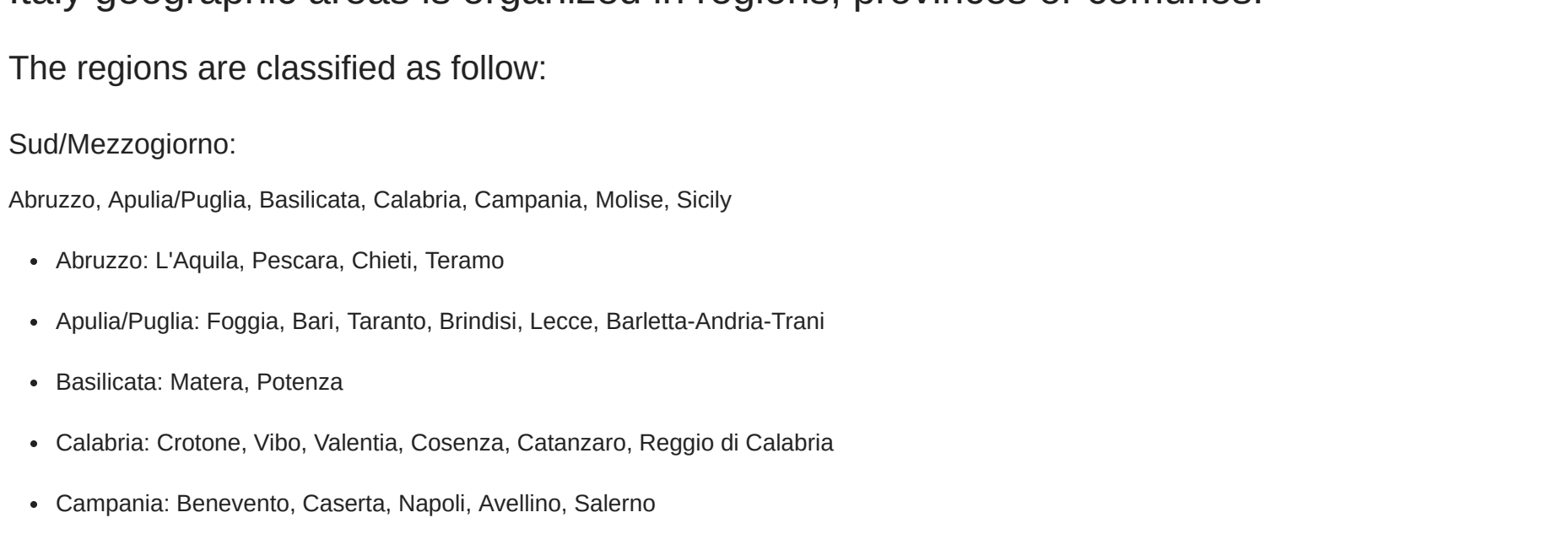
	City	Data_type	Type_crop	Year	Total_production
3	Torino	total production - quintals	common wheat	2020	844910
4	Torino	total production - quintals	common wheat	2021	925705
5	Torino	total production - quintals	common wheat	2022	836750
12	Vercelli	total production - quintals	common wheat	2020	64250
13	Vercelli	total production - quintals	common wheat	2021	74550
...
12059	Trentino Alto Adige / Südtirol	total production - quintals	winter barley	2022	200
12064	Trentino Alto Adige / Südtirol	total production - quintals	spring barley	2021	1890
12065	Trentino Alto Adige / Südtirol	total production - quintals	spring barley	2022	1700
12070	Trentino Alto Adige / Südtirol	total production - quintals	oats and spring cereal mixtures (mixed grain o...	2021	372
12071	Trentino Alto Adige / Südtirol	total production - quintals	oats and spring cereal mixtures (mixed grain o...	2022	280

4042 rows × 5 columns

	City	Data_type	Type_crop	Year	Total_production
3	Torino	total production - quintals	common wheat	2020	844910
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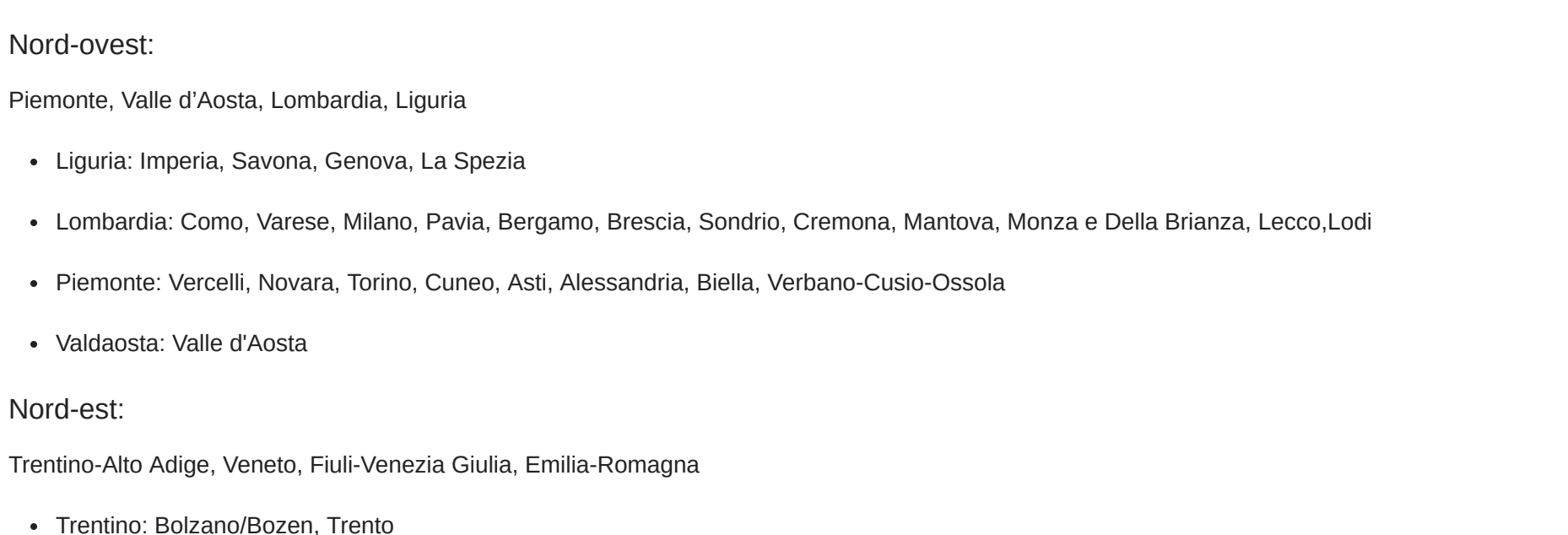
4042 rows × 4 columns

Total cereal production in 2020-2022



Cereal production by Cities

City	Total_production
93	Torino 23124980
32	Ferrara 2346682
34	Foggia 22442368
65	Pavia 19838758
29	Cuneo 19837083
82	Rovigo 18998091
51	Mantova 18620664
62	Padova 18030596
100	Venezia 17475472
14	Bologna 16205989



Italy geographic areas is organized in regions, provinces or communes.

The regions are classified as follow:

Sud/Mezzogiorno:

Abruzzo, Puglia, Basilicata, Calabria, Campania, Molise, Sicily

- Abruzzo: L'Aquila, Pescara, Chieti, Teramo
- Apulia/Puglia: Foggia, Bari, Taranto, Brindisi, Lecce, Barletta-Andria-Trani
- Basilicata: Matera, Potenza
- Calabria: Crotone, Vibo, Valentia, Cosenza, Catanzaro, Reggio di Calabria
- Campania: Benevento, Caserta, Napoli, Avellino, Salerno
- Molise: Campobasso, Isernia
- Sicilia: Messina, Siracusa, Agrigento, Caltanissetta, Trapani, Enna, Palermo, Catania, Ragusa
- Sardegna: Oristano, Carbonia-Iglesias, Olbia-Tempio, Ogliastra, Medio Campidano, Sassari, Nuoro, Cagliari

Centro:

Toscana, Umbria, Marche, Lazio

- Toscana: Pistoia, Firenze, Massa-Carrara, Lucca, Arezzo, Livorno, Pisa, Grosseto, Siena, Prato
- Umbria: Perugia, Terni
- Marche: Ancona, Macerata, Ascoli Piceno, Pesaro e Urbino, Fermo
- Lazio: Roma, Viterbo, Rieti, Latina, Frosinone

Nord-ovest:

Piemonte, Valle d'Aosta, Lombardia, Liguria

- Liguria: Imperia, Savona, Genova, La Spezia
- Lombardia: Como, Varese, Milano, Pavia, Bergamo, Brescia, Sondrio, Cremona, Mantova, Monza e Della Brianza, Lecco, Lodi
- Piemonte: Vercelli, Novara, Torino, Cuneo, Asti, Alessandria, Biella, Verbanio-Cusio-Ossola
- Val d'Aosta: Valle d'Aosta

Nord-est:

Trentino-Alto Adige, Veneto, Friuli-Venezia Giulia, Emilia-Romagna

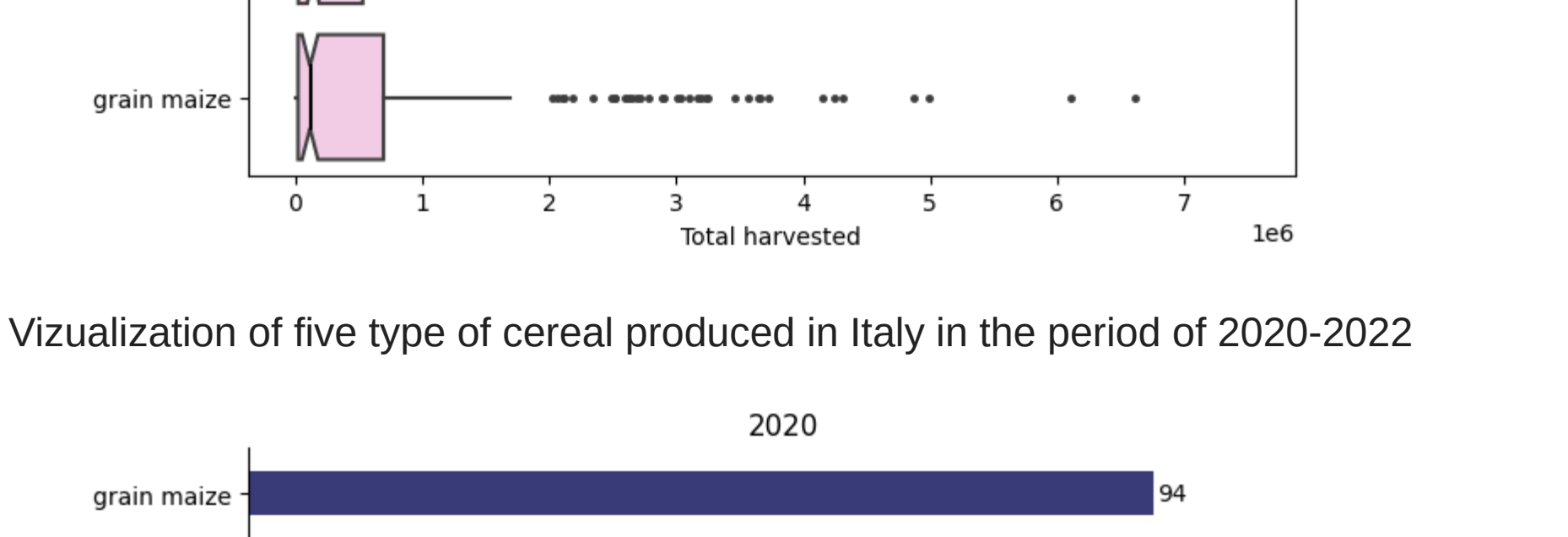
- Trentino: Bolzano/Bozen, Trento
- Veneto: Belluno, Verona, Vicenza, Rovigo, Treviso, Venezia, Padova
- Friuli: Udine, Gorizia, Trieste, Pordenone
- Emilia-Romagna: Parma, Reggio nell'Emilia, Piacenza, Forlì-Cesena, Modena, Bologna, Ferrara, Ravenna, Rimini

Cereals highest production 2020-2022

winter cereal mixtures (maslin)	368
oats	299
durum wheat	286
common wheat	284
grain maize	284
broad bean	284
chick-peas	235
other cereals	226
dried kidney beans	221
oats and spring cereal mixtures (mixed grain other than maslin)	195
protein pea	193
common winter wheat and spelt	187
winter cereal mixtures (maslin)	174
lentil	171
rye	163
grain pea	155
triticale	144
rye and winter cereal mixtures (maslin)	168
peas	69
sweet lupin	46
spring barley	42
common spring wheat and spelt	42
winter cereal mixtures (maslin)	129
spring cereal mixtures (mixed grain other than maslin)	4
Name: Type_crop, dtype: int64	

Dataset shows there are 24 different types of cereals cultivated in Italy. The top five most produced crops are Wheat, Barley, Maize, Beans and Oats.

	Year	Total_production
count	4042.000000	4.042000e+03
mean	2021.082880	1.411529e+05
std	0.788942	4.820117e+05
min	2020.000000	0.000000e+00
25%	2020.000000	7.200000e+02
50%	2021.000000	5.032500e+03
75%	2022.000000	6.139200e+04
max	2022.000000	7.500000e+06

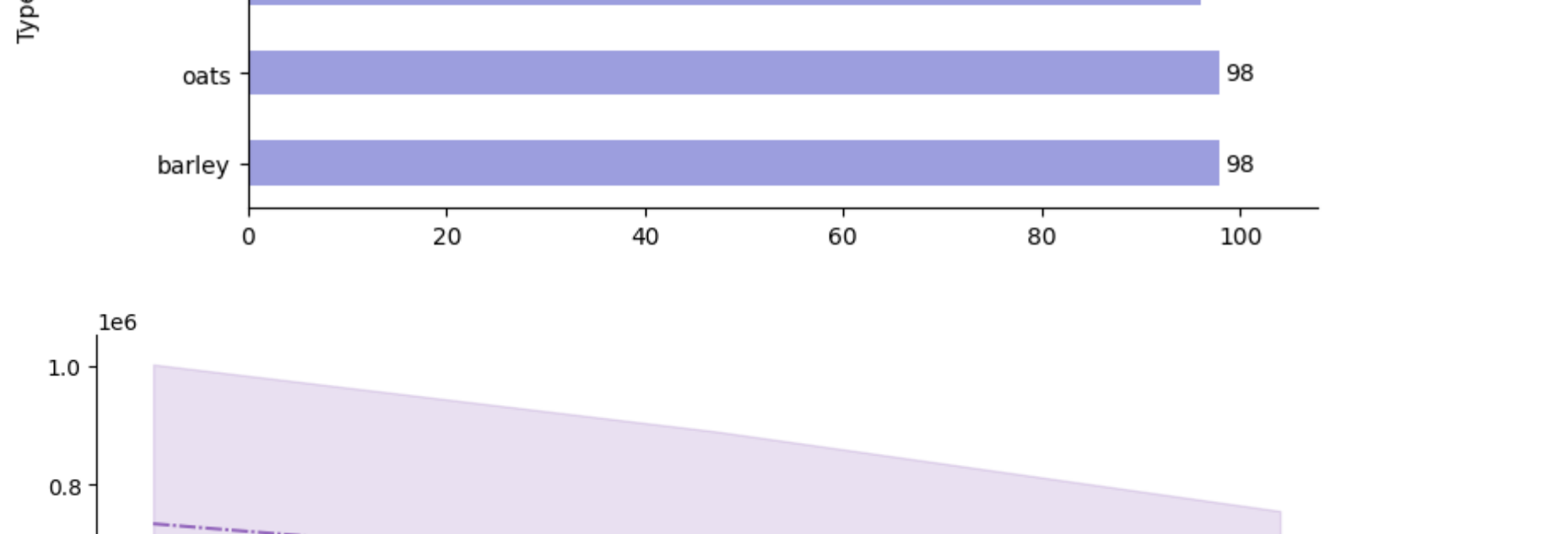


Subsetting data

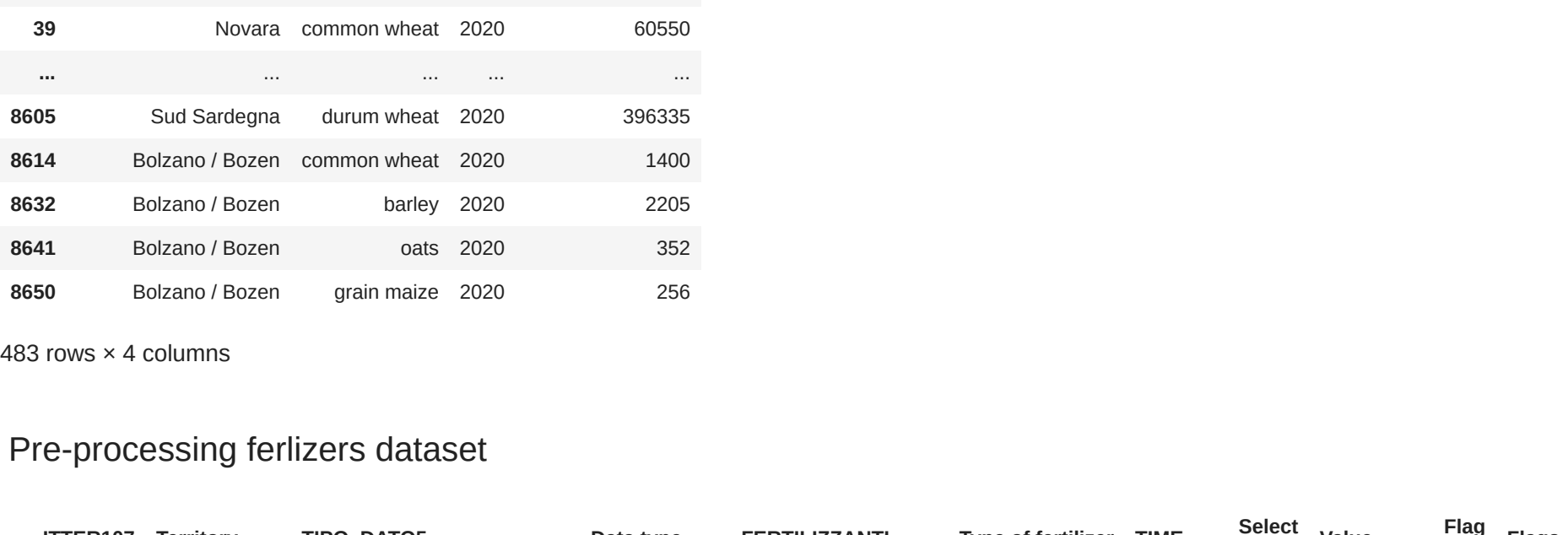
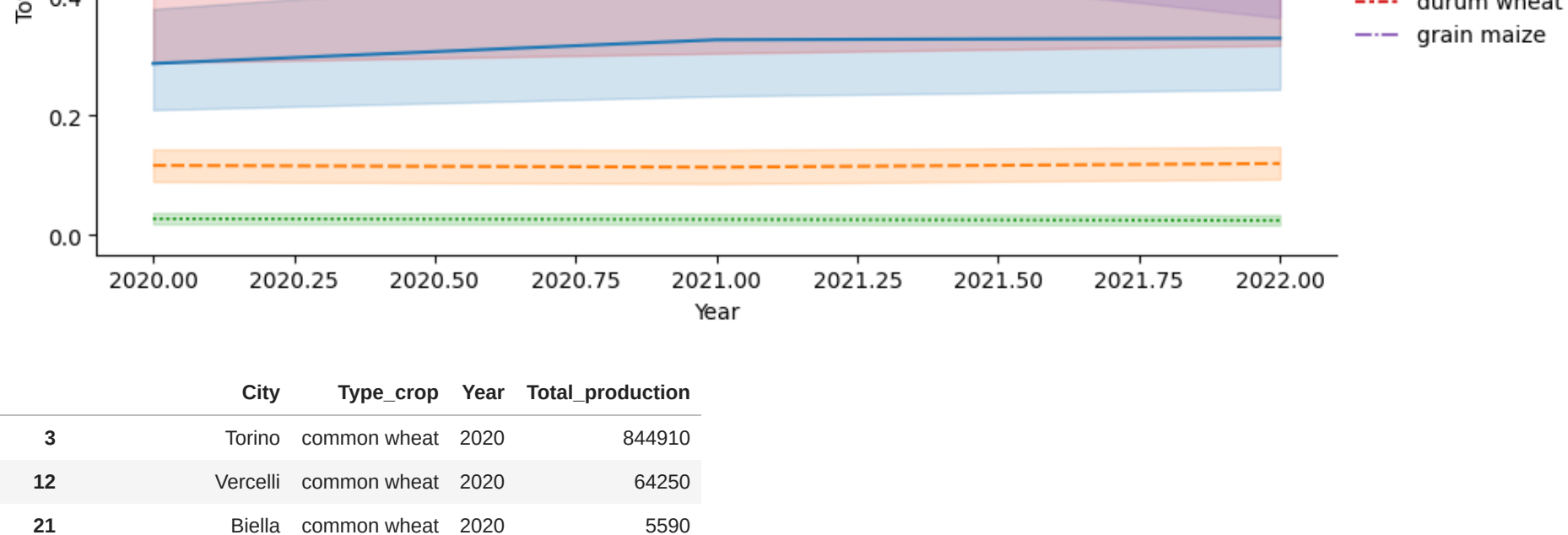
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12	Vercelli	common wheat	2020	64250
13	Vercelli	common wheat	2021	74550

Stats

	Year	Total_production
count	1444	1444
mean	2020	304859
std	0	696586
min	2020	0
25%	2020	5606
50%	2021	62000
75%	2022	232845
max	2022	7500000



Vizualization of five type of cereal produced in Italy in the period of 2020-2022



	City	Type_crop	Year	Total_production
3	Torino	common wheat	2020	844910
12	Vercelli	common wheat	2020	64250
21	Biella	common wheat	2020	5590
30	Verbanio-Cusio-Ossola	common wheat	2020	130
39	Novara	common wheat	2020	60550
...
8605	Sud Sardegna	durum wheat	2020	396335
8614	Bolzano / Bozen	common wheat	2020	1400
8632	Bolzano / Bozen	barley	2020	2205
8641	Bolzano / Bozen	oats	2020	352
8650	Bolzano / Bozen	grain maize	2020	256

483 rows × 4 columns

Pre-processing fertilizers dataset

16764	Sud Sardegna	fertilizers distributed - tonnes	specific action products -	2021	193
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16765 rows x 5 columns

```
array(['Rimini', 'Trieste', 'Pisa', 'Pordenone', 'Venezia', 'Firenze',  
       'Perugia', 'Enna', 'Nuoro', 'Ferrara', 'Bologna', 'Ascoli Piceno',  
       'Roma', 'Verona', 'Messina', 'Parma', 'Oristano', 'Siena',  
       'Vibo Valentia', 'Monza e della Brianza', 'Varese', 'Novara',  
       'Cuneo', 'Grassano', 'Rieti', 'Pavia', 'Ancona', 'Pesaro e Urbino',  
       'Forlì-Cesena', 'Reggio di Calabria', 'Chieti', 'Cremona', 'Udine',  
       'Lecce', 'Avellino', 'Potenza', 'Lucca', 'Padova', 'Gorizia',  
       'Savona', 'Pescarara', 'Caltanissetta', 'Brescia',  
       'Trentino Alto Adige / Südtirol', 'Benevento', 'Viterbo',  
       'Sassari', 'Treviso', 'Como', 'Provincia Autonoma Bolzano / Bozen',  
       'Teramo', 'Latina', 'Catania', 'Valle d'Aosta / Vallée d'Aoste',  
       'Verbanio-Cusio-Ossola', 'Belluno', 'Catanzaro', 'Genova',  
       'Cagliari', 'Matera', 'Agrigento', 'Cosenza', 'Mantova', 'Pescara',  
       'Piemonte', 'Puglia', 'Ragusa', 'Salerno', 'Sardinia', 'Sicily',  
       'Trentino', 'Tuscany', 'Umbria', 'Veneto', 'Abruzzo', 'Basilicata',  
       'Calabria', 'Emilia-Romagna', 'Friuli Venezia Giulia', 'Liguria',  
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```

	Territory	Data type	Type of fertilizer	Select time	Value
0	Rimini	fertilizers distributed - tonnes	containing micronutrients	2019	11
1	Rimini	fertilizers distributed - tonnes	containing micronutrients	2020	11
2	Rimini	fertilizers distributed - tonnes	containing micronutrients	2021	3
3	Trieste	fertilizers distributed - tonnes	peaty soil amendment	2019	8
4	Trieste	fertilizers distributed - tonnes	peaty soil amendment	2020	105
...
17670	Sud Sardegna	fertilizers distributed - tonnes	specific action products -	2020	422
17671	Sud Sardegna	fertilizers distributed - tonnes	specific action products -	2021	543
17672	Sud Sardegna	fertilizers distributed - tonnes	specific action products -	2019	164
17673	Sud Sardegna	fertilizers distributed - tonnes	specific action products -	2020	135
17674	Sud Sardegna	fertilizers distributed - tonnes	specific action products -	2021	193

17675 rows × 5 columns

	City	Type_fertilizer	Year	Fertilizers_tonnes
0	Rimini	containing micronutrients	2019	11
1	Rimini	containing micronutrients	2020	11
2	Rimini	containing micronutrients	2021	3
3	Trieste	peaty soil amendment	2019	8
4	Trieste	peaty soil amendment	2020	105
...
17670	Sud Sardegna	specific action products -	2020	422
17671	Sud Sardegna	specific action products -	2021	543
17672	Sud Sardegna	specific action products -	2019	164
17673	Sud Sardegna	specific action products -	2020	135
17674	Sud Sardegna	specific action products -	2021	193

17675 rows × 4 columns

	City	Type_fertilizer	Year	Fertilizers_tonnes
1	Rimini	containing micronutrients	2020	11
4	Trieste	peaty soil amendment	2020	105
7	Pisa	specific action products	2020	87
10	Pordenone	three components - nitrogen-phosphorus-phosphorus	2020	2547
13	Venezia	soil correctives - sulphur for agricultural use	2020	5
...
17661	Sud Sardegna	soil correctives - other soil correctives	2020	2
17664	Sud Sardegna	crop substrates	2020	112
17667	Sud Sardegna	specific action products	2020	557
17670	Sud Sardegna	specific action products -	2020	422
17673	Sud Sardegna	specific action products -	2020	135

5892 rows × 4 columns

Selecting only 6 type of fertilizers for future analysis

```
array(['containing micronutrients', 'peaty soil amendment', 'specific action products', 'three components - nitrogen-phosphorus-phosphorus', 'soil correctives - sulphur for agricultural use', 'two components - nitrogen-potassium', 'containing micronutrients containing only a micronutrient', 'organic fertilizers - compound', 'manure amendment', 'vegetable soil amendment', 'containing micronutrients containing several micronutrients in chelated form', 'containing micronutrients containing several micronutrients in mineral form', 'other fertilizers different from sulphate and chloride', 'two components - phosphorus-potassium', 'potassium fertilizers - containing macronutrients', 'triple superphosphate', 'organic-mineral fertilizers - straight nitrogen', 'other soil amendments', 'other fertilizers different from calcium cyanamide, nitrates, ammonium sulphate, urea', 'mixed soil amendment', 'crop substrates', 'containing only one secondary macronutrient - calcium oxide', 'compound
```


	City	Type_fertilizer	Year	Fertilizers_tonnes	
				ammonium sulphate	calcium cyanamide
76	Pavia	ammonium sulphate	2020	747	0
154	Benevento	calcium cyanamide	2020	0	1423
172	Provincia Autonoma Bolzano / Bozen	ammonium sulphate	2020	31	0
235	Alessandria	nitrogen fertilizers	2020	2251	0

Create new dataframe with the selected type of fertilizers as columns

		Fertilizers_tonnes					
City	Type_fertilizer	ammonium sulphate	calcium cyanamide	nitrogen fertilizers	organic fertilizers	phosphorus fertilizers	potassium fertilizers
	Year						
Agrigento	2020	155	12	1715	4006	142	16
Alessandria	2020	135	105	20968	2251	782	743
Ancona	2020	567	17	22511	2695	1258	33
Arezzo	2020	68	26	3675	2053	72	209
Ascoli Piceno	2020	8	158	1065	1284	22	267
...
Vercelli	2020	14	2570	7604	6585	0	1013
Verona	2020	3919	258	66460	9529	9363	6141
Vibo Valentia	2020	1433	0	2487	92	157	0
Vicenza	2020	1350	225	10182	1252	220	351
Viterbo	2020	176	0	14138	2673	603	10

108 rows × 6 columns

		Fertilizers_tonnes					
City	Type_fertilizer	ammonium sulphate	calcium cyanamide	nitrogen fertilizers	organic fertilizers	phosphorus fertilizers	potassium fertilizers
	Year						
Agrigento	2020	155	12	1715	4006	142	16
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		Fertilizers_tonnes					
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	Year						
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Viterbo	2020	176	0	14138	2673	603	10

108 rows × 6 columns

	Total_production	ammonium sulphate	calcium cyanamide	nitrogen fertilizers	organic fertilizers	phosphorus fertilizers	potassium fertilizers
cereal cyanamide	0.49	0.12	1	0.35	0.49	0.13	0.36
nitrogen fertilizers	0.3	0.54	0.39	1	0.34	0.77	0.72
organic fertilizers	0.04	0.46	0.48	0.34	1	0.25	0.21
phosphorus fertilizers	0.22	0.56	0.13	0.77	0.25	1	0.42
potassium fertilizers	0.25	0.29	0.36	0.72	0.21	0.42	1

The correlation analysis shows that total cereal production in Italy with correlation greater or equal to 0.5 between phosphorus and potassium with nitrogen fertilizer.

Modelling

References

<http://daa1.istat.it>

<https://maps.princeton.edu/catalog?stanford-mn871399778>

https://www.crea.gov.it/documents/68457/0/ITACONTA+2020_ENG+DEF+web+%281%29.pdf?95c6b30a-1e18-8e94-d4ac-ce884ae76e6?t=1619527317576

<https://seaborn.pydata.org/generated/seaborn.relplot.html>

108 rows × 8 columns

		Fertilizers_tonnes								
City	Type_crop	Year	Total_production	ammonium sulphate	calcium cyanamide	nitrogen fertilizers	organic fertilizers	phosphorus fertilizers	potassium fertilizers	
0	Torino	common wheat	2020	844910	107.0	356.0	33960.0	1973.0	105.0	7853.0
1	Vercelli	common wheat	2020	64250	14.0	2570.0	7604.0	6585.0	0.0	1013.0
2	Biella	common wheat	2020	5590	0.0	18.0	379.0	127.0	0.0	15.0
3	Verbano-Cusio-Ossola	common wheat	2020	130	0.0	0.0	0.0	18.0	0.0	0.0
4	Novara	common wheat	2020	60550	151.0	882.0	7034.0	1723.0	56.0	1137.0
...
478	Sud Sardegna	durum wheat	2020	396335	6.0	0.0	430.0	138.0	7.0	59.0
479	Bolzano / Bozen	common wheat	2020	1400	NaN	NaN	NaN	NaN	NaN	NaN
480	Bolzano / Bozen	barley	2020	2205	NaN	NaN	NaN	NaN	NaN	NaN
481	Bolzano / Bozen	oats	2020	352	NaN	NaN	NaN	NaN	NaN	NaN
482	Bolzano / Bozen	grain maize	2020	256	NaN	NaN	NaN	NaN	NaN	NaN

483 rows × 10 columns

Correlation analysis



The correlation analysis shows that total cereal production in Italy with correlation greater or equal to 0.5 between phosphorus and potassium with nitrogen fertilizer.

Modelling

References

- <http://dati.istat.it>
- <https://maps.princeton.edu/catalog/stanford-mm871sp9778>
- https://www.crea.gov.it/documents/68457/0/ITACONTA+2020_ENG+DEF+xweb+%281%29.pdf/95c6b30a-1e18-8e94-d4ac-ce884ae176e8?t=1619527317576
- <https://seaborn.pydata.org/generated/seaborn.relplot.html>