Pacific Institute for the Mathematical Sciences

Math INDUSTRY

Analysis of components of food production for sustainability in Canada

TheoryMesh

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Outline

TheoryMesh and food sustainability challenge

A bit background

Co-founders:

- Chris Bunio (mentor), Paul Westdal, Sephanie Westdal, Anne Kirk.
- Started 2019.
- Increasing transparency in the food supply chain.

Vision and Goals

1. Provide the platform to integrate data from first inputs to consumer purchase, creating a traceable, efficient and intelligent supply chain.
2. Certification.
3. Tracability.
4. Sustainability.

Outline

The problem proposed

What TheoryMesh is looking for through the PIMS 2021 challenge can be condensed to the following:

- Develop a model and a system of action using open data to better understand and ideally, predict the environmental impact from agricultural practices.
- Leveraging said model to complement the current TheoryMesh system which is capturing individual operation level impact from farm activities.
- Combining the macro-level environmental indicators from agricultural practices and micro-level data from farm activities and operations, TheoryMesh can, ideally, measure and predict sustainability levels of consumer-level products to better inform the consumers and help companies meet their sustainability goals.

The problem requires us to analyze indicators like air and GHG emissions, fish and meat consumption levels, the impact of organic farming, the usage rate of various types of pesticides and herbicides, the chemical spread on total agricultural land, and many other factors.

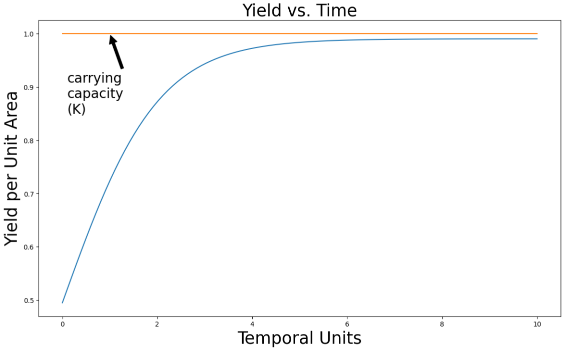
Relevance of the problem

Outline

Availability of information for producers

- Information is power.
- Currently, the relavent information resides in technical journals that is penetrable only for researchers and experts in the field.
- Needs to be available/intelligible to producers.
- The general sentiment conveyed by industry participants:
  - There needs to be a change in the way that information is disseminated.
  - It used to be that the when/where/how questions of crop production were passed by word of mouth: "Do this because it has always worked."
  - This is no longer tenable with the rapidly changing climate/environmental conditions.
  - Over the coming decades that will span a contemporary producer's career, they will invariably need to adjust their approaches.

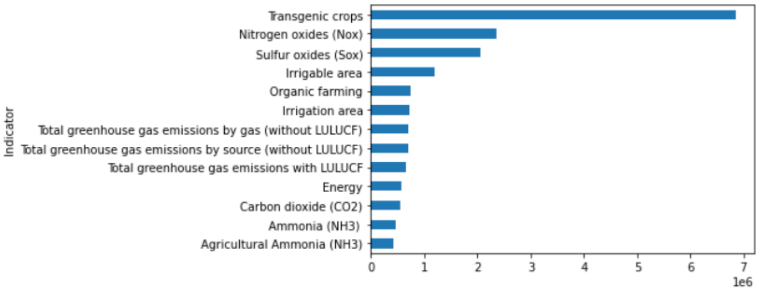
What can be gleaned from the data?

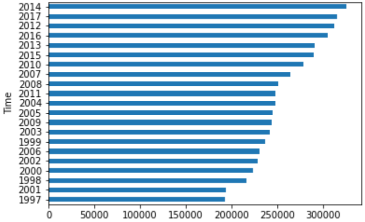


- $K = K(x_1, x_2, \ldots, x_n)$, where no x_i is a temporal variable.

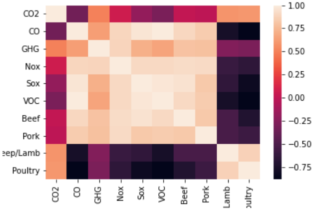
Factors Affecting K

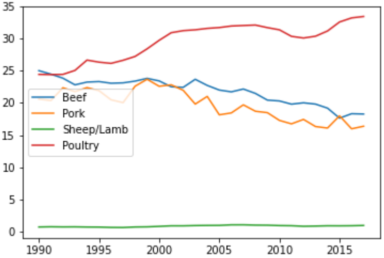
Outline

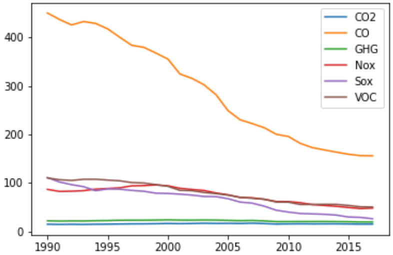

Transgenic crops
Nitrogen oxides (Nox)
Sulfur oxides (Sox)
Irrigable area
Organic farming
Irrigation area
Total greenhouse gas emissions by gas (without LULUCF)
Total greenhouse gas emissions by source (without LULUCF)
Total greenhouse gas emissions with LULUCF
Energy
Carbon dioxide (CO2)
Ammonia (NH3)
Agricultural Ammonia (NH3)
Indicator
0 1 2 3 4 5 6 7
1e6

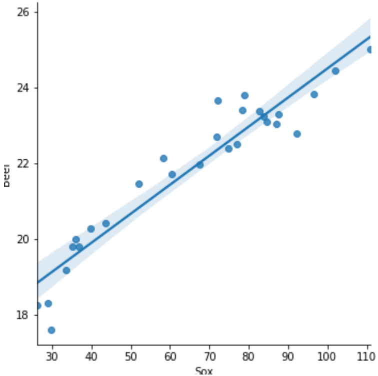

2014
2017
2012
2016
2013
2015
2010
2007
2008
2011
2004
2005
2009
2003
1999
2006
2002
2000
1998
2001
1997
Time
0 50000 100000 150000 200000 250000 300000

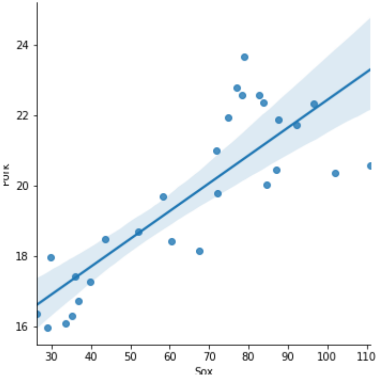
	CO2	CO	GHG	Nox	Sox	VOC	Beef	Pork	Sheep/Lamb	Poultry
CO2	1.00	-0.34	0.50	0.07	-0.19	-0.30	0.02	-0.00	0.59	0.60
CO	-0.34	1.00	0.63	0.89	0.97	1.00	0.90	0.84	-0.77	-0.88
GHG	0.50	0.63	1.00	0.89	0.71	0.66	0.80	0.79	-0.26	-0.29
Nox	0.07	0.89	0.89	1.00	0.91	0.91	0.93	0.91	-0.60	-0.65
Sox	-0.19	0.97	0.71	0.91	1.00	0.97	0.95	0.83	-0.64	-0.82
VOC	-0.30	1.00	0.66	0.91	0.97	1.00	0.91	0.85	-0.77	-0.88
Beef	0.02	0.90	0.80	0.93	0.95	0.91	1.00	0.82	-0.52	-0.72
Pork	-0.00	0.84	0.79	0.91	0.83	0.85	0.82	1.00	-0.53	-0.58
Sheep/Lamb	0.59	-0.77	-0.26	-0.60	-0.64	-0.77	-0.52	-0.53	1.00	0.87
Poultry	0.60	-0.88	-0.29	-0.65	-0.82	-0.88	-0.72	-0.58	0.87	1.00

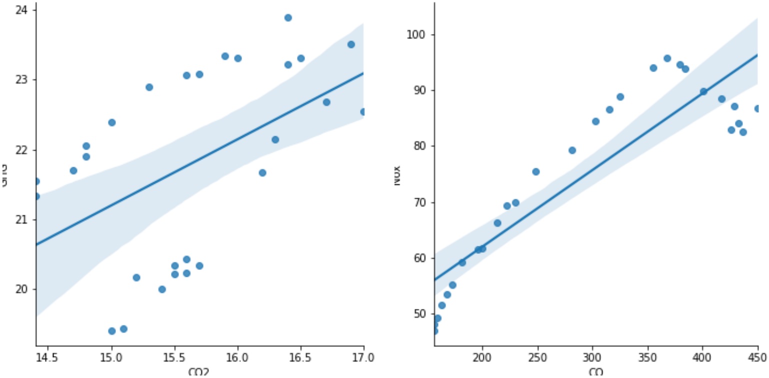



35
30
25
20
15
10
5
0
1990
1995
2000
2005
2010
2015
Beef
Pork
Sheep/Lamb
Poultry


400
300
200
100
0
1990
1995
2000
2005
2010
2015
CO2
CO
GHG
Nox
Sox
VOC


26
24
22
20
18
30 40 50 60 70 80 90 100 110
Sox


24
22
20
18
16
30 40 50 60 70 80 90 100 110
Sox


24
23
22
21
20
14.5
15.0
15.5
16.0
16.5
17.0
CO2
100
90
80
70
60
50
200
250
300
350
400
450
CO

References

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OECD Publishing, K. Parris et-al. (2010), Sustainable management of water resources in agriculture.