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Are South African grape growers aware of their climatic comparative advantages for growing certain grape varieties? A hedonic approach applying machine learning

AAWE Meeting - Vienna 2019



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RUB



Are South African grape growers ware of their climatic comparative advantages for growing certain grape varieties? A hedonic approach applying machine learning

- 1. Wine Production in South Africa**
- 2. Climate in South Africa**
- 3. Research Questions**
- 4. Data**
- 5. Model**
- 6. Results**



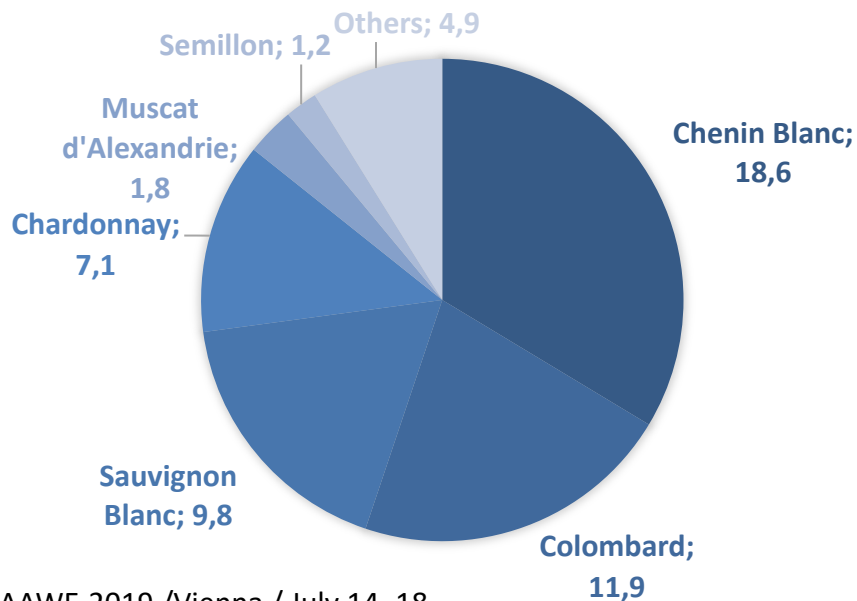
Franschhoek / wikipedia.com

1. Wine Production in South Africa (Sawis 2019)

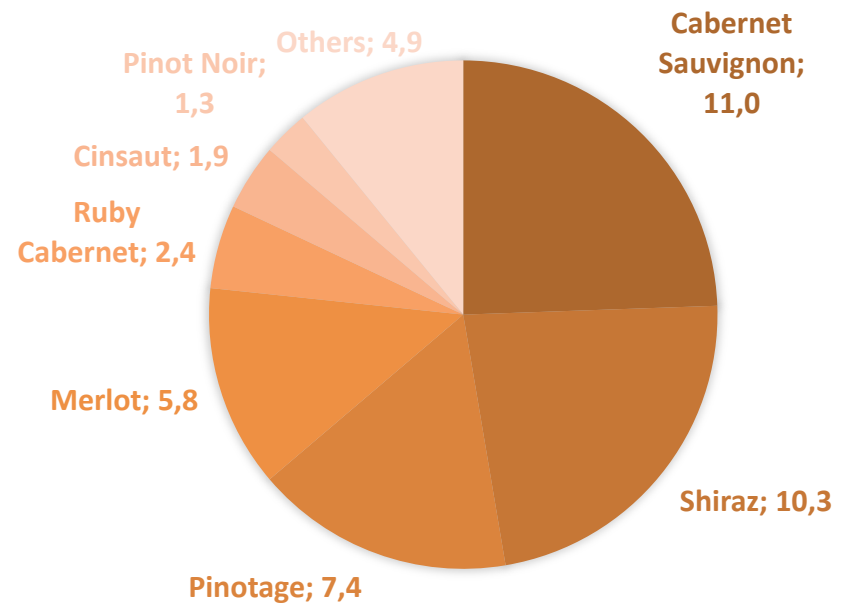


94,545 ha for wine grapes
10 regions
10.8 million hl (2017)

WHITE GRAPES IN %

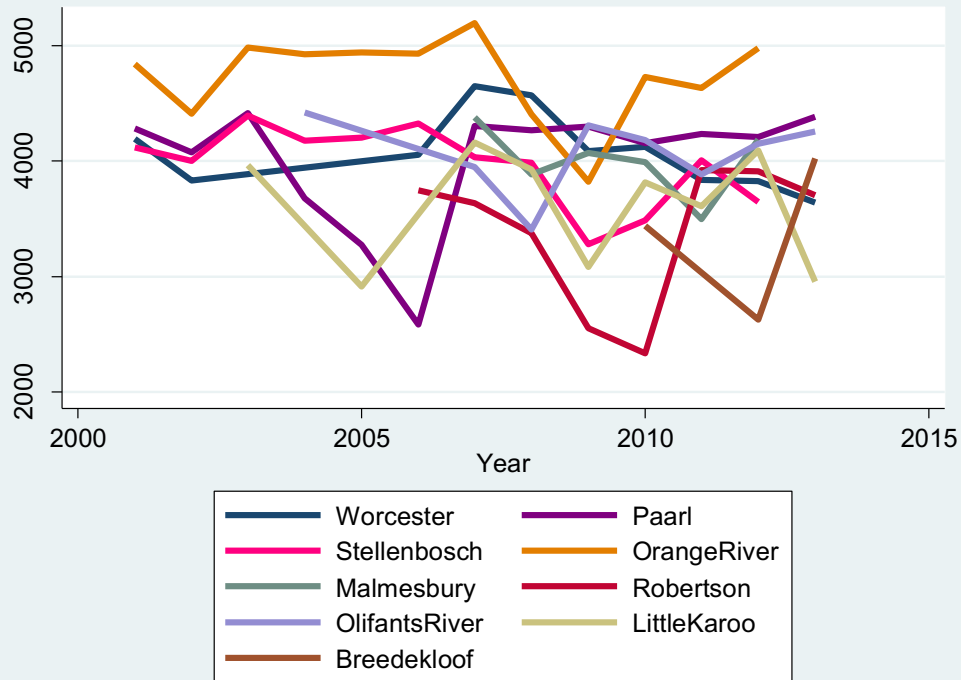


RED GRAPES IN %

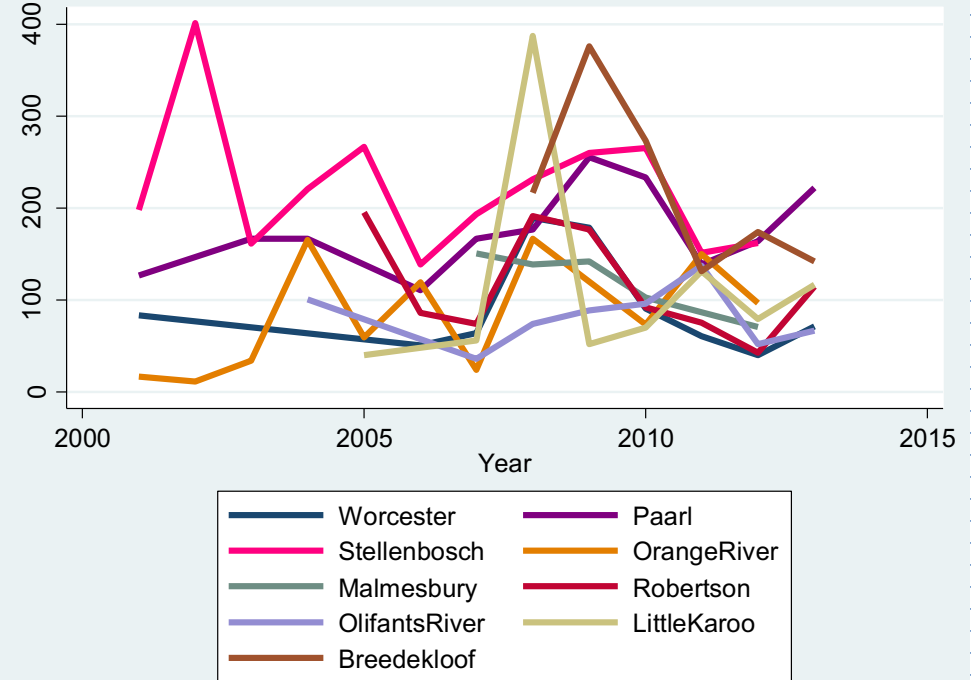


2. Climate in South Africa

sum of radiation growing time



sum of rainfall growing time



3. Research Questions

Assumption:
Each region has its own competitive advantage in growing certain grape varieties!

1

- Which weather is advantageous for which grape variety in terms of yields?

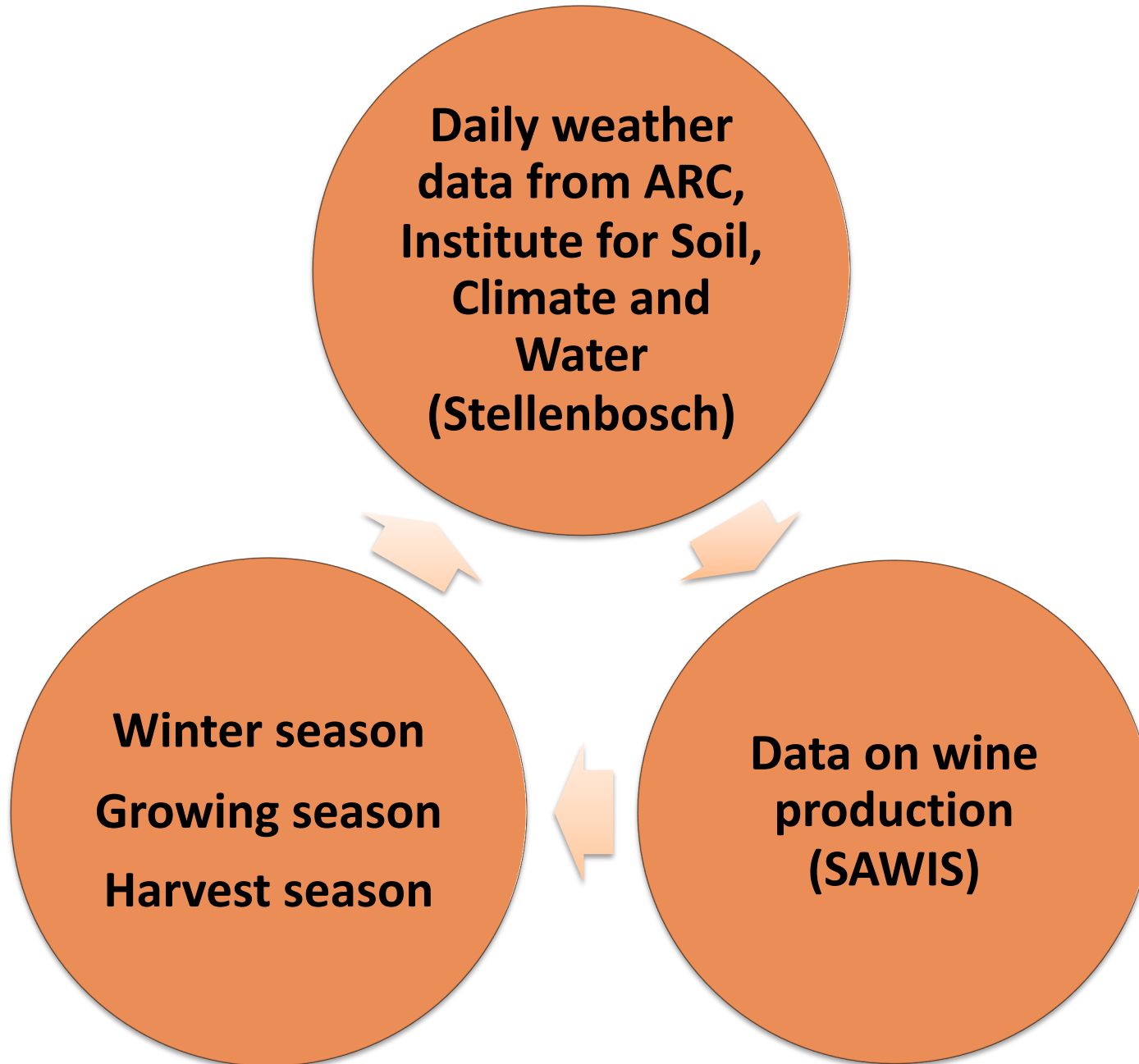
2

- Which region should grow which grape variety?

3

- Are South African producers aware of their comparative advantages of growing certain grape varieties in their region?

4. Data (Years 2001 – 2013)



Grape Varieties

Chenin Blanc,
Colombard,
Sauvignon Blanc,
Chardonnay
Semillon

Cab. Sauvignon,
Shiraz,
Pinotage,
Merlot,
Ruby Cabernet

4. Data

Descriptive Statistics for White Wine (all regions)

Attributes	Obs.	Mean	Std.Dev.	Min.	Max.
Year	64	2008.73	3.10	2001.00	2013.00
Trend	64	10.73	3.10	3.00	15.00
Age	64	13.48	1.15	10.42	15.34
Temperature Winter	64	12.73	1.08	10.12	15.35
Temperature Growing	64	20.11	1.70	18.48	24.88
Temperature Harvest	64	22.85	1.67	19.67	27.60
Percipitation Growing	64	137.79	78.89	17.00	401.20
Percipitation Harvest	64	22.63	20.82	1.00	98.30
Radiation Growing	64	3969.09	594.00	2333.99	5192.16
Radiation Harvest	64	936.87	127.58	526.79	1156.92
Yield/ha Chenin Blanc	64	14.56	6.69	4.88	27.75
Yield/ha Colombard	63	18.32	7.28	4.38	33.89
Yield/ha Sauvignon Blanc	58	8.76	4.11	1.64	19.85
Yield/ha Chardonnay	64	8.83	3.58	2.83	21.82
Yield/ha Semillon	50	11.21	4.29	5.10	20.86

4. Data

Descriptive Statistics for Red Wine (all regions)

Attributes	Obs.	Mean	Std.Dev.	Min.	Max.
Year	64	2008.73	3.10	2001.00	2013.00
Trend	64	10.35	1.52	5.77	13.16
Age	64	10.73	3.10	3.00	15.00
Temperature Winter	64	12.73	1.08	10.12	15.35
Temperature Growing	64	20.11	1.70	18.48	24.88
Temperature Harvest	64	22.85	1.67	19.67	27.60
Percipitation Growing	64	137.79	78.89	17.00	401.20
Percipitation Harvest	64	22.63	20.82	1.00	98.30
Radiation Growing	64	3969.09	594.00	2333.99	5192.16
Radiation Harvest	64	936.87	127.58	526.79	1156.92
Yield/Ha Cabernet Sauvignon	64	7.29	2.75	2.14	13.53
Yield/Ha Shiraz	64	9.39	3.38	3.49	18.32
Yield/Ha Pinotage	64	11.30	3.90	3.73	21.64
Yield/Ha Merlot	64	9.39	3.39	3.07	17.15
Yield/Ha Ruby Cabernet	64	19.53	34.54	5.98	62.73

5. Model

Hedonic approach

1. Artificial neural networks to build regression models for each grape variety

$$\log \text{ yield/ha} = f(\text{weather variables, trend, age}).$$

2. Sensitivity Analysis to find advantageous weather scenarios for each grape.

3. Calculating the trend b for independent variables

$$b = \frac{n \sum xy - (\sum x)(\sum y)}{n \sum x^2 - (\sum x)^2}$$

4. Matching trends of weather in region and sensitivities (trend) of independent variables for each grape variety + recommendations.

5. Matching of ha distribution trends of each grape variety/region with recommendations.

6. Results

1. Artificial neural networks to build regression models for each grape variety
2. Sensitivity Analysis to find advantageous weather scenarios for each grape.

ANN MODEL Log(yield/ha) Semillon	MSE	RMSE	MAE	R2							
	Depend.	avg. elast	Breedekloof	Little Karoo	Malmesbury	Olifants River	Orange River	Paarl	Robertson	Stellenbosch	Worcester
	0,069	0,263	0,186	0,934							
Trend	0,15	-0,0756	-0,2969	-0,1208	-0,0075	-0,052	-0,0646	-0,1173	0,0178	-0,0217	-0,0694
Age	0,31	-0,0518	0,1006	-0,1509	-0,1818	0,0513	-0,1711	0,0248	-0,196	0,1301	0,238
Temperature Winter	0,751	0,2085	1,2117	0,1995	-0,2269	0,287	-0,0176	0,4795	-0,346	0,3115	0,6654
Temperature Growing	0,577	-0,0484	-0,8441	-0,1086	0,2999	-0,0982	0,107	-0,2223	0,3509	-0,0744	-0,2487
Temperature Harvest	1	-0,6099	-2,0854	-0,7487	-0,1154	-0,5332	-0,444	-0,9699	0,111	-0,4441	-0,9489
Percipitation Growing	0,182	-0,1104	-0,2902	-0,0766	-0,0383	-0,1254	-0,0618	-0,1802	0,0081	-0,1496	-0,2707
Percipitation Harvest	0,32	0,1762	0,6529	0,255	0,0252	0,1342	0,1423	0,2755	-0,036	0,0817	0,2063
Radiation Growing	0,211	-0,1258	-0,3898	-0,1147	-0,0266	-0,132	-0,0743	-0,2078	0,0249	-0,1414	-0,2704
Radiation Harvest	0,31	0,1362	0,5414	0,2642	0,03	0,0625	0,1473	0,1922	-0,007	-0,0257	0,0204

6. Results

3. Calculating the trends

ID	Year	Temp Winter	Temp Growing	Temp Harvest	Percipitation Growing	Percipitation Harvest	Radiation Growing	Radiation Harvest
Stellenbosch	2001	14,09	18,58	21,36	198,4	3,8	4117,8	1013,14
Stellenbosch	2002	13,19	18,84	22,68	401,2	18,2	4003,11	989,89
Stellenbosch	2003	12,03	18,79	20,64	161,4	97,8	4391,41	966,66
Stellenbosch	2004	12,59	18,74	19,67	220,8	37	4178,51	1039,62
Stellenbosch	2005	13,46	19,45	22,13	266,6	21	4201,26	825,96
Stellenbosch	2006	13,34	19,58	20,56	139,1	32,8	4324,33	951,16
Stellenbosch	2007	13,62	19,47	21,29	193,8	37,7	4032,47	1011,71
Stellenbosch	2008	13,18	19,36	21,52	231,4	32,8	3986,73	886,78
Stellenbosch	2009	13,17	18,9	22,1	260,4	15,3	3277,95	845,71
Stellenbosch	2010	13,98	19,15	22,86	265,8	27,7	3486,02	776,72
Stellenbosch	2011	13,78	19,96	22,95	151,8	8,2	4008,49	907,6
Stellenbosch	2012	13,57	18,81	21,52	162,1	37,4	3647,85	883,45
Stellenbosch	2013	12,78						
trend		0,025	0,054	0,108	-6,175	-0,977	-59,080	-14,767

6. Results

4. Matching trends of weather in region and sensitivities of independent variables for each grape variety + recommendations (≥ 5 matching trends).

Stellenbosch	trend	sensitivity	
		Semillion	matching
		4,992	1
Trend	1	-0,0217	0
Age	1	0,1301	1
Temperature Winter	0,025	0,3115	1
Temperature Growing	0,054	-0,0744	0
Temperature Harvest	0,108	-0,4441	0
Percipitation Growing	-6,175	-0,1496	1
Percipitation Harvest	-0,977	0,0817	0
Radiation Growing	-59,080	-0,1414	1
Radiation Harvest	-14,767	-0,0257	1

6. Results

5. Matching of ha distribution trends of each grape variety/region with recommendations.

Stellenbosch	Slope	Chenin Blanc	Colombard	Sauvignon Blanc	Chardonnay	Semillon	Caberne Sauvignon	Pinotage	Merlo	Shiraz	Ruby Cabernet
ha – uproot or plant		-1	-1	1	1	1	-1	-1	1	1	1
Age	1	1	1	1	0	0	0	0	0	1	0
Trend	1	1	1	1	1	1	1	1	1	0	1
Temp_Winter	1	1	1	1	0	1	0	0	1	0	0
Temp_Growing	1	0	1	0	0	0	0	1	0	1	1
Temp_Harvest	1	0	0	0	0	0	0	0	0	0	0
Rain_Growing	-1	1	1	1	1	1	1	0	0	1	0
Rain_Harvest	-1	1	0	0	1	0	1	1	0	1	1
Radiation_Growing	-1	1	0	1	1	1	0	0	1	0	0
Radiation_Harvest	-1	0	0	1	0	1	0	0	0	1	1
Metric match climate		6	5	6	4	5	3	3	3	5	4

5 grape varieties match the climate and should be planted there:

- Chenin Blanc, Colombard, Sauvignon Blanc, Semillon
- Shiraz

50% of the uprooting and planting decisions follow the model suggestions.

6. Results

Breedekloof	Slope	Chenin Blanc	Colombard	Sauvignon Blanc	Chardonay	Semillon	Caberne Sauvignon	Pinotage	Merlot	Shiraz	Ruby Cabernet
ha – uproot or plant		1	1	1	-1	1	-1	1	1	1	-1
Age	1	1	1	1	0	0	0	0	0	0	1
Trend	1	1	1	1	1	1	1	1	1	1	1
Temperature Winter	-1	0	1	0	1	0	0	1	0	1	1
Temp_Growing	-1	1	0	1	1	1	1	0	1	1	0
Temp_Harvest	-1	1	1	1	1	1	1	1	1	1	1
Rain_Growing	-1	1	1	0	0	1	0	1	0	1	0
Rain_Harvest	1	0	1	1	0	1	1	0	1	0	0
Radiation_Growing	1	0	1	1	0	0	1	1	0	1	1
Radiation_Harvest	-1	0	0	0	0	0	0	1	0	1	1
Metric match climate		5	7	6	4	5	5	6	4	7	6

8 grape varieties match the climate and should be planted there:

- Chenin Blanc, Colombard, Sauvignon Blanc, Semillon
- Cabernet Sauvignon, Pinotage, Shiraz, Ruby Cabernet

70% of the uprooting and planting decisions follow the model suggestions.

6. Results

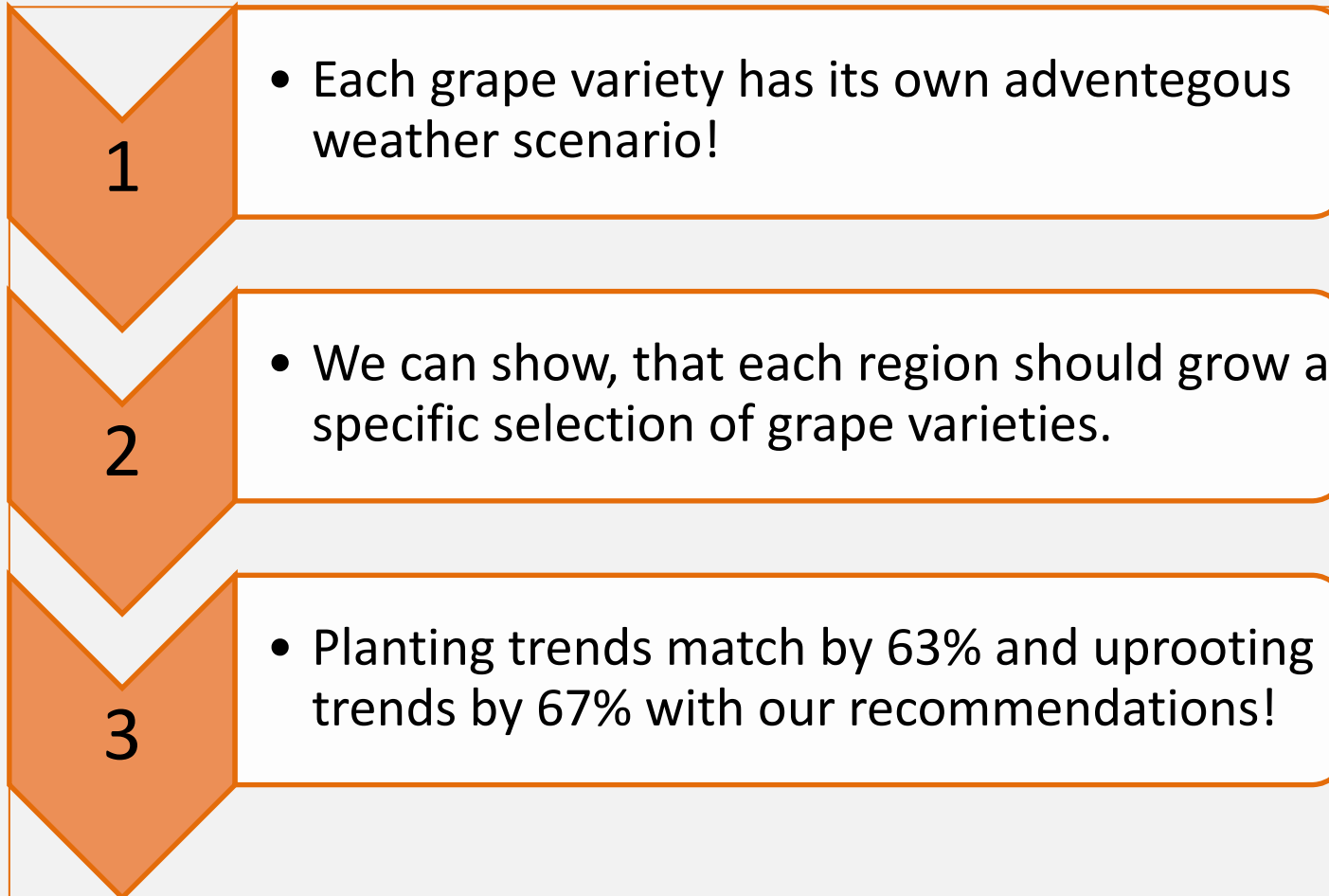
LittleKaroo	Slope	Chenin Blanc	Colombard	Sauvignon Blanc	Chardonay	Semillon	Caberne Sauvignon	Pinotage	Merlot	Shiraz	Ruby Cabernet
ha – uproot or plant		-1	1	1	-1	-1	1	-1	1	-1	-1
Age	1	0	0	1	0	0	0	0	0	0	1
Trend	1	1	0	0	1	0	1	1	1	1	0
Temp_Winter	1	0	0	0	0	1	0	0	0	0	1
Temp_Growing	1	0	1	0	0	0	0	1	0	0	1
Temp_Harvest	1	1	1	0	1	0	0	0	0	0	0
Rain_Growing	1	0	0	0	0	0	0	0	0	0	1
Rain_Harvest	-1	1	0	1	1	0	0	1	1	1	1
Radiation_Growing	-1	0	0	1	1	1	0	0	1	0	0
Radiation_Harvest	1	0	1	1	1	1	1	0	1	0	1
Metric match climate		3	3	4	5	3	2	3	4	2	6

2 grape varieties match the climate and should be planted there:

- Chardonnay
- Ruby Cabernet

40% of the uprooting and planting decisions follow the model suggestions.

7. Conclusion



So some regions are pretty much in line with the recommendations!

- Breedekloof, Malmesbury, Pararl are aware of their comparative advantages!
- Orange River and Olifants River don't seem to be aware of their comparative advantages for growing specific grape varieties!

Thank you for your attention!!!

