

Empirical regression models using NDVI, rainfall and temperature data for the early prediction of wheat grain yields in Morocco

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CGMS 2006 – GEOLAND meeting
Arlon 23-25 October 2006

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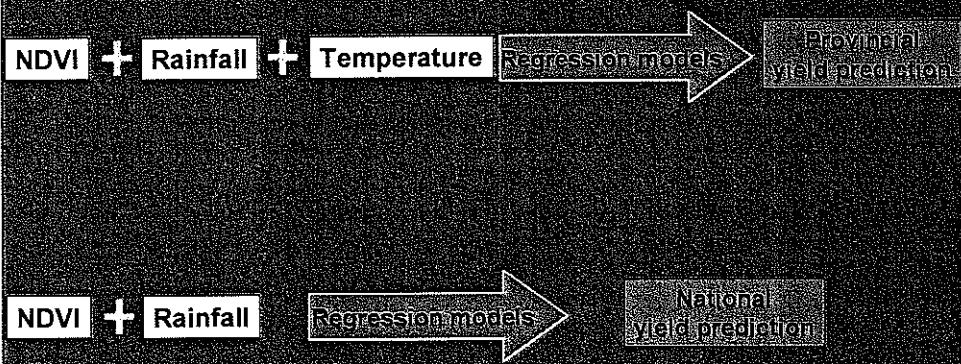
JUSTIFICATION

- Cereal production strongly fluctuates from year to year due to an erratic climate, in a situation where 85% of agricultural lands are rainfed
- Cereals are a strategic food in Morocco, with a consumption of 210 kg per capita, one of the highest in the world (159 kg at world level) which is not entirely covered by local production
- The coverage ratio of the cereal needs strongly fluctuates from year to year (most of years in deficit)
- There is a need for yield prediction models to manage wheat imports
- Actually, no specific yield prediction models exist for Morocco

HYPOTHESIS

1. Wheat yields could be predicted using models based on easily available indices or weather data
2. The models predict accurately and well in advance yields

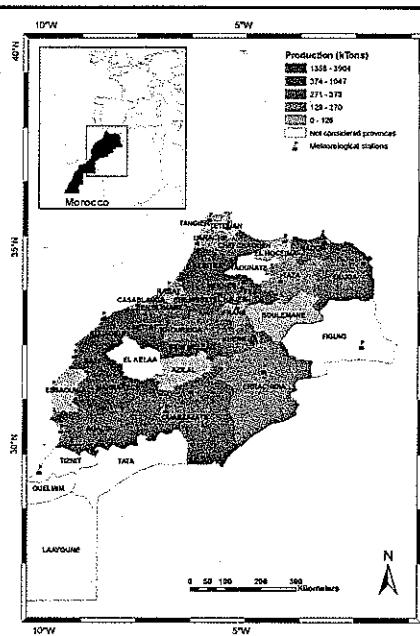
Methodology



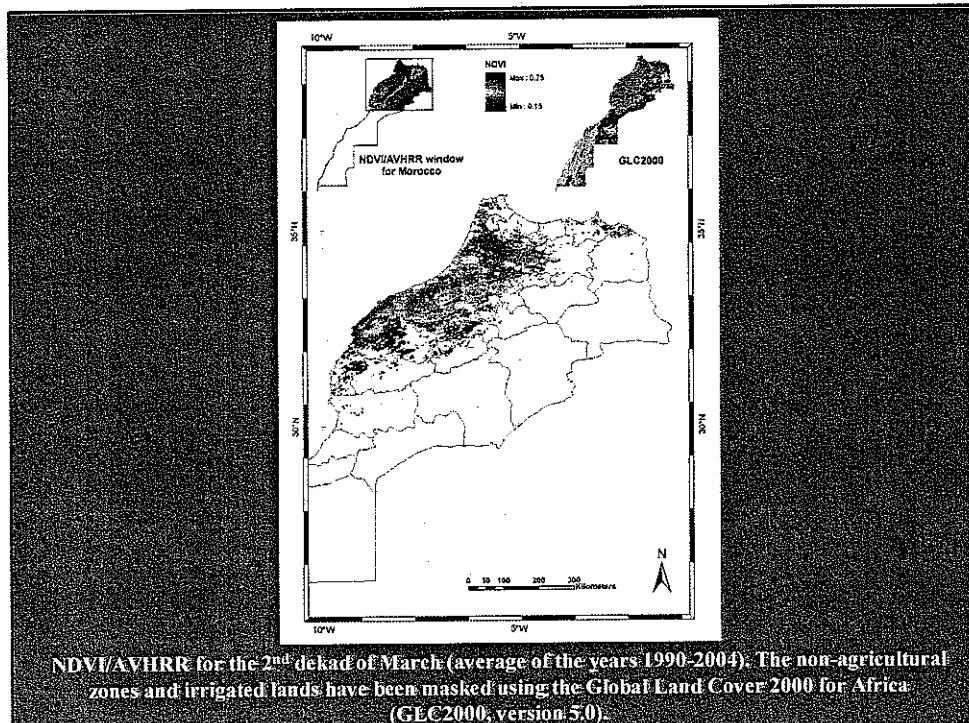
Methodology

Available Database:

- Wheat production and area by province from 1979 to 2004
- Dekadal rainfall by province from 1987 to 2004 (23 provinces)
- Monthly temperature by province from 1987 to 2004 (17 provinces)
- Dekadal NDVI/AVHRR from 1990 to 2004
(15 years from which 3 years have been dropped due to bad quality)



The considered provinces in Morocco (Moroccan Sahara not shown) with their average wheat production (1990-2004; Data source: Economic Services of the Ministry of Agriculture) and the location of the meteorological stations



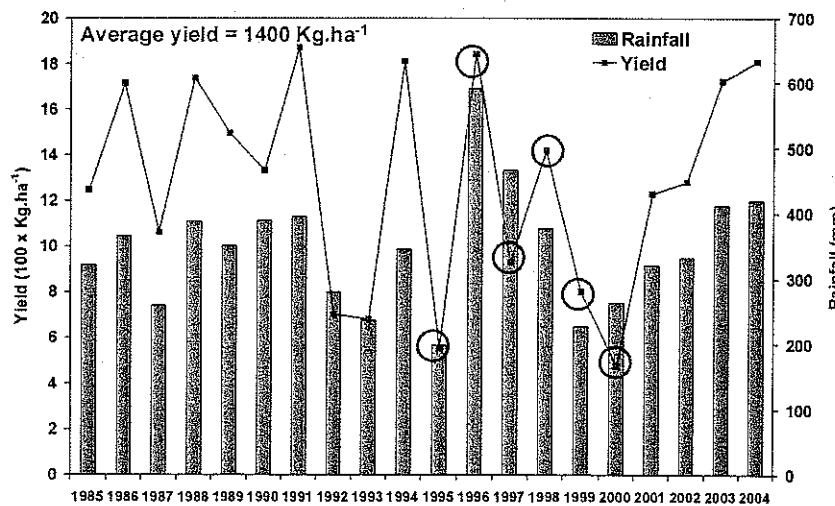
Regression models:

- Ordinary least squares regressions using:
 - Moving sums of dekadal rainfall
(2 till 11 dekads, from September to May)
 - Moving means of monthly temperature
(from September to May)
 - Sums of dekadal NDVI from February to April (Σ NDVI)
 - Stepwise selection of the best predictors, by removing time overlapping predictors if they appear automatically
 - « Leave-one-out » cross-validation in order to verify the replicability of results and checks the prediction performance of the model for "new" years

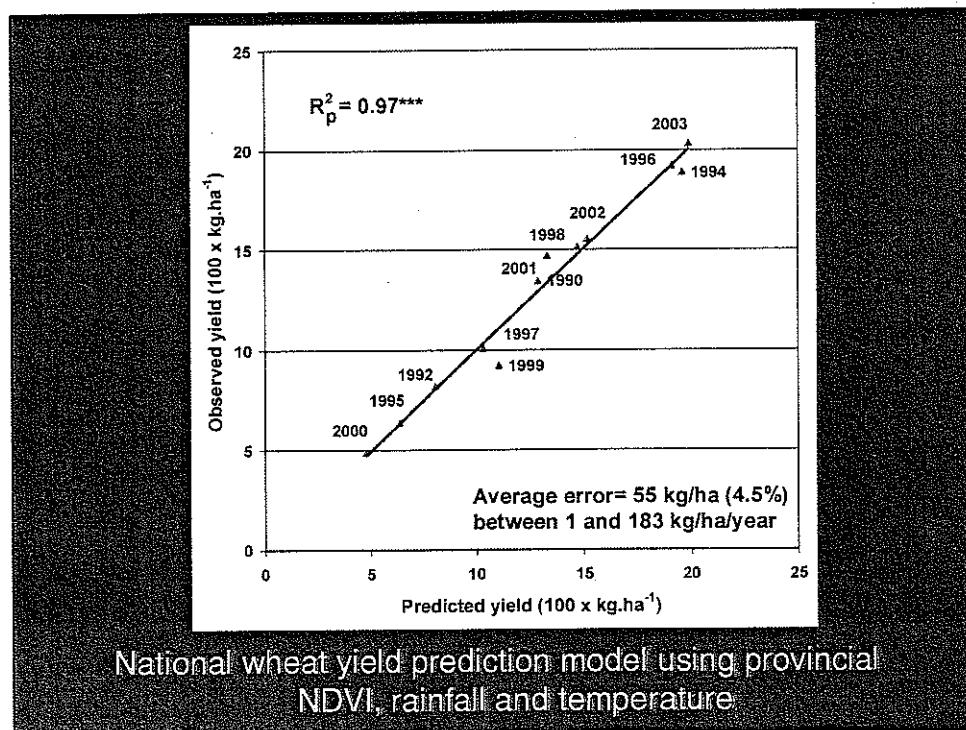
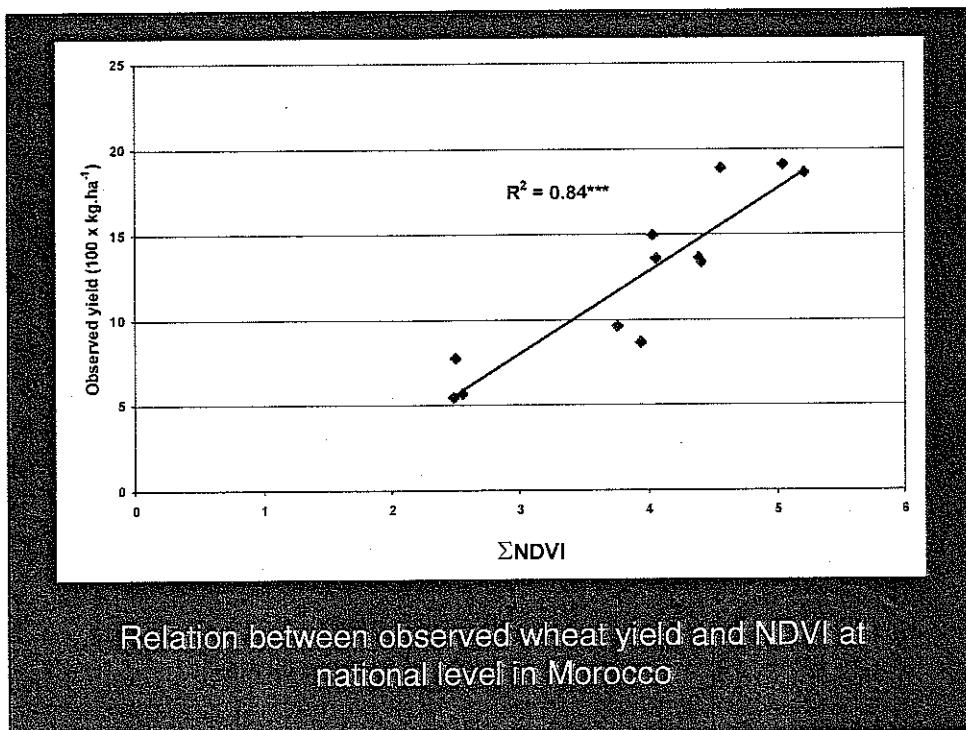
$R_p^2 = R^2$ in validation = coefficient of determination between observed and predicted yields

Error = (Kg.ha⁻¹) Relative error = (%)

- Prediction models :
1. By province, using provincial NDVI, rainfall and temperature (23 provinces = 64% of the national wheat production)
 - National yield prediction using provincial predicted yields weighted by their corresponding agricultural area
 2. For the whole country, using national NDVI and rainfall (31 provinces = 98% of the national wheat production)
 - National yield prediction directly

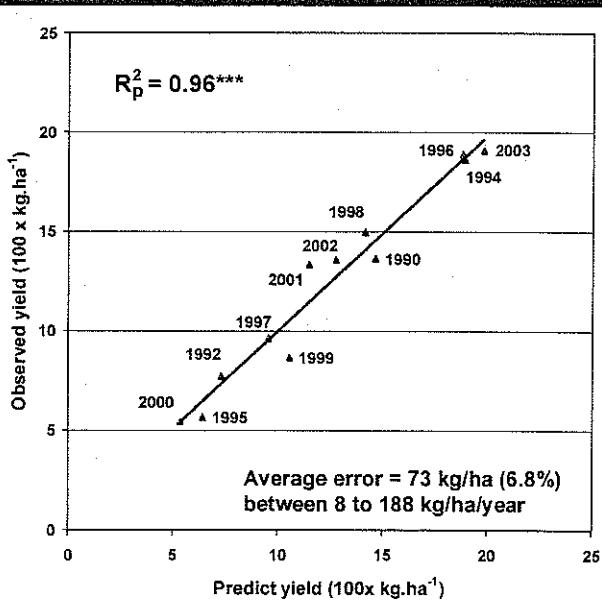


National wheat yield and rainfall variations



National wheat yield prediction models using national NDVI and rainfall

Model	Dekad*	Σ NDVI	Rainfall	df	R^2	R_p^2	Error	
							$100 \times \text{kg.ha}^{-1}$	%
1	2 nd March	-9.499 ± 7.195	Σ NDVI + 0.022 s3d2 + 0.106 f1m1 (66) (4) (28)	12	98***	96***	0.84	8.6
2	3 rd March	-9.943 ± 6.079	Σ NDVI + 0.021 s3d2 + 0.096 f1m1 (73) (4) (21)	12	98***	96***	0.79	7.7
3	1 st April	-9.090 ± 5.001	Σ NDVI + 0.023 s3d2 + 0.076 f1m1 (83) (4) (10)	11	97***	94***	1.00	9.0
4	2 nd April	-10.309 ± 4.487	Σ NDVI + 0.026 s1d1 + 0.050 f1a1 (82) (6) (9)	11	97***	92***	1.11	9.5
5	3 rd April	-8.829 ± 3.765	Σ NDVI + 0.030 s3n3 + 0.032 f3a2 (84) (7) (7)	11	98***	96***	0.73	6.8
6	1 st May	-8.823 ± 3.593	Σ NDVI + 0.028 s3n3 + 0.028 f3a1 (85) (6) (6)	11	98***	95***	0.82	7.4
7	1 st May	-7.427 ± 4.584	Σ NDVI	11	85***	81***	1.65	14.6



National wheat yield prediction model using national NDVI and rainfall

Conclusion

- Average error = 73 kg/ha (8 to 188 kg/year) using national data ($R_p^2 = 96.1\%^{***}$)
- Average error = 55 kg/ha (1 to 183 kg/year) using provincial data ($R_p^2 = 97.7\%^{***}$)
- Early predictions, starting from March using national model
- Σ NDVI is the most important predictor (85% of yield variability for national model)
- 3 time non-overlapping predictors for national model

Perspectives

- Potential improvements:
 - Use of better quality NDVI images (SPOT/Veget.)
 - Use of higher resolution NDVI images and land cover maps (CORINE)
 - Use of more climatic stations
 - Use of models taking into account phenological phases at province level

- Possibility to extend the models to other crops:
durum wheat and barley
- Possibility to extend the approach to countries
with similar agroclimatic environments
- Possibility to incorporate the proposed models
to MARS regional forecasting system

Thank you

