How Investment in RD&E Offset the Negative Impact of Climate Change on the Tunisian Agricultural Productivity Sector

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Introduction and Objectives

- The role of TFP growth in accelerating and sustaining the pace of agricultural growth is widely recognized
- This is especially relevant for countries suffering from wide yield gaps, and increasing growing population and climate change pressures
- Agricultural productivity growth may face several challenges including natural (climate), socioeconomic (knowledge and skills) and institutional (incentives) constraints

Introduction and Objectives

- This problem is mainly relevant for the MENA countries (Tunisian case)
- Food insecurity in this country is a recurring challenge related to several critical factors including climate change, scarcity of water and limited area for agricultural production
- Agriculture in the country is highly climate-sensitive
- A large share of population and economic activities in the country are located in urban coastal zones, which partly disconnect the farming activities from other economic sectors

Introduction and Objectives

- By 2050 water availability per capita will fall by 50 percent, (Warren et al. 2006)
- Growing competition for water is expected to reduce the share of agriculture in total GDP to 50 percent by 2050
- A high potential for food crises due to increasing demand (population) and declining supply factors (precipitation and yields)
- A need to focus on food production inefficiencies and work on enhancing the productivity of the agricultural sector

Introduction and Objectives

- Importance of analysing the agricultural productivity at the global scale and investigate the potential policies and macro-variables affecting this productivity
- The Overall objective of this study is to analyse the agricultural productivity of the agricultural sector in Tunisia and its main determinants, particularly:

✓ The magnitude and sustainability of the agricultural productivity (TFP) growth over the last four decades

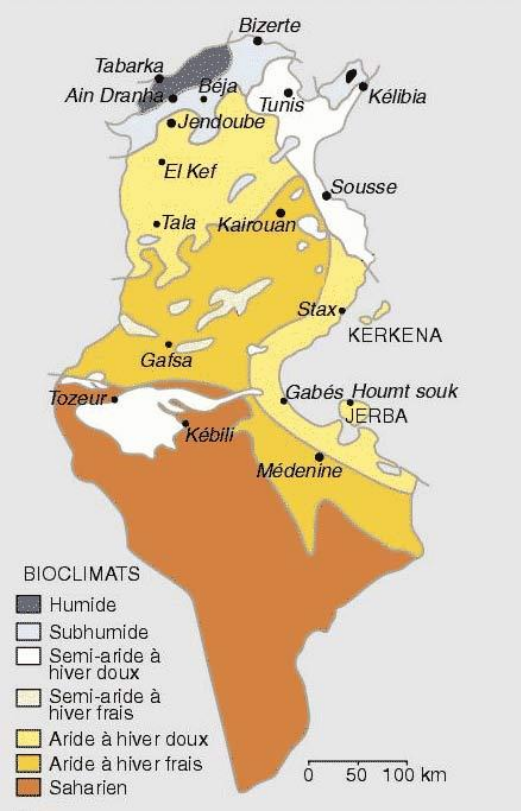
✓ Sources of the TFP growth

✓ The role of different types of agricultural investments on the TFP growth (Investment in RD&E)

✓ The impact of climate change (measured in terms of change in rainfall)

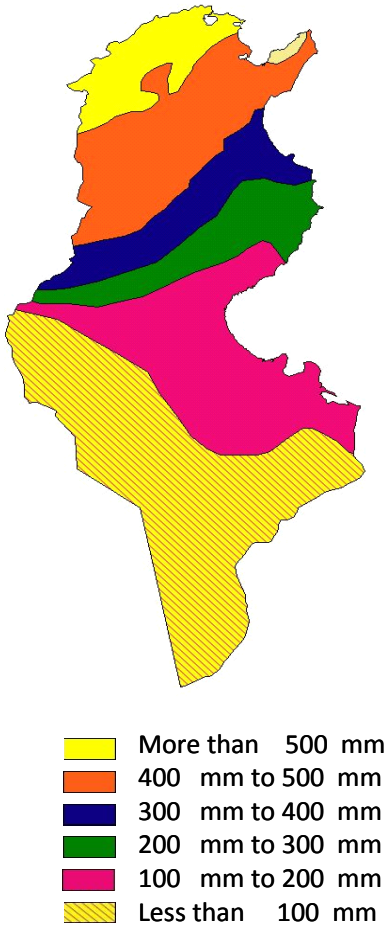
Overview of the Tunisian Agriculture

- 4 bioclimatic stages: the humid, sub-humid, sub-arid, and arid
- Average annual rainfall all over the country is estimated at 207 mm/year



Overview of the Tunisian Agriculture

- The annual rain is highly variable among regions, with a value of 600 mm in the North of the country, 296 mm in the center, and 156 mm in the arid Southern region
- Almost 80% of the annual precipitation is usually falling between October and Marsh



Overview of the Tunisian Agriculture

Main characteristics of the Tunisian population

Source: National Statistics Institute (INS), 2012

	2008	2009	2010	2011	2012
Total population (1000 persons)	10328.9	10439.6	10547.1	10673.8	10777.5
Males in the total population (%)	50.0	50.0	49.9	49.8	-
Urban population (%)	65.8	65.9	66.1	66.2	66.3
Population density per km²	66.3	67.0	67.7	68.9	-
Number of households (1000)	2407.2	2474.6	2539.1	2605.6	-

Overview of the Tunisian Agriculture

- 11.5 % to the national GDP
- Agricultural investments represent 10% of the total investments in Tunisia and 21% of the agricultural GDP
- 57% of these investments are done by private sector while 43% are public
- 17.6% of the total active population in 2010
- 11% to the total export at the same year

Percentage of employment contribution of different economic sectors
Source: Central Bank of Tunisia, 2012

	1975	1984	1994	2004	2010
Agriculture	36.5	27.3	21.2	16.2	17.6
Manufacturing industries	17.6	19.7	19.6	19.4	18.3
Non-manufacturing industries	12.6	15.8	13.7	14.5	14.4
Services	29.7	35.2	43.9	48.9	48.8

Importance of the agriculture in the national economy
Source: ONAGRI, 2012

Year	Added value (Million TND)	% of the total GDP
2000	2383	13.8
2002	2001	10.9
2003	2432	12.6
2004	2664	13.0
2005	2478	11.6
2006	2565	11.4
2007	2650	11.1
2008	2634	10.34
2009	2847	11.67
Average	2489	11.42

Overview of the Tunisian Agriculture

- The area cultivated with permanent crops is only around 22 % of the total agricultural area
- Water resources in the country are estimated to be around 4700 Mm3
- 27 large dams, 182 hill dams and 698 artificial lakes
- Groundwater resources for around 43 % of the total water potential
- Irrigated area represents only 8% of the total agricultural surface
- They provide however 35% of the agricultural output value, 20 % of total agricultural exports and 27 % of agricultural employment

Distribution of the agricultural area in Tunisia (in Km2) Source: INS, 2012

Unit : Km^2 (1 km^2 = 100 ha)	2008
Total Agricultural areas (a)	98 017.5
Cropland (b)	27 561.9
Permanent crops areas (c)	22 060.2
Rangelands	48 395.4
Forests	8 307.4
Others	1 948.5
(c/a)*100	22.5
(c/b)*100	80.0

Water infrastructure in Tunisia/ Source: Plan Bleu, 2006 (cited in (GTZ, 2008))

	2005	2010	2015
Large Dams	27	42	49
Earth-fill dams	220	255	275
Small lakes	800	1400	1660
Mobilized resources	2200	2400	2500
Total mobilized resources compared to total exploitable resources	88%	96%	100%

Overview of the Tunisian Agriculture

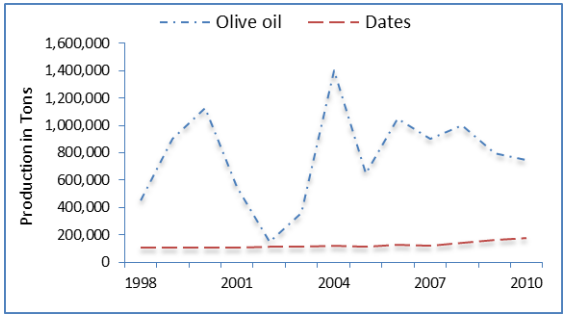
- 20 000 ha are lost each year because of erosion
- Groundwater aquifers are overused in more than 25 % of the irrigated areas
- The intensification rate in some irrigated areas is still below the targeted potentials
- Problems of social organization
- Small average size of the farms (most farms in Tunisia are smaller than 10 ha), and the continuous land fragmentation phenomenon

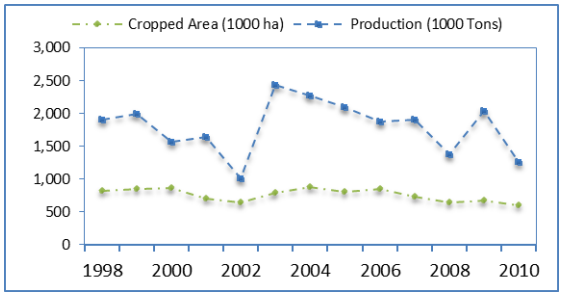
… To this we have to add other problems specific to the rain fed Agriculture

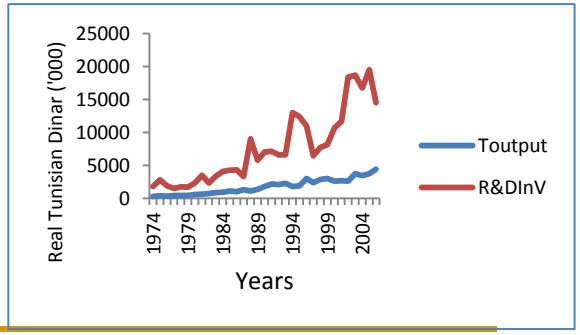
Overview of the Tunisian Agriculture

- Highly dependent to climate variation,
- Low profitability, …
- Negative national food balance, … importations bills are usually depending on the climate conditions of the year,
- Weak and lowly performing value chains for the rain fed commodities
- Low and decreasing contribution to the national export,
- Low investment (public & private) in RD&E

Problems of the rain fed agriculture in Tunisia







Methodological Framework

- Tornqvist indexes: used to construct both the aggregate output and input indexes
- Tornqvist can be used to divide the “technical change” into output and inputs changes
- Which are the main components for assessing the TFP growth …

Methodological Framework

Output index: $Ln\left(\frac{Q_t}{Q_{t-1}}\right) = {}^1/_2 \sum_j \left(R_{j,t} + R_{j,t-1}\right) Ln\left(\frac{Q_{j,t}}{Q_{j,t-1}}\right)$

Input index: $Ln\left(\frac{X_t}{X_{t-1}}\right) = {}^1/_2 \sum_i \left(S_{i,t} + S_{i,t-1}\right) Ln\left(\frac{X_{i,t}}{X_{i,t-1}}\right)$

TFPG index: $Ln\left(\frac{TFP_t}{TFP_{t-1}}\right) = Ln\left(\frac{Q_t}{Q_{t-1}}\right) - Ln\left(\frac{X_t}{X_{t-1}}\right)$

Where;

$R_{j,t}$ is the share of output (*j*) in total revenue in time (t),

$Q_{j,t}$ is the output (*j*) in time (*t*),

$S_{i,t}$ is the share of input (*i*) in total input cost, and

$X_{i,t}$ is the input (*i*) in time (*t*),

Methodological Framework

- The TFP growth scores will be regressed on a set of variables:

$$TFPG = f(RDE, RFTN, RFTC, RFTS, BTD, RR, TO, INF)$$

Methodological Framework

$$TFPG = f(RDE, RFTN, RFTC, RFTS, BTD, RR, TO, INF)$$

Variable	Description	ES
RDE	Annual stock of RD&E expenditure in the Tunisian Agricultural sector (TND)	+
RFTN	Annual mean rainfall in the North of Tunisia (mm)	+
RFTC	Annual mean rainfall in the Center of Tunisia (mm)	+
RFTS	Annual mean rainfall in the South of Tunisia (mm)	+
BTD	Balanced territorial development Indicators (Annual rural GDP per capita expressed in current TND/Capita/Year)	+
RR	Resources reallocation: (share of annual agricultural employment)	+
TO	Trade Openness (%) = (agricultural Import + agricultural export)/(total agricultural production).	+
INF	Infrastructure: Road density (km /km2 agricultural land)	+

Methodological Framework

$$TFPG = f(RDE, RFTN, RFTC, RFTS, BTD, RR, TO, INF)$$

- The log-linear form was considered as functional form
- The log-linear form allows for estimating coefficients that can be directly interpreted as elasticities
- In addition, the log-linear form contains a weak residual variance relative to other functional forms for the same data set and adjusts the data better than the linear specification for both forecasted parameter signs and statistical significance
- Period of analysis T: 1970-2011

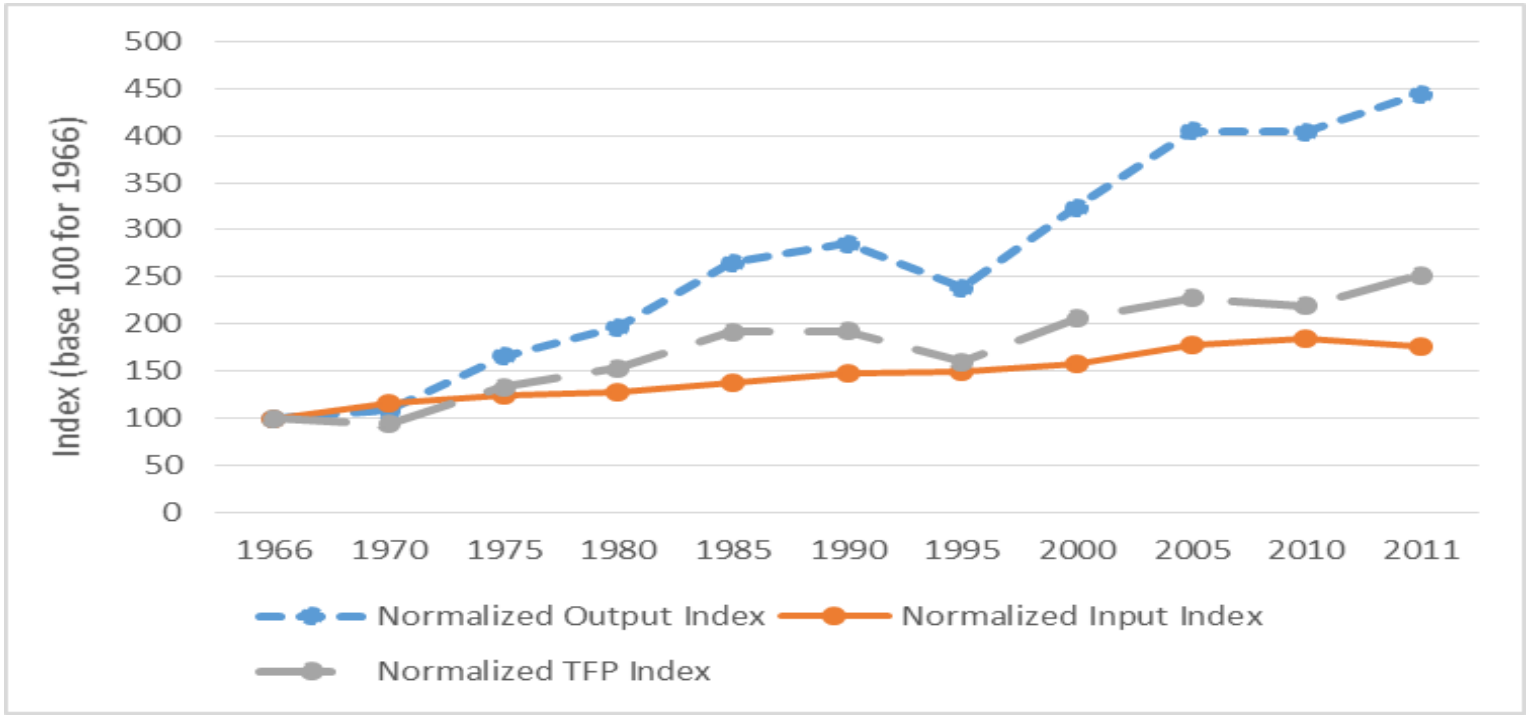
Data Sources

- The data used in this study was collected from different sources.
- FAO's annual time series (from 1961 to 2012….1970-2011) are used to construct the Törnqvist index:
  - ✓ Tunisian agricultural (crops and livestock) production; Total cultivated area; Total labor employed in the agricultural sector; Machinery deployed in the agricultural activities; Animal capital, and Fertilizer consumption ….
- The FAO data is complemented, when needed, with data from national statistical agencies, especially when such alternative data is more accurate or up to date.
- Climate data: Tunisian National Meteorological Institute

Empirical Findings

	Normalized Output Index	Normalized Input Index	Normalized TFPG Index
1966	100	100	100
1970	107.70	115.31	93.41
1975	165.57	124.31	133.19
1980	196.64	128.06	153.56
1985	265.10	138.11	191.95
1990	285.15	148.02	192.65
1995	238.66	149.09	160.08
2000	324.07	157.18	206.18
2005	404.77	177.73	227.74
2010	403.90	184.40	219.04
2011	444.42	176.24	252.16

Empirical Findings



Trends of the output, inputs, and TFPG indexes (base 100 for 1966)

Empirical Findings

	Dependent variable $LnTFPG_t$		
Parameters	**Estimated coefficients**	**t-ratios**	**p-value**
Constant	0.915	2.43**	0.021
RDE_t	0.05	1.44***	0.141
$RFTN_t$	0.21	1.63***	0.113
$RFTC_t$	-0.109	-0.835	0.410
$RFTS_t$	0.054	0.347	0.731
BTD_t	0.037	0.309	0.759
RR_t	0.057	0.213	0.833
TO_t	-0.169	-1.471***	0.151
INF_t	0.090	1.79***	0.100
T	43		
R^2	0.37		
F-statistic	0.784 (p<0.63)		
Log likelihood	2.85		

*Significant at 1%; **Significant at 5%; ***Significant at 10%.

Results

- Both RD&E and RFT (North, Center and South) are strongly correlated with output and TFP growth
- Except the RFTC and TO, the rest of variables have the expected signs
- The variables RFT's are significant at a 1 per cent level for the RFTN while that of RFTC and RFTS are not statistically insignificant
- A one per cent increase in RD&E stock and RFTCN would increase TFPG by 0.05 and 0.21 per cent, respectively
- The rise of 1% in investments in roads resulted in an average increase of 0.09% in TFP, at 10% of significance.

Discussions

- Even when TO is negatively affecting TFP growth, more analysis should be undertaken to identify the distribution of the revenues generated by this trade
- Especially if we know that many foreign direct agricultural investments have been done in Tunisia during the last two centuries…
- A focus should be made on the rain fed agriculture since even with the extension of the irrigated areas, the agricultural productivity in Tunisia remains very variable from one year to another

Conclusions

- RD&E expenditure and rainfall are important for the growth of agricultural productivity
- Climate variability has a heavier negative effect on the TFP, compared to the low positive effect of RD&E expenditures
- keeping the same RD&E strategy, these is much evidence that the TFP of the agricultural sector in Tunisia will be negatively affected by climate variability which expected to further increase with climate change

Implications

- Proper utilization of rainfall is necessary; mainly in the north part of the country where rain is relatively abundant and yields of different rain fed crops have a large potential to further increase
- Technical packages and farmers' skills are to be enhanced
- Increasing and prioritization of RD&E expenditures in the agricultural sector are also necessary to redress the expected deteriorating climate conditions (Public-Private Partnership)
- These investments have the potential to improve the long-run prospects for productivity growth

Thank you, any questions?