

Supplemental file- equations

1-Consumption

1.a. Moroccan Urban Consumption (kg)

$$\text{Moroccan Urban Consumption (kg)} = 181 \times \text{Moroccan Urban Population} \quad (1.a)$$

1.b. Moroccan Rural Consumption (kg)

$$\text{Moroccan Rural Consumption (kg)} = 191 \times \text{Moroccan Rural Population} \quad (1.b)$$

1.c. Total Moroccan Consumption (kg)

$$\text{Total Moroccan Consumption (kg)} = \text{Moroccan Urban Consumption} + \text{Moroccan Rural Consumption} \quad (1.c)$$

1.d. Fraction of the Urban Population (%)

$$\text{Fraction of the Urban Population of Region Rx (\%)} = \frac{\text{Urban Population of Region Rx}}{\text{Moroccan Urban Population}} \times 100 \quad (1.d)$$

1.e. Fraction of the Rural Population (%)

$$\text{Fraction of the Rural Population of Region Rx (\%)} = \frac{\text{Rural Population of Region Rx}}{\text{Moroccan Rural Population}} \times 100 \quad (1.e)$$

1.f. Regional Urban Consumption of Rx (Kg)

$$\text{Regional Urban Consumption of Rx (Kg)} = \text{Moroccan Urban Consumption} \times \text{Fraction of the Urban Population of Region Rx} \quad (1.f)$$

1.g. Regional Rural Consumption of Rx (Kg)

$$\text{Regional Rural Consumption of Rx (Kg)} = \text{Moroccan Rural Consumption} \times \text{Fraction of the Rural Population of Region Rx} \quad (1.g)$$

1.h. Regional Rural Consumption of Rx (Kg)

$$\text{Total Regional Consumption of Rx (Kg)} = \text{Regional Urban Consumption of Rx} + \text{Regional Rural Consumption of Rx} \quad (1.h)$$

1.i. Regional Consumption by person (kg/p)

$$\text{Regional Consumption by person} = \frac{\text{Total Regional Consumption}}{\text{Total Regional Population}} \quad (1.i)$$

1.j. Moroccan Consumption (kg/p)

$$\frac{\text{Moroccan Consumption}}{\text{Moroccan Population}} = 186 \text{ Kg/P} \quad (1.j)$$

1.k. Corrected Consumption (kg/p)

Corrected Consumption = Average Consumption by Person in each region (1.k)

1.l. Percentage of Actual of Consumption (%)

Actual of Consumption by Production (%) = $\frac{\text{Total Regional Consumption}}{\text{Total Regional Production}} \times 100$ (1.l)

1.m. Deficit/Gain of Consumption by production (%)

Deficit(–)Gain (+) of Consumption by Production (%) = $100 - \text{Actual of Consumption by Production (\%)}$
(1.m)

1.n. Deficit/Gain Kg of Consumption by production (kg)

Deficit(–)Gain (+) Kg of Consumption by Production = $\frac{\text{Total Regional Production} \times (\text{Deficit (–)Gain (+) \%})}{100}$ (1.n)

1.o. Moroccan Deficit/Gain kg of Consumption by production (kg)

Moroccan Deficit(–)Gain (+) Kg of Consumption by Production = Sum of Deficit(–)Gain (+) Kg (1.o)

1.p. Confirmation of the ration after adjustment of Deficit/Gain

Confirmation of the ration after adjustment of deficit/gain = $\frac{\text{Total Regional Consumption}}{\text{Total Regional Production} + \text{ABS (Deficit (–)Gain (+) Kg)}}$ (1.p)

1.q. Deficit/Gain (Kg)

Deficit (–) Gain (+)Kg = Production – Consommation (1.q)

1.r. Normalized Deficit

Normalized Deficit = $\frac{\text{Deficit (–)Gain (+) by region}}{\text{Deficit (–) Gain (+) of Region 9}}$ (1.r)

2-Population

Projected Population

2.a. Urban population (p)

Urban population (n + 1) = Urban population (n) + (1.22% × Urban population (n)) (2.a)

2.b. Rural population (p)

Rural population (n + 1) = Rural population (n) + (1.22% × Rural population (n)) (2.b)

2.c. Growth rate of the total population (%)

$$\text{Growth rate of total population} = \frac{\frac{\text{population 2034} - \text{population 2014}}{\text{population 2014}}}{20} \quad (2.c)$$

2.d. Total population (n+1) (p)

$$\text{total population (n + 1)} = \text{Total population (n)} + (1.22\% \times \text{Total population (n)}) \quad (2.d)$$

2.e.QAM (Urban) using corrected consumption (kg/p)

$$\text{QAM(Urban)} = \frac{\text{Urban corrected Consumption}}{\text{Urban Population}} \quad (2.e)$$

2.f.QAM (Rural) using corrected consumption (kg/p)

$$\text{QAM(Rural)} = \frac{\text{Rural corrected Consumption}}{\text{Rural Population}} \quad (2.f)$$

2.g.QAM (weighted average) (kg/p)

$$\text{QAM(weighted average)} = \frac{\text{Urban population} \times \text{QAM(Urban)} + \text{Rural population} \times \text{QAM(Rural)}}{\text{Urban Population}} \quad (2.g)$$

2.h. Urban percentage relative to weighted average (%)

$$\text{Urban percentage relative to weighted average} = \frac{\text{QAM(Urban)}}{\text{QAM(weighted average)}} \times 100 \quad (2.h)$$

2.i. Rural percentage relative to weighted average (%)

$$\text{Rural percentage relative to weighted average} = \frac{\text{QAM(Rural)}}{\text{QAM(weighted average)}} \times 100 \quad (2.i)$$

3-Mediterranean and European affluence:

3.a. Urban Consumption growth based on Mediterranean and European averages (155.87 and 126.80) (kg)

$$\text{Urban Consumption growth} = \text{Urban population} \times \text{Urban New QAM using corrected consumption} \quad (3.a)$$

3.b. Rural Consumption growth based on Mediterranean and European averages (155.87 and 126.80) (kg)

$$\text{Rural Consumption growth} = \text{Rural population} \times \text{Rural New QAM using corrected consumption} \quad (3.b)$$

3.c. Total Consumption growth based on Mediterranean and European averages (155.87 and 126.80) (kg)

Total Consumption growth = Total population × weighted average New QAM using corrected consumption (3.c)

3.d. Urban Moroccan Consumption Scenario Under Mediterranean affluence (kg)

Urban Moroccan Consumption Scenario Under Mediterranean affluence = Urban population × QAM Urban Mediterranean (3.d)

3.e. Rural Moroccan Consumption Scenario Under Mediterranean affluence (kg)

Rural Moroccan Consumption Scenario Under Mediterranean affluence = Rural population × QAM Rural Mediterranean (3.e)

3.f. Total Moroccan Consumption Scenario Under Mediterranean affluence (kg)

Total Moroccan Consumption Under Mediterranean affluence = Total population × QAM Weighted average Mediterranean (3.f)

3.g. Urban Moroccan Consumption Scenario Under European affluence (kg)

Urban Moroccan Consumption Scenario Under European affluence = Urban population × QAM Urban European (3.g)

3.h. Rural Moroccan Consumption Under European affluence (kg)

Rural Moroccan Consumption Under European affluence = Rural population × QAM Rural European (3.h)

3.i. Total Moroccan Consumption Under European affluence (kg)

Total Moroccan Consumption Under European affluence = Total population × QAM Weighted average European (3.i)

3.j. Gain/Deficit (kg)

Gain (+)Deficit (–) = Moroccan production (2014) – consumption S1 (2014) (3.j.a)

Gain (+)Deficit (–) = Moroccan production (2014) – consumption S1 (2024) (3.j.b)

Gain (+)Deficit (–) = Moroccan production (2014) – consumption S1 (20134) (3.j.c)

3.k. MAS/ P (Mean Annual Quantity per person) (kg/p)

MAS/P (Kg/P) (2014) = $\frac{\text{production 2014}}{\text{population 2014}}$ (3.k. a)

MAS/P (Kg/P) (2024) = $\frac{\text{production 2014}}{\text{population 2024}}$ (3.k. b)

MAS/P (Kg/P) (2034) = $\frac{\text{production 2014}}{\text{population 2024}}$ (3.k. c)

3.l. MAC/ P (Mean Annual Quantity per person) (kg/p)

MAC/P (Kg/P) (2014) = $\frac{\text{Consumption 2014}}{\text{Popolation 2014}}$ (3.l. a)

MAC/P (Kg/P) (2024) = $\frac{\text{Consumption 2024}}{\text{Popolation 2024}}$ (3.l.b)

$$\text{MAC/P (Kg/P)} = \frac{\text{Consumption 2034}}{\text{Population 2034}} \quad (3.1.c)$$

3.m. Necessary change (%)

$$\text{necessary change \% (2024)} = \frac{\text{MAC/P (2014)} - \text{MAS/P (2024)}}{\text{MAC/P (2014)}} \times 100 \quad (3.m.a)$$

$$\text{necessary change \% (2034)} = \frac{\text{MAS/P (2024)} - \text{MAS/P (2034)}}{\text{MAS/P (2024)}} \times 100 \quad (3.m.b)$$

3.n. Futures values (kg/p)

$$\text{Futures values (2024)} = \frac{\text{MAC/P (2014)} - (\text{MAC/P (2014)} \times \text{necessary change (2024)})}{100} \quad (3.n.a)$$

$$\text{Futures values (2034)} = \frac{\text{MAS/P (2024)} - (\text{MAS/P (2024)} \times \text{necessary change (2034)})}{100} \quad (3.n.b)$$

3.o.2014 MAC/p (kg/p)

$$2014\text{MAC/p(2014)} = \frac{\text{Production 2014} - \text{Consumption S1(2014)}}{\text{Population 2014}} \quad (3.o.a)$$

$$2014 \text{ MAC/p(2024)} = \frac{\text{Production 2014} - \text{Consumption S1 (2024)}}{\text{Population 2024}} \quad (3.o.b)$$

$$2014 \text{ MAC/p(2034)} = \frac{\text{Production 2014} - \text{Consumption S (2034)}}{\text{Population 2034}} \quad (3.o.c)$$

3.p. Mediterranean MAC/p (kg/p)

$$\text{Mediterranean MAC/p (2014)} = \frac{\text{Production 2014} - \text{Consumption S2 (2014)}}{\text{Population 2014}} \quad (3.p.a)$$

$$\text{Mediterranean MAC/p (2024)} = \frac{\text{Production 2014} - \text{Consumption S2 (2024)}}{\text{Population 2024}} \quad (3.p.b)$$

$$\text{Mediterranean MAC/p (2034)} = \frac{\text{Production 2014} - \text{Consumption S2 (2034)}}{\text{Population 2034}} \quad (3.p.c)$$

3.q. European MAC/p (kg/p)

$$\text{European MAC/p (2014)} = \frac{\text{Production 2014} - \text{Consumption S3 (2014)}}{\text{Population 2014}} \quad (3.q.a)$$

$$\text{European MAC/p (2024)} = \frac{\text{Production 2014} - \text{Consumption S3 (2024)}}{\text{Population 2024}} \quad (3.q.b)$$

$$\text{European MAC/p (2034)} = \frac{\text{Production 2014} - \text{Consumption S3 (2034)}}{\text{Population 2034}} \quad (3.q.c)$$

4-Change in Climate by temperature

4.a. Rainfed Production 2024 of Temperature Low Scenario (Kg)

$$\text{Raifed Production (2024)} = \text{Rainfed Production 2014} - (\text{Rainfed Production 2014} \times 2.3 \%) \quad (4.a)$$

4.b. Irrigated Production 2024 of Temperature Low Scenario (kg)

$$\text{Irrigated Production (2024)} = \text{Irrigated Production 2014} - (\text{Irrigated Production 2014} \times 1.6 \%) \quad (4.b)$$

4.c. Total Production 2024 of Temperature Low Scenario (kg)

$$\text{Total Production (2024)} = \text{Rainfed production 2024} + \text{Irrigated Production 2024} \quad (4.c)$$

4.d. Rainfed Production 2034 of Temperature Hight Impact Scenario (kg)

$$\text{Raifed Production (2034)} = \text{Rainfed Production 2014} - (\text{Rainfed Production 2014} \times 5.4\%) \quad (4.d)$$

4.e. Irrigated Production 2034 of Temperature Hight Impact Scenario (kg)

$$\text{Irrigated Production (2034)} = \text{Irrigated Production 2014} - (\text{Irrigated Production 2014} \times 3.4 \%) \quad (4.e)$$

4.f. Total Production 2034 of Temperature Hight Impact Scenario (kg)

$$\text{Total Production (2034)} = \text{Rainfed Production 2034} + \text{Irrigated Production 2034} \quad (4.f)$$

5-Change in Climate by precipitation

5.a. Decreased yield due to precipitation (Qx/ha/ml)

$$\frac{\text{Yield 2008} - \text{Yield 1991}}{\text{Precipitation 2008} - \text{Precipitation 1991}} = \frac{7-15}{250-400} = \frac{-8}{-150} = \frac{8 \text{ Qx/ha}}{150 \text{ ml}} \quad (5.a)$$

5.b. Rainfed Production 2024 of precipitation Low scenario (kg)

$$\text{Raifed Production (2024)} = \text{Rainfed Production 2014} - (\text{Rainfed Production 2014} \times 23.55 \%) \quad (5.b)$$

5.c. Rainfed Production 2034 of precipitation Low scenario (kg)

$$\text{Raifed Production (2034)} = \text{Rainfed Production 2014} - (\text{Rainfed Production 2014} \times 28.75 \%) \quad (5.c)$$

6-Technology

6.a. Regional Rainfed percentage of production (%)

$$\text{Regional Rainfed percentage of production \%} = \frac{\text{Regional Rainfed production of Rx}}{\text{Total Regional production of Rx}} \times 100 \quad (6.a)$$

6.b. Regional Irrigated percentage of production (%)

$$\text{Regional Irrigated percentage of production \%} = \frac{\text{Regional Irrigated preproduction of Rx}}{\text{Total Regional production of Rx}} \times 100 \quad (6.b)$$

6.c. Yield_{year (n+1)} (Qx/ha)

$$\text{Yield}_{\text{year (n+1)}} = \text{Yield}_{\text{Year n}} + 0.11 \quad (6.c)$$

6.d. Production under Yield (kg)

6.e. Percentage of production (2024) and (2034) (%)

$$\text{Percentage production (2024) \%} = \frac{100 \times (\text{production 2024} - \text{production 2014})}{\text{production 2014}} \quad (6.e.a)$$

$$\text{Percentage of production (2034) \%} = \frac{100 \times (\text{production 2034} - \text{production 2014})}{\text{production 2014}} \quad (6.e.b)$$

6.f. Regional Rainfed percentage of Land cereal (%)

$$\text{Regional Rainfed percentage of land Cereal (\%)} = \frac{\text{Regional Rainfed land of Region X}}{\text{Total Regional land of Region X}} \times 100 \quad (6.f)$$

6.g. Regional Irrigated percentage of land cereal (%)

$$\text{Regional Irrigated percentage of land cereal (\%)} = \frac{\text{Regional Irrigated land of Region X}}{\text{Total Regional land of Region X}} \times 100 \quad (6.g)$$

6.h. Rate of cereal land change

$$\text{Rate of change} = \frac{100 \times (\text{Land production of 2017} - \text{Land production of 2005})}{\text{Land production of 2005}} \times \frac{1}{2} \quad (6.h)$$

6.i Projected total cereal land and projected production

$$\text{Land production}_{\text{year (n+1)}} = \text{Land production}_{\text{Year n}} + 0.99 \quad (6.i.a)$$

$$\text{Projected production} = \text{Projected yield} \times \text{Projected Land} \quad (6.i.b)$$

6.j. Increase of land under cereal production from 2014 to 2034 (ha).

$$\text{Increase of Rainfed land} = \text{Rainfed land 2034} - \text{Rainfed land 2014} \quad (6.j.a)$$

$$\text{Increase of Irrigated land} = \text{Irrigated land 2034} - \text{irrigated land 2014} \quad (6.j.b)$$

$$\text{Increase of total land} = \text{Total land 2034} - \text{Total land} \quad (6.j.c)$$

6.k. Percentage of increase of land under cereal production from 2014 to 2034 (%).

$$\text{Percentage of increase of Rainfed land} = \frac{100 \times (\text{Rainfed land 2034} - \text{Rainfed land 2014})}{\text{Rainfed land 2014}} \quad (6.k.a)$$

$$\text{Percentage of increase of Irrigated land} = \frac{100 \times (\text{Irrigated land 2034} - \text{Irrigated land 2014})}{\text{Irrigated land 2014}} \quad (6.k.b)$$

$$\text{Percentage of increase of Total land} = \frac{100 \times (\text{Total land 2034} - \text{Total land 2014})}{\text{Total land 2014}} \quad (6.k.c)$$

6.l. Percentage increase of total projected production compared to 2014 (%)

$$\begin{aligned} \text{Percentage increase of total projected production 2024}(\%) \\ = \frac{100 \times (\text{Total projected production 2024} - \text{Total projected production 2014})}{\text{Total projected production 2014}} \end{aligned} \quad (6.l.a)$$

$$\begin{aligned} \text{Percentage increase of total projected production 2034}(\%) \\ = \frac{100 \times (\text{Total projected production 2034} - \text{Total projected production 2014})}{\text{Total projected production 2014}} \end{aligned} \quad (6.l.b)$$

6.m. Percentage of rainfed projected production compared to Total (%)

$$\text{Percentage of rainfed projected production 2024}(\%) = \frac{\text{Rainfed projected production 2024}}{\text{Total projected production 2024}} \times 100 \quad (6.m.a)$$

$$\text{Percentage of rainfed projected production 2034}(\%) = \frac{\text{Rainfed projected production 2034}}{\text{Total projected production 2034}} \times 100 \quad (6.m.b)$$

6.n. Percentage of Irrigated projected production compared to Total (%)

$$\text{Percentage of irrigated projected production 2024}(\%) = \frac{\text{Irrigated projected production 2024}}{\text{Total projected production 2024}} \times 100 \quad (6.n.a)$$

$$\text{Percentage of irrigated projected production 2034}(\%) = \frac{\text{Irrigated projected production 2034}}{\text{Total projected production 2034}} \times 100 \quad (6.n.b)$$

6.o. Difference in Rainfed production (Tons, Kg)

$$\begin{aligned} \text{Difference in Rainfed production 2014} \\ = \text{Rainfed projected production 2014 based on projected land and projected yield} \\ - \text{Rainfed projected production based on projected land and 2014 yield} \end{aligned}$$

(6.o.a)

Difference in Rainfed production 2024

- = Rainfed projected production 2024 based on projected land and projected yield
- Rainfed projected production based on projected land and 2014 yield

(6.o.b)

Difference in Rainfed production 2034

- = Rainfed projected production 2034 based on projected land and projected yield
- Rainfed projected production based on projected land and 2014 yield

(6.o.c)

6.p. Difference in irrigated production (Tons, Kg)

Difference in Irrigated production 2014

- = Irrigated projected production 2014 based on projected land and projected yield
- Irrigated projected production based on projected land and 2014 yield

(6.p.a)

Difference in Irrigated production 2024

- = Irrigated projected production 2024 based on projected land and projected yield
- Irrigated projected production based on projected land and 2014 yield

(6.p.b)

Difference in Irrigated production 2034

- = Irrigated projected production 2034 based on projected land and projected yield
- Irrigated projected production based on projected land and 2014 yield

(6.p.c)

6.q. Difference in Total production (Tons, Kg)

Difference in Total production 2014

- = Total projected production 2014 based on projected land and projected yield
- Total projected production based on projected land and 2014 yield

(6.q.a)

Difference in Total production 2024

- = Total projected production 2024 based on projected land and projected yield
- Total projected production based on projected land and 2014 yield

(6.q.b)

Difference in Total production 2034

- = Total projected production 2034 based on projected land and projected yield
- Total projected production based on projected land and 2014 yield

(6.q.c)