**Evidence of collaborative opportunities to ensure long term sustainability in African farming**

Imane El Fartassia,b,c,\***,** Alice E Milnea, Rafiq El Alamic, Maryam Rafiqic, Kirsty L. Hassalld, Toby W. Waineb, Joanna Zawadzkab, Alhousseine Diarrac, Ron Corstanjeb

*a Net-zero and resilient farming, Rothamsted Research, Harpenden, Hertfordshire, AL5 2JQ, United Kingdom*

*b Cranfield University, College Road, Cranfield, Bedford, MK43 0AL, United Kingdom*

c *Mohammed IV Polytechnic university, Benguerir, Morocco*

*d Intelligent Data Ecosystems, Rothamsted Research, Harpenden, Hertfordshire, AL5 2JQ, United Kingdom*

\*Corresponding author

E-mail address: [i.el-fartassi@cranfield.ac.uk](mailto:i.el-fartassi@cranfield.ac.uk) (I. El-Fartassi).

Telephone: + 447466798344

**Appendix A. Supplementary data**

**S1: Survey questions**

**Section 1: General background**

*Question 1.1: Surname.* Text entry.

*Question 1.2: First name.* Text entry.

*Question 1.3: Email* *address.* Text entry.

*Question 1.4: Which category below includes your age?* Answer selected from the following responses: A) 18 – 24; B) 18 – 24; C) 35 – 44; D) 45 – 54; E) Above 55.

*Question 1.5: What is your gender?* Answer selected from the following responses: A) Male; B) Female.

*Question 1.6: What is the highest degree or level of education you have completed?* Answer selected from the following responses: A) Technician diploma; B) Bachelor's Degree; C) Master’s degree; D) Engineering degree; E) PhD or higher; F) Other.

*Question 1.7a: What is your occupation?* A) Agronomist; B) Agronomist developer; C) Agronomist consultant; D) Agronomist adviser; E) other.

*Question 1.7b: If other, please specify.* Text entry.

*Question 1.8: Years of field experience.* Answer selected from the following responses: A) 0-5; B) 5-10; C) Above 10.

*Question 1.9: What does your current headquarter area?* Answer selected from the following responses: A) Tanger-Tétouan-Al Hoceïma; B) L'Oriental; C) Fès-Meknès; D) Rabat-Salé-Kénitra; E) Béni Mellal-Khénifra; F) Casablanca-Settat; G) Marrakech-Safi; H) Drâa-Tafilalet; I) Souss-Massa; J) Guelmim-Oued Noun; K) Laâyoune-Sakia El Hamra; L) Dakhla-Oued Ed Dahab.

**Section 2: Crop choices**

*Question 2.1: To what extent do the following environmental factors influence the choice of crops?* Respondents were asked to evaluate the contribution of 4 factors: A) Climate; B) Soil and land characteristics; C) Water availability; D) Previous crop; via a Likert scale with 3 points that range from not important, to very important.

*Question 2.2: To what extent do the following economic factors influence the choice of crops?* Respondents were asked to evaluate the contribution of 6 factors: A) Subsidies and grants; B) Labour availability; C) Capacity and readiness to invest; D) Contract with industries; E) Crop insurance; F) Profitability via a Likert-scale with 3 points that range from not important, to very important.

*Question 2.3: To what extent do the following social factors influence the choice of crops?* Respondents were asked to evaluate the contribution of 3 factors: A) Prior experience with the crop; B) Passed down through the generations; C) Education; via a Likert scale with 3 points that range from not important, to very important.

*Question 2.4: To what extent do the following “crop characteristics” factors influence the choice of crops?* Respondents were asked to evaluate the contribution of 5 factors: A) Resistance to pests and diseases; B) Drought resistance; C) Maturity dates; D) High yield; E) Length of the growing season; via a Likert scale with 3 points that ranges from not important, to very important.

*Question 2.5: To what extent do the following “farm size and facilities” factors influence the choice of crops?* Respondents were asked to evaluate the contribution of 4 factors: A) Farming system; B) Availability of machinery and maintenance facilities; C) Storage facility or accessibility; D) Technology; via a Likert-scale with 3 points that ranges from not important, to very important.

*Question 2.6: Have you noticed any behavioural persistence or slow adoption of agroforestry?* Answer Yes or No.

*Question 2.7: If yes expand, if not, why do you think so?* Text entry.

*Question 2.8: In your opinion, are there opportunities to improve agroforestry adoption through collaboration networks or co-creation plans?* Answer Yes or No.

*Question 2.9: If yes expand, if not, why do you think so?* Text entry.

**Section 3: Tillage practices**

*Question 3.1: Rank the following tillage systems according to how commonly they are used in your area from 1 (most common) to 3 (least common).* Answer selected from the following three responses: A) Conventional tillage; B) Reduced tillage; C) No-tillage.

To identify what factors most likely drive farmers' decision to adopt a tillage system, we asked respondents to evaluate the contribution of seven factors to the implementation of conventional tillage, reduced tillage, and no-till via a Likert scale with 3 points that range from not important, to very important. These factors, which we validated with local experts before the circulation of the survey, were A) Soil and land characteristics; B) Crop characteristics; C) Water availability; D) Subsidies and grants; E) farm size; F) Passed down through the generations; G) Phytosanitary management.

*Question 3.2: To what extent do the following factors influence the choice of conventional tillage?*

*Question 3.3: To what extent do the following factors influence the choice of reduced tillage?*

*Question 3.4: To what extent do the following factors influence the choice of No-tillage?*

*Question 3.5: Have you noticed any behavioural persistence or slow adoption of no-tillage practice?* Answer Yes or No.

*Question 3.6: If yes expand, if not, why do you think so?* Text entry.

*Question 3.7: In your opinion, are there opportunities to improve tillage practices through collaboration networks or co-creation plans?* Answer Yes or No.

*Question 3.8: If yes expand, if not, why do you think so?* Text entry.

**Section 4: Irrigation practices**

*Question 4.1: Rank the following irrigation systems according to how commonly they are used in your area from 1 (most common) to 4 (least common).* Answer selected from the following four responses: A) Surface irrigation; B) Localised irrigation; C) Sprinkler irrigation ; D) Rainfed lands.

To identify what factors most likely drive farmers' decision to adopt an irrigation system, we asked respondents to evaluate the contribution of 10 factors to the adoption of surface irrigation, Localised irrigation, and Sprinkler irrigation via a Likert scale with 3 points that range from not important, to very important. These factors were: A) Climate; B) Soil and land characteristics; C) Crop characteristics; D) Farm size; E) Labour availability; F) Availability of machinery and maintenance facilities; G) Capacity and readiness to invest; H) Profitability; I) Subsidies and grants; J) Water availability.

*Question 4.2: To what extent do these factors lead farmers to adopt surface irrigation in your area?*

*Question 4.3: To what extent do these factors lead farmers to adopt localised irrigation in your area?*

*Question 4.4: To what extent do these factors lead farmers to adopt sprinkler irrigation in your area?*

*Question 4.5: In your area, how do farmers adapt to water shortages and other weather conditions? 1*Text entry.

*Question 4.6: In your opinion, are there opportunities to improve water management through collaboration networks or co-creation plans?* Answer Yes or No.

*Question 4.7: If yes expand, if not, why do you think so?* Text entry.

**Section 5: Fertilizer management**

*Question 5.1: In your area, what type of fertilizer do farmers use the most?* Answer selected from the following three responses: A) Organic fertilizers only; B) Predominance of organic fertilizers and limited use of chemical fertilizers; C) Equal use of both organic and chemical fertilizers; D) Predominance of chemical fertilizers and lower use of organic fertilizers.

To identify what factors most likely drive farmers' decision to adopt chemical or organic fertilizers, we asked respondents to evaluate the contribution of five factors with 3 points that range from not important, to very important. These factors were: A) Profitability; B) Improved nutrient content; C) Environmentally friendly; D) High yield; E) Subsidies and grants.

*Question 5.2:* *To what extent do the following factors influence the use of chemical fertilizers?*

*Question 5.3: To what extent do the following factors influence the use of organic fertilizers?*

*Question 5.4: How can you describe changes in the use of fertilizers?* Answer selected from the following three responses: A) Predominance of organic fertilizers and absence or lower use of chemical fertilizers; B) Increase in the use of chemical fertilizers with a maintained use of organic fertilizers; C) Increase in the use of chemical fertilizers at the expense of organic fertilizers.

*Question 5.5: To what extent do the following factors influence* ***change*** *in fertilizer use?* To identify what factors, influence the change in fertilizer use, we asked respondents to evaluate the contribution of five factors with 3 points that range from not important, to very important. These factors were: A) Profitability; B) Improved nutrient content; C) Environmentally friendly; D) High yield; E) Subsidies and grants.

*Question 5.6: In your opinion, are there opportunities to improve fertilizer practices through collaboration networks or co-creation plans?* Answer Yes or No.

*Question 5.7: If yes expand, if not, why do you think so?* Text entry.

**S2: Climatic zones**

**Table S1**

Climatic zones in Morocco based on the De Martonne aridity index.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Region** | **Land Use** | **Climatic Zone** | | | | | **Total region area** |
| **Arid** | **Humid and Subhumid** | **Hyperarid** | **Semi-arid** | **Grand Total** |
| Béni Mellal-Khénifra | Cropland |  | 2775 |  | 4671 | 7446 |  |
| Other |  | 7415 |  | 12710 | 20125 | 27571 |
| Drâa-Tafilalet | Cropland | 446 | 60 | 553 | 610 | 1669 |  |
| Other | 24755 | 3320 | 42149 | 13461 | 83685 | 85353 |
| Eddakhla-Oued Eddahab | Cropland |  |  | 573 |  | 573 |  |
| Other |  |  | 129450 |  | 129450 | 130023 |
| Fès-Meknès | Cropland | 171 | 4744 |  | 6153 | 11068 |  |
| Other | 8681 | 4928 |  | 14626 | 28235 | 39303 |
| Grand Casablanca-Settat | Cropland | 2 |  |  | 8887 | 8889 |  |
| Other | 47 |  |  | 11106 | 11152 | 20041 |
| Guelmim-Oued Noun | Cropland | 53 |  | 129 |  | 182 |  |
| Other | 3236 |  | 41712 |  | 44948 | 45131 |
| Laayoune-Sakia El Hamra | Cropland |  |  | 895 |  | 895 |  |
| Other |  |  | 138871 |  | 138871 | 139765 |
| Marrakech-Safi | Cropland | 815 | 596 |  | 4848 | 6260 |  |
| Other | 8387 | 3277 |  | 21085 | 32749 | 39009 |
| Oriental | Cropland | 627 | 53 | 7 | 2482 | 3169 |  |
| Other | 27142 | 376 | 472 | 34470 | 62460 | 65628 |
| Rabat-Salé-Kénitra | Cropland |  | 3067 |  | 6132 | 9199 |  |
| Other |  | 2369 |  | 6006 | 8375 | 17574 |
| Souss-Massa | Cropland | 1537 | 192 | 64 | 862 | 2657 |  |
| Other | 18835 | 1571 | 16014 | 13558 | 49979 | 52635 |
| Tanger-Tetouan-Al Hoceima | Cropland | 9 | 7792 |  | 279 | 8080 |  |
| Other | 22 | 6227 |  | 1759 | 8008 | 16087 |
|  | Grand Total | 94765 | 48762 | 370888 | 163706 | 678121 | 678121 |

**Table S2**

Agro-climatic zones of administrative regions of Morocco.

To aggregate the responses per climatic zones, we considered only the cropland area of each region. Some of the administrative regions comprised a mixture of climatic zones. When the percentage of Subhumid to humid was between 30% and 90%, the region was attributed to the “Semi-arid and Subhumid to humid” classification. When the percentage exceeded 90%, it was attributed to the “Subhumid to humid” classification.

|  |  |
| --- | --- |
| **Agro-climatic zones** | **Administrative regions** |
| Humid and Subhumid | Tanger-Tetouan-Al Hoceima |
| Semi-arid and subhumid to humid | Béni Mellal-Khénifra  Fès-Meknès  Rabat-Salé-Kénitra |
| Semi-arid | Grand Casablanca-Settat  Marrakech-Safi  Oriental |
| Arid to hyper-arid | Drâa-Tafilalet  Eddakhla-Oued Eddahab  Souss-Massa  Guelmim-Oued Noun  Laayoune-Sakia El Hamra |

For the sources of the climatic zone and cropland maps, the bioclimatic parameters (annual mean temperature, maximum temperature of warmest month, minimum temperature of coldest month and annual precipitation) used to generate the climatic zones map were obtained from the WorldClim database version 2 (Fick and Hijmans 2017).

The cropland extent map comes from the Digital Earth Africa platforms which are open source and freely available online through the Digital Earth Africa website: <https://www.digitalearthafrica.org/> (accessed 10 Apr 2022).

Fick SE, Hijmans RJ. 2017. WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. Int J Climatol. 37(12):4302–4315.

**S3: Contextual questions**

***Crop choices***

**Table S3**

Crop distribution across Morocco.

|  |  |  |
| --- | --- | --- |
| Crops | Total surface area (1000 ha) | Rank |
| Cereals | 3795.46 | **1** |
| Olive trees | 1008.37 | **2** |
| Forage crops | 416.28 | **3** |
| Horticultural crops | 218.46 | 4 |
| Legumes | 210.04 | 5 |
| Rosacea | 206.08 | 6 |
| Almond trees | 165.82 | 7 |
| Citruses | 122.47 | 8 |
| Industrial crops | 64.87 | 9 |
| Date palm trees | 58.12 | 10 |
| Oilseed crop | 54.49 | 11 |
| Vine | 46.00 | 12 |

**Table S4**

Estimated crop areas in 2016 for each climatic zone in Morocco.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Crops | Surface area (1000 ha) | | | |
| Subhumid to humid | Semi-arid and subhumid to humid | Semi-arid | Arid to hyperarid |
| Cereals | 382.59 | 1630.25 | 1607.66 | 174.96 |
| Legumes | 36.57 | 151.32 | 21.25 | 0.91 |
| Oilseed crop | 6.95 | 47.54 | 0.00 | 0.00 |
| Industrial crops | 30.00 | 28.48 | 4.48 | 1.91 |
| Forage crop | 51.79 | 217.45 | 133.85 | 13.20 |
| Horticultural crops | 22.43 | 87.72 | 86.44 | 21.86 |
| Citruses | 1.94 | 44.52 | 36.03 | 39.98 |
| Almond tree | 29.41 | 53.64 | 42.04 | 40.72 |
| Olive tree | 157.39 | 479.64 | 337.02 | 34.32 |
| Date palm trees | 0.00 | 0.00 | 1.74 | 56.38 |
| Vine | 1.71 | 16.91 | 26.83 | 0.55 |
| Rosacea | 28.01 | 107.68 | 39.63 | 30.76 |

***Tillage***

**Table S5**

The contingency table showing how many individuals selected a given response according to climatic zones. The table is presented according to climatic zones and pooled by conventional tillage.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Rank | Arid-hyperarid | Subhumid to humid | Semi-arid | Semi-arid / Subhumid to humid | Total |
| 1 | 8 | 4 | 15 | 26 | 53 |
| 2 | 0 | 0 | 1 | 2 | 3 |
| 3 | 2 | 0 | 0 | 2 | 4 |

**Table S6**

The contingency table showing how many individuals selected a given response according to climatic zones. The table is presented according to climatic zones and pooled by reduced tillage.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Rank | Arid-hyperarid | Subhumid to humid | Semi-arid | Semi-arid / Subhumid to humid | Total |
| 1 | 0 | 0 | 0 | 3 | 3 |
| 2 | 8 | 4 | 12 | 17 | 41 |
| 3 | 2 | 0 | 4 | 10 | 16 |

**Table S7**

The contingency table showing how many individuals selected a given response according to climatic zones. The table is presented according to climatic zones and pooled by no-tillage.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Rank | Arid-hyperarid | Subhumid to humid | Semi-arid | Semi-arid / Subhumid to humid | Total |
| 1 | 2 | 0 | 1 | 3 | 6 |
| 2 | 2 | 0 | 3 | 10 | 15 |
| 3 | 6 | 4 | 12 | 17 | 39 |

**Table S8**

Friedman's test – tillage.

|  |  |
| --- | --- |
| Data variate | Rank |
| Blocks | Participant\_ID |
| Treatments | Tillage systems |
| Number of blocks | 87 |
| Number of treatments | 3 |
| Friedman's statistic | 94.36 |
| Adjusted for ties | 96.58 |
| Degrees of freedom | 2 |
| P-value using chi-square approximation (2 d.f.) | 0.000 |

***Irrigation***

**Table S9**

The contingency table showing how many individuals selected a given response according to climatic zones. The table is presented according to climatic zones and pooled by the rank of surface irrigation.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Rank | Arid-Hyperarid | Subhumid to humid | Semi-arid | Semi-arid / Subhumid to humid | Total |
| 1 | 1 | 0 | 3 | 4 | 8 |
| 2 | 3 | 2 | 3 | 9 | 17 |
| 3 | 7 | 0 | 3 | 3 | 13 |
| 4 | 1 | 1 | 3 | 2 | 7 |

**Table S10**

The contingency table showing how many individuals selected a given response according to climatic zones. The table is presented according to climatic zones and pooled by the rank of localized irrigation.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Rank | Arid-Hyperarid | Subhumid to humid | Semi-arid | Semi-arid / Subhumid to humid | Total |
| 1 | 8 | 2 | 7 | 6 | 23 |
| 2 | 1 | 0 | 2 | 2 | 5 |
| 3 | 2 | 1 | 2 | 5 | 10 |
| 4 | 1 | 0 | 1 | 5 | 7 |

**Table S11**

The contingency table showing how many individuals selected a given response according to climatic zones. The table is presented according to climatic zones and pooled by the rank of sprinkler irrigation.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Rank | Arid-Hyperarid | Subhumid to humid | Semi-arid | Semi-arid / Subhumid to humid | Total |
| 1 | 1 | 0 | 0 | 0 | 1 |
| 2 | 6 | 1 | 2 | 3 | 12 |
| 3 | 0 | 1 | 5 | 7 | 13 |
| 4 | 5 | 1 | 5 | 8 | 19 |

**Table S12**

The contingency table showing how many individuals selected a given response according to climatic zones. The table is presented according to climatic zones and pooled by the rank of rain-fed lands.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Rank | Arid-Hyperarid | Subhumid to humid | Semi-arid | Semi-arid / Subhumid to humid | Total |
| 1 | 3 | 1 | 3 | 8 | 15 |
| 2 | 1 | 1 | 4 | 4 | 10 |
| 3 | 4 | 1 | 3 | 4 | 12 |
| 4 | 4 | 0 | 2 | 2 | 8 |

**Table S13**

Friedman’s test – irrigation

|  |  |
| --- | --- |
| Data variate | Rank |
| Blocks | Respondents \_ID |
| Treatments | Irrigation systems |
| Number of blocks | 46 |
| Number of treatments | 4 |
| Friedman's statistic | 17.71 |
| Adjusted for ties | 17.75 |
| Degrees of freedom | 3 |
| P-value using chi-square approximation (3 d.f.) | p<0.0001 |

***Fertilizer management***

**Table S14**

The contingency table showing how many individuals selected a given response according to climatic zones. The table is presented according to climatic zones and pooled by fertilizer type.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Fertilizers | Arid-Hyperarid | Subhumid to humid | Semi-arid | Semi-arid / Subhumid to humid | Total |
| Equal use of both organic and chemical fertilizers | 1 | 1 | 1 | 2 | 5 |
| Organic fertilizers only | 0 | 0 | 1 | 1 | 2 |
| The predominance of chemical fertilizers and lower use of organic fertilizers | 5 | 3 | 8 | 11 | 27 |
| The predominance of organic fertilizers and limited use of chemical fertilizers | 4 | 1 | 2 | 2 | 9 |

**S4:Factors affecting management choices**

***Crop choices***

**Table S15**

The contingency table showing how many individuals selected a given general factor influencing crop selection. The table is presented according to factors and pooled by the degree of importance.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Influencing factors | Environmental factors | Economic factors | Social factors | Crop characteristics | Farm size and facilities |
| Not important | 30 | 69 | 52 | 29 | 46 |
| Moderately important | 87 | 177 | 91 | 154 | 147 |
| Very important | **184** | 205 | 83 | **189** | 102 |
|  | Expected values - came out of GenStat | | | | |
| Not important | 41.35 | 61.96 | 31.05 | 51.11 | 40.53 |
| Moderately important | 120.03 | 179.85 | 90.13 | 148.35 | 117.64 |
| Very important | **139.61** | 209.19 | 104.83 | **172.54** | 136.83 |

**Table S16**

The contingency table showing how many individuals selected a given response to Question 2.1. The table is presented according to factors and pooled by the degree of importance.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Environmental factors | | | |
|  | Climate | Soil and land characteristics | Water availability | Previous crop |
| Not important | 0 | 3 | 3 | 24 |
| Moderately important | 13 | 29 | 9 | 36 |
| Very important | **63** | 43 | **62** | 16 |
|  | Expected values - came out of GenStat | | | |
| Not important | 7.58 | 7.48 | 7.38 | 7.58 |
| Moderately important | 21.97 | 21.68 | 21.39 | 21.97 |
| Very important | **46.46** | 45.85 | **45.24** | 46.46 |

**Table S17**

The contingency table showing how many individuals selected a given response to Question 2.2. The table is presented according to factors and pooled by the degree of importance.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Economic factors | | | | | |
|  | Subsidies and grants | Labour availability | Capacity and readiness to invest | Contract with industries | Crop insurance | Profitability |
| Not important | 5 | 4 | 10 | 20 | 29 | 1 |
| Moderately important | 25 | 28 | 49 | 29 | 29 | 17 |
| Very important | **45** | **43** | 17 | 25 | 18 | **57** |
|  | Expected values - came out of GenStat | | | | | |
| Not important | 11.47 | 11.47 | 11.63 | 11.32 | 11.63 | 11.47 |
| Moderately important | 29.43 | 29.43 | 29.83 | 29.04 | 29.83 | 29.43 |
| Very important | **34.09** | **34.09** | 34.55 | 33.64 | 34.55 | **34.09** |

**Table S18**

The contingency table showing how many individuals selected a given response to Question 2.3. The table is presented according to factors and pooled by the degree of importance.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Social factors** | | |
|  | Prior experience with the crop | Passed down through the generations | Education |
| Not important | 5 | 12 | 35 |
| Moderately important | 25 | 39 | 27 |
| Very important | **46** | 24 | 13 |
|  | Expected values - came out of GenStat | | |
| Not important | 17.49 | 17.26 | 17.26 |
| Moderately important | 30.6 | 30.2 | 30.2 |
| Very important | **27.91** | 27.54 | 27.54 |

**Table S19**

The contingency table showing how many individuals selected a given response to Question 2.4. The table is presented according to factors and pooled by the degree of importance.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Crop characteristics | | | | |
|  | Resistance to pests and diseases | Drought resistance | Maturity dates | High yield | Length of the growing season |
| Not important | 9 | 7 | 9 | 0 | 4 |
| Moderately important | 29 | 30 | 37 | 17 | 41 |
| Very important | 37 | 36 | 30 | **56** | 30 |
|  | Expected values - came out of GenStat | | | | |
| Not important | 5.85 | 5.69 | 5.92 | 5.69 | 5.85 |
| Moderately important | 31.05 | 30.22 | 31.46 | 30.22 | 31.05 |
| Very important | 38.1 | 37.09 | 38.61 | **37.09** | 38.1 |

**Table S20**

The contingency table showing how many individuals selected a given response to Question 2.5. The table is presented according to factors and pooled by the degree of importance.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Farm size and facilities | | | |
|  | Farming system | Availability of machinery and maintenance facilities | Storage facility or accessibility | Technology |
| Not important | 6 | 9 | 13 | 18 |
| Moderately important | 34 | 36 | 40 | 37 |
| Very important | 32 | 30 | 20 | 20 |
|  | Expected values - came out of GenStat | | | |
| Not important | 11.23 | 11.69 | 11.38 | 11.69 |
| Moderately important | 35.88 | 37.37 | 36.38 | 37.37 |
| Very important | 24.89 | 25.93 | 25.24 | 25.93 |

|  |  |
| --- | --- |
| Sub-factors | |
| Environmental factors |  |
| Economic factors |  |
| Social factors |  |
| Crop characteristics |  |
| Farm size and facilities |  |

**Fig. S1** Number of responses recorded per sub-factor influencing crop choices.

***Tillage***

**Table S21**

Accumulated analysis of deviance of tillage systems.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Change | d.f. | Deviance | Mean deviance | Deviance ratio | Approx pr |
| Tillage | 2 | 0.6523 | 0.3262 | 0.33 | 0.722 |
| Factor | 6 | 0.0596 | 0.0099 | 0.01 | 1.000 |
| Tillage.Factor | 12 | 0.1393 | 0.0116 | 0.01 | 1.000 |
| Importance | 2 | 106.9309 | 53.4655 | 53.47 | <.001 |
| **Tillage.Importance** | **4** | **12.8177** | **3.2044** | **3.20** | **0.012** |
| **Factor.Importance** | **12** | **97.4109** | **8.1176** | **8.12** | **<.001** |
| Residual | 24 | 21.6974 | 0.9041 |  |  |
| Total | 62 | 239.7080 | 3.8663 |  |  |

|  |  |
| --- | --- |
| Conventional tillage |  |
| Reduced tillage |  |
| No-tillage |  |

**Fig. S2** Number of responses recorded per factors influencing the choice of tillage systems.

**Table S22**

The contingency table showing how many individuals selected a given response to Question 3.2. The table is presented according to factors and pooled by the degree of importance. The Influencing factors are A) soil and land characteristics; B) Crop characteristics; C) water availability; D) Subsidies and grants; E) farm size; F) passed down through the generations; G) phytosanitary management.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Conventional tillage** | | | | | | |
|  | Soil and land characteristics | Crop characteristics | Water availability | Subsidies and grants | farm size | Passed down through the generations | Phytosanitary management |
| Not important | 10 | 6 | 15 | 23 | 20 | 13 | 21 |
| Moderately important | 28 | 32 | 34 | 38 | 32 | 30 | 36 |
| Very important | **48** | **47** | **38** | 23 | 33 | **41** | 29 |
|  | Expected values - came out of GenStat | | | | | | |
| Not important | 15.56 | 15.38 | 15.74 | 15.2 | 15.38 | 15.2 | 15.56 |
| Moderately important | 33.13 | 32.75 | 33.52 | 32.36 | 32.75 | 32.36 | 33.13 |
| Very important | **37.31** | **36.88** | **37.74** | 36.44 | 36.88 | **36.44** | 37.31 |

**Table S23**

The contingency table showing how many individuals selected a given response to Question 3.3. The table is presented according to factors and pooled by the degree of importance. The Influencing factors are A) soil and land characteristics; B) Crop characteristics; C) water availability; D) Subsidies and grants; E) farm size; F) passed down through the generations; G) phytosanitary management.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Reduced tillage** | | | | | | |
|  | Soil and land characteristics | Crop profile | Water availability | Subsidies and grants | farm size | Passed down through the generations | Phytosanitary management |
| Not important | 11 | 8 | 14 | 30 | 23 | 28 | 22 |
| Moderately important | 29 | 38 | 28 | 34 | 31 | 25 | 39 |
| Very important | **41** | **36** | **40** | 18 | 28 | 27 | 21 |
|  | Expected values - came out of GenStat | | | | | | |
| Not important | 19.29 | 19.53 | 19.53 | 19.53 | 19.53 | 19.05 | 19.53 |
| Moderately important | 31.78 | 32.17 | 32.17 | 32.17 | 32.17 | 31.38 | 32.17 |
| Very important | **29.93** | **30.3** | **30.3** | 30.3 | 30.3 | 29.56 | 30.3 |

**Table S24**

The contingency table showing how many individuals selected a given response to Question 3.4. The table is presented according to factors and pooled by the degree of importance. The Influencing factors are A) soil and land characteristics; B) Crop characteristics; C) water availability; D) Subsidies and grants; E) farm size; F) passed down through the generations; G) phytosanitary management.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **No-tillage** | | | | | | |
|  | Soil and land characteristics | Crop profile | Water availability | Subsidies and grants | farm size | Passed down through the generations | Phytosanitary management |
| Not important | 16 | 11 | 16 | 27 | 23 | 27 | 23 |
| Moderately important | 23 | 25 | 20 | 31 | 31 | 35 | 31 |
| Very important | **44** | **46** | **47** | 25 | 27 | 21 | 27 |
|  | Expected values - came out of GenStat | | | | | | |
| Not important | 20.61 | 20.36 | 20.61 | 20.61 | 20.11 | 20.61 | 20.11 |
| Moderately important | 28.24 | 27.9 | 28.24 | 28.24 | 27.56 | 28.24 | 27.56 |
| Very important | **34.15** | **33.74** | **34.15** | 34.15 | 33.33 | 34.15 | 33.33 |

***Irrigation***

**Table S25**

Accumulated analysis of deviance across all irrigation systems.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Change | d.f. | Deviance | Mean deviance | Deviance ratio | Approx. chi pr |
| Irrigation\_systems | 2 | 5.344 | 2.672 | 2.67 | 0.069 |
| Factors | 7 | 1.203 | 0.172 | 0.17 | 0.991 |
| Irrigation\_systems.Factors | 14 | 0.129 | 0.009 | 0.01 | 1 |
| Importance | 2 | 117.09 | 58.545 | 58.55 | <.001 |
| **Irrigation\_systems.Importance** | **4** | **49.317** | **12.329** | **12.33** | **<.001** |
| **Factors.Importance** | **14** | **97.532** | **6.967** | **6.97** | **<.001** |
| Residual | 28 | 41.359 | 1.477 |  |  |
| Total | 71 | 311.975 | 4.394 |  |  |

**Table S26**

Accumulated analysis of deviance of localized and sprinkler irrigation.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Change | d.f. | Deviance | Mean deviance | Deviance ratio | Approx chi pr |
| Irrigation\_systems | 1 | 0.33 | 0.33 | 0.33 | 0.566 |
| Factors | 1 | 0.021 | 0.021 | 0.02 | 0.886 |
| Irrigation\_systems.Factors | 1 | 0.000 | 0.000 | 0.00 | 0.995 |
| Importance | 2 | 55.258 | 27.629 | 27.63 | <.001 |
| **Irrigation\_systems.Importance** | **2** | **34.653** | **17.327** | **17.33** | **<.001** |
| **Factors.Importance** | **2** | **8.809** | **4.404** | **4.4** | **0.012** |
| Residual | 2 | 5.04 | 2.52 |  |  |
| Total | 11 | 104.111 | 9.465 |  |  |

|  |  |
| --- | --- |
| Surface irrigation |  |
| Localised irrigation |  |
| Sprinkler irrigation |  |

**Fig. S3** Number of responses recorded per factors influencing the choice of irrigation systems.

**Table S27**

The contingency table showing how many individuals selected a given response to Question 4.2. The table is presented according to factors and pooled by the degree of importance.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Surface irrigation | | | | | | | |
|  | Climate | Soil and land characteristics | Crop characteristics | Farm size | Labour availability | Availability of machinery and maintenance facilities | Profitability | Water availability |
| Not important | 19 | 15 | 9 | 8 | 18 | 13 | 13 | 5 |
| Moderately important | 22 | 26 | 17 | 21 | 19 | 24 | 19 | 5 |
| Very important | 17 | 15 | **28** | **23** | 16 | 15 | 21 | **44** |
|  | Expected values - came out of GenStat | | | | | | | |
| Not important | 13.43 | 12.96 | 12.5 | 12 | 12.27 | 12.04 | 12.27 | 12.5 |
| Moderately important | 20.54 | 19.83 | 19.13 | 18.4 | 18.77 | 18.42 | 18.77 | 19.13 |
| Very important | 24.03 | 23.2 | **22.37** | **21.6** | 21.96 | 21.55 | 21.96 | **22.38** |

**Table S28**

The contingency table showing how many individuals selected a given response to Question 4.3. The table is presented according to factors and pooled by the degree of importance.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Localized irrigation | | | | | | | | | |
|  | Climate | Soil and land characteristics | Crop characteristics | Farm size | Labour availability | Availability of machinery and maintenance facilities | Capacity and readiness to invest | Profitability | Subsidies and grants | Water availability |
| Not important | 10 | 10 | 3 | 8 | 16 | 6 | 4 | 1 | 1 | 4 |
| Moderately important | 15 | 18 | 12 | 14 | 13 | 19 | 15 | 9 | 4 | 17 |
| Very important | 30 | 23 | **35** | 28 | 20 | 25 | **31** | **40** | **46** | 29 |
|  | Expected values - came out of GenStat | | | | | | | | | |
| Not important | 6.85 | 6.35 | 6.23 | 6.23 | 6.1 | 6.23 | 6.23 | 6.23 | 6.35 | 6.23 |
| Moderately important | 14.78 | 13.71 | 13.44 | 13.4 | 13.17 | 13.44 | 13.44 | 13.44 | 13.71 | 13.44 |
| Very important | 33.37 | 30.94 | **30.34** | 30.3 | 29.73 | 30.34 | **30.34** | **30.34** | **30.94** | 30.34 |

**Table S29**

The contingency table showing how many individuals selected a given response to Question 4.4. The table is presented according to factors and pooled by the degree of importance.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Sprinkler irrigation | | | | | | | | | |
|  | Climate | Soil and land characteristics | Crop characteristics | Farm size | Labour availability | Availability of machinery and maintenance facilities | Capacity and readiness to invest | Profitability | Subsidies and grants | Water availability |
| Not important | 13 | 13 | 6 | 7 | 16 | 11 | 9 | 11 | 14 | 4 |
| Moderately important | 26 | 22 | 14 | 26 | 20 | 23 | 21 | 19 | 15 | 15 |
| Very important | 10 | 11 | **26** | 11 | 10 | 11 | **16** | 15 | **18** | **27** |
|  | Expected values - came out of GenStat | | | | | | | | | |
| Not important | 11.08 | 10.4 | 10.4 | 9.95 | 10.4 | 10.17 | 10.4 | 10.17 | 10.63 | 10.4 |
| Moderately important | 21.41 | 20.1 | 20.1 | 19.23 | 20.1 | 19.66 | 20.1 | 19.66 | 20.54 | 20.1 |
| Very important | 16.51 | 15.5 | **15.5** | 14.83 | 15.5 | 15.16 | **15.5** | 15.16 | **15.84** | **15.5** |

***Fertilizer management***

**Table S30**

Accumulated analysis of deviance of fertilizers.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Change | d.f. | Deviance | Mean deviance | Deviance ratio | Approx chi pr |
| Fertilizers | 1 | 0.009 | 0.009 | 0.01 | 0.924 |
| Factors | 4 | 0.054 | 0.014 | 0.01 | 1 |
| Fertilizers.Factors | 4 | 0.036 | 0.009 | 0.01 | 1 |
| Importance | 2 | 20.1 | 10.05 | 10.05 | <.001 |
| Fertilizers.Importance | 2 | 4.844 | 2.422 | 2.42 | 0.089 |
| **Factors.Importance** | **8** | **105.501** | **13.188** | **13.19** | **<.001** |
| Residual | 8 | 53.957 | 6.745 |  |  |
| Total | 29 | 184.502 | 6.362 |  |  |

|  |  |
| --- | --- |
| Chemical fertilizers |  |
| Organic fertilizers |  |

**Fig. S4** Number of responses recorded per factors influencing the choice of fertilizers.

**Table S31**

The contingency table showing how many individuals selected a given response to Question 5.2. The table is presented according to factors and pooled by the degree of importance.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Chemical fertilizers | | | | |
|  | Profitability | Improved nutrient content | Environmentally friendly | High yield | Grants and subsidies |
| Not important | 4 | 2 | 33 | 0 | 16 |
| Moderately important | 16 | 21 | 8 | 3 | 13 |
| Very important | **25** | 20 | 4 | **42** | 16 |
|  | Expected values - came out of GenStat | | | | |
| Not important | 11.1 | 10.61 | 11.1 | 11.1 | 11.1 |
| Moderately important | 12.31 | 11.76 | 12.31 | 12.31 | 12.31 |
| Very important | **21.59** | 20.63 | 21.59 | **21.59** | 21.59 |

**Table S32**

The contingency table showing how many individuals selected a given response to Question 5.3. The table is presented according to factors and pooled by the degree of importance.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Organic fertilizers | | | | |
|  | Profitability | Improved nutrient content | Environmentally friendly | High yield | Grants and subsidies |
| Not important | 12 | 7 | 14 | 4 | 23 |
| Moderately important | 12 | 21 | 10 | 19 | 15 |
| Very important | **20** | 16 | **20** | **21** | 7 |
|  | Expected values - came out of GenStat | | | | |
| Not important | 11.95 | 11.95 | 11.95 | 11.95 | 12.22 |
| Moderately important | 15.33 | 15.33 | 15.33 | 15.33 | 15.68 |
| Very important | **16.72** | 16.72 | **16.72** | **16.72** | 17.1 |

**S5: Behavioural persistence, change or adaptation**

***Crop choices***

**Table S33**

The contingency table showing how many individuals selected a given response according to climatic zones. The table is presented according to climatic zones and pooled by the willingness/unwillingness to adopt agroforestry.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Agroforestry | Arid to hyperarid | Subhumid to humid | Semi-arid | Semi-arid / Subhumid to humid |
| Willingness | 7 | 2 | 17 | 18 |
| Unwillingness | 8 | 3 | 5 | 7 |

***Fertilizer management***

**Table S34**

The contingency table showing how many individuals selected a given response to Question 5.4. The table is presented according to factors and pooled by the degree of importance.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Change in the use of fertilizers | | | | |
|  | Profitability | Improved nutrient content | Environmentally friendly | High yield | Grants and subsidies |
| Not important | 4 | 2 | 14 | 1 | 11 |
| Moderately important | 6 | 11 | 14 | 2 | 7 |
| Very important | **29** | **25** | 11 | **37** | 21 |
|  | Expected values - came out of GenStat | | | | |
| Not important | 6.4 | 6.24 | 6.4 | 6.56 | 6.4 |
| Moderately important | 8 | 7.79 | 8 | 8.21 | 8 |
| Very important | **24.6** | **23.97** | 24.6 | **25.23** | 24.6 |