The challenge of making climate adaptation profitable for farmers: evidence from Sri Lanka’s rice sector

Antonio Scognamillo\textsuperscript{1*}, Nicholas Sitko\textsuperscript{2}, Sidath Bandara\textsuperscript{3}, Shantha Hewage\textsuperscript{3}, Thilani Munaweera\textsuperscript{3} and Jihae Kwon\textsuperscript{1}

\textsuperscript{1}Agrifood Economics Division, Food and Agricultural Organization of the United Nations, Rome, Italy, \textsuperscript{2}Inclusive Rural Transformation and Gender Equity Division, Food and Agricultural Organization of the United Nations, Rome, Italy, \textsuperscript{3}Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo, Sri Lanka

*Contact author. Email: Antonio.Sognamillo@fao.org

ONLINE APPENDIX
Table A1. Descriptive household level statistics for selected variables

| HH-Level Means                                      | Mean     | Standard Errors | Diff. 5th-1st quintiles of income |
|-----------------------------------------------------|----------|-----------------|-----------------------------------|
| Gender of HH head (1=female)                        | 0.036    | 0.006           | -0.040                            |
| Age of HH head                                      | 53.825   | 0.413           | -5.380                            |
| Highest education of HH head                        | 10.138   | 0.120           | 1.320                             |
| HH size                                             | 3.943    | 0.051           | 1.248                             |
| Field area (acres)                                  | 6.391    | 0.162           | 4.405                             |
| Normalized ag asset wealth index (0-1)               | 0.146    | 0.006           | 0.140                             |
| HH has raised or owned livestock (1=yes)            | 0.192    | 0.015           | -0.019                            |
| HH has sole ownership of its largest field (1=yes)  | 0.752    | 0.016           | 0.110                             |
| HH head’s primary employment is off farm (1=yes)    | 0.135    | 0.012           | 0.130                             |
| HH received subsidy for fertilizers or other input  | 0.677    | 0.017           | 0.190                             |
| HH sold other crop on the market                    | 0.816    | 0.017           | 0.209                             |
| HH received food aid (1=yes)                        | 0.416    | 0.018           | -0.222                            |
| HH received a loan for ag. activity                 | 0.453    | 0.018           | 0.050                             |
| HH participated in crop insurance scheme (1=yes)    | 0.436    | 0.018           | 0.115                             |
| HH received info on improved seeds (1=yes)          | 0.121    | 0.012           | 0.097                             |
| HH received info on new ag. technologies(1=yes)    | 0.121    | 0.012           | 0.069                             |
| Total field area with agro-wells (acres)           | 0.685    | 0.058           | 0.842                             |
| HH rented a tractor                                 | 0.671    | 0.017           | 0.010                             |
| HH bought input from commercial sources            | 0.821    | 0.014           | 0.191                             |
| Distance (km) to agrarian services center          | 6.301    | 0.192           | 0.293                             |
| Distance (km) to established marketplace            | 13.170   | 0.576           | 5.601                             |
| Distance (km) to fertilizers retailer               | 4.205    | 0.179           | 0.057                             |
| Share of land that is irrigated                     | 0.663    | 0.010           | 0.082                             |
| Off-farm income share (of gross income)            | 0.443    | 0.013           | 0.176                             |
| Income share from transfers (of gross income)      | 0.074    | 0.006           | -0.252                            |
| Agricultural income share (of gross income)        | 0.480    | 0.013           | 0.089                             |
| Off-farm income (rupees)                            | 343300.2 | 16278.1         | 635856.8                          |
| Value of transfer (rupees)                          | 20958.5  | 1696.2          | -16775.7                          |
| Total value of harvest production                   | 433240.5 | 24595.9         | 922042.4                          |
| Gross income (rupees)                               | 832270.1 | 40448.1         | 1910546.9                         |

Observations 1,100

Notes: The table also includes the inter-quintile difference between variable means calculated at highest and the lowest quintile of the gross income distribution. With the only exception of the “distance from fertilizer retailers”, all the inter-quintile differences are statistically different from zero at 1% significance level.
**Table A1.** Descriptive field level statistics for selected variables

| Variables                                                                 | Maha season | Yala season |
|--------------------------------------------------------------------------|-------------|-------------|
|                                                                         | Lowland     | Upland      | Lowland | Upland |
| **Characteristics of the fields and production**                         |             |             |         |        |
| Rice yield (kg/acre)                                                     | 1712.49     | 66.28       | 1667.39 | 12.61  |
| Field harvested less than planted due to wilting (1=yes)                 | 0.244       | 0.414       | 0.107   | 0.144  |
| Field area (acres)                                                       | 2.189       | 2.533       | 1.944   | 2.469  |
| Field applied with inorganic fertilizer (1=yes)                          | 0.993       | 0.890       | 0.993   | 0.593  |
| Quantity of inorganic fertilizer used (kg) on field                      | 276.189     | 371.764     | 219.957 | 159.087|
| Quantity of inorganic fertilizer used (kg/acre) on field                 | 133.845     | 165.583     | 139.040 | 100.825|
| Field applied with organic fertilizer (1=yes)                            | 0.043       | 0.035       | 0.029   | 0.058  |
| Quantity of organic fertilizer used (kg) on field                        | 17.743      | 30.155      | 10.765  | 19.684 |
| Field sprayed with herbicide (1=yes)                                     | 0.936       | 0.579       | 0.815   | 0.130  |
| Times herbicide was sprayed on field                                     | 1.162       | 0.652       | 1.208   | 0.170  |
| Quantity of herbicide used (kg/acre) on uplands                         | 0.881       | 0.428       | 0.933   | 0.115  |
| Field preventatively weeded(1=yes)                                       | 0.032       | 0.046       | 0.066   | 0.061  |
| Field acquired via *bethma* (1=yes)                                      | 0.028       | -           | 0.108   | -      |
| Gini-Simpson index (land area) of crop cultivated                        | 0.021       | 0.078       | 0.097   | 0.127  |
| Adjusted Gini-Simpson index (land area) of crop cultivated               | 0.013       | 0.041       | 0.044   | 0.055  |
| **Conventional practices**                                               |             |             |         |        |
| Field mechanically ploughed (1=yes)                                      | 0.994       | 0.931       | 0.984   | 0.914  |
| Field levelled with mechanized methods (1=yes)                           | 0.125       | 0.045       | 0.081   | 0.030  |
| Field sown with manual direct seeding methods(1=yes)                     | 0.030       | 0.630       | 0.139   | 0.343  |
| Retained crop residue on field (1=yes)                                   | 0.971       | 0.714       | 0.952   | 0.690  |
| **Adaptation practices**                                                 |             |             |         |        |
| Field sown with short duration rice seeds(1=yes)                         | 0.364       | 0.036       | 0.264   | 0.0014 |
| HH grew maize on field (1=yes)                                           | 0.0018      | 0.534       | 0.049   | 0.026  |
| HH grew other crops(1=yes) on the field                                  | 0.048       | 0.864       | 0.209   | 0.995  |
| Field with improved water management practices (1=yes)                   | 0.0019      | 0.0018      | 0.013   | 0.014  |
| Retained trees on field (1=yes)                                          | 0.085       | 0.234       | 0.103   | 0.221  |
| Soil erosion barriers on field (1=yes)                                   | 0.014       | 0.151       | 0.013   | 0.155  |
| Retained crop residue for 5 yrs and added water/urea (1=yes)             | 0.118       | 0.0014      | 0.125   | 0.0017 |
| **Observations**                                                         | 1,013       | 629         | 508     | 336    |
### Table A3. Summary table of the main results from the impact assessment of the adoption of single practices

| List of Variables                      | Sensitivity | Direct effect | Indirect effect | Net effect | Direct effect | Indirect effect | Net effect | Direct effect | Indirect effect | Net effect | Direct effect | Indirect effect | Net effect | Direct effect | Indirect effect | Net effect | Direct effect | Indirect effect | Net effect |
|----------------------------------------|-------------|---------------|-----------------|------------|---------------|----------------|------------|---------------|----------------|------------|---------------|----------------|------------|---------------|----------------|------------|---------------|----------------|------------|
| **MAHA LOW**                           |             |               |                 |            |               |                 |            |               |                 |            |               |                 |            |               |                 |            |               |                 |            |
| Short duration rice seeds              | -0.017      | 0.006         | 0.038           | 0.043      | 0.048         | 0.016          | 0.064      | -0.017        | 0.014          | -0.002     |               |                 |            |               |                 |            |               |                 |            |
| Residue retention[+5yrs&wat/urea]      | -0.148***   | 0.286*        | 0.249           | 0.535***   | 0.169*        | 0.105          | 0.274***   | -0.090        | 0.177*         | 0.087      |               |                 |            |               |                 |            |               |                 |            |
| **MAHA UP**                            |             |               |                 |            |               |                 |            |               |                 |            |               |                 |            |               |                 |            |               |                 |            |
| Other crops in the field               | -0.187***   | -0.005        | 0.236**         | 0.231      | -0.206        | 0.147**        | -0.059     | 0.063         | 0.018          | 0.080      |               |                 |            |               |                 |            |               |                 |            |
| Cultivating maize                      | 0.164***    | 0.028         | -0.308***       | -0.280     | -0.136        | -0.164***      | -0.300**   | 0.114         | -0.103***       | 0.010      |               |                 |            |               |                 |            |               |                 |            |
| Retaining trees                        | 0.027       | -0.144        | -0.037          | -0.181     | -0.364***     | -0.013         | -0.378***   | 0.031         | -0.016          | 0.015      |               |                 |            |               |                 |            |               |                 |            |
| Soil erosion barriers                   | 0.020       | -0.120        | -0.041          | -0.161     | 0.255**       | -0.013         | 0.242*     | 0.102         | -0.010          | 0.092      |               |                 |            |               |                 |            |               |                 |            |
| **YALA LOW**                           |             |               |                 |            |               |                 |            |               |                 |            |               |                 |            |               |                 |            |               |                 |            |
| Short duration rice seeds              | -0.053**    | 0.061         | 0.240           | 0.301***   | -0.272        | 0.407          | 0.135      | 0.135         | 0.017          | 0.152      |               |                 |            |               |                 |            |               |                 |            |
| Other crops in the field               | -0.093***   | 0.061         | -0.277          | -0.216     | -1.016        | 1.006          | -0.011     | 0.143         | -0.109          | 0.035      |               |                 |            |               |                 |            |               |                 |            |
| Retaining trees                        | -0.020      | -0.075        | 0.141           | 0.065      | -0.331        | 0.240          | -0.092     | -0.008        | -0.121          | -0.129     |               |                 |            |               |                 |            |               |                 |            |
| Residue retention[+5yrs&wat/urea]      | 0.038       | 0.481***      | -0.052          | 0.429***   | 0.504***      | -0.109         | 0.395***   | 0.195**       | -0.014          | 0.181*     |               |                 |            |               |                 |            |               |                 |            |
| **YALA UP**                            |             |               |                 |            |               |                 |            |               |                 |            |               |                 |            |               |                 |            |               |                 |            |
| Retaining trees                        | -0.027      | -0.165        | 0.044           | -0.121*    | -0.246        | 0.037          | -0.209     | -0.053        | 0.034           | -0.019     |               |                 |            |               |                 |            |               |                 |            |
| Soil erosion barriers                   | -0.057      | 0.194         | 0.104           | 0.298**    | 0.164         | 0.126          | 0.290**    | -0.012        | 0.074           | 0.062      |               |                 |            |               |                 |            |               |                 |            |

*Notes: Levels of significance are * p<0.10; ** p<0.05; ***p<0.01.*
Table A4. Average labour by adaptive strategy (person days)

| Activity                                              | HH labour | Hired labour | Total labour |
|-------------------------------------------------------|-----------|--------------|--------------|
| Short duration rice seeds (low-<em>maha</em>)         | 14.377    | 13.734       | 28.111       |
| Short duration rice seeds (low-<em>yala</em>)         | 19.257    | 20.954       | 40.211       |
| Other crops in the field (up/<em>maha</em>)           | 44.931    | 12.320       | 57.251       |
| Other crops in the field (low/<em>yala</em>)          | 68.609    | 21.564       | 90.173       |
| Cultivating maize (up/<em>maha</em>)                  | 77.010    | 11.633       | 88.643       |
| Retaining trees (up-<em>maha</em>)                    | 24.300    | 12.443       | 36.743       |
| Retaining trees (low-<em>yala</em>)                   | 30.876    | 20.654       | 51.530       |
| Soil erosion barriers (up-<em>maha</em>)              | 24.215    | 21.345       | 45.561       |
| Soil erosion barriers (up-<em>yala</em>)              | 30.697    | 15.577       | 46.274       |
| Residue retention [+5yrs<wat>/urea] (low-<em>maha</em>)| 34.108    | 24.596       | 58.704       |
| Residue retention [+5yrs<wat>/urea] (low-<em>yala</em>)| 33.994    | 15.243       | 51.197       |
| Residue retention [+5yrs<wat>/urea] (low-<em>yala</em>)| 30.563    | 17.531       | 51.009       |
Table A2. Adoption determinants of selected practices affecting sensitivity to water-stress at HH level

| List of Variables                              | Short duration rice seeds on lowlands yala | Other crops in the field on lowlands yala | Improved Residue retention lowlands maha | Other crops in the field on uplands maha | Cultivating maize uplands maha |
|------------------------------------------------|-------------------------------------------|------------------------------------------|------------------------------------------|------------------------------------------|---------------------------------|
| Gender of HH head (1=female)                   | 0.01                                      | -0.08                                    | 0.04                                     | -0.04*                                   | -0.13                          |
| Age of HH head                                 | -0.00                                    | -0.00**                                  | -0.00                                    | -0.00*                                   | -0.00                          |
| Highest education of HH head                   | -0.00                                    | 0.00                                     | -0.00                                    | 0.00*                                    | 0.01                           |
| HH family size                                 | 0.03**                                   | 0.03*                                    | -0.01                                    | 0.00                                     | 0.01                           |
| Field area                                     | 0.01                                     | -0.01                                    | -0.00                                    | 0.01***                                  | 0.01                           |
| Normalized ag asset wealth index (0-1)          | -0.25                                    | 0.36**                                   | -0.08                                    | -0.08**                                  | -0.05                          |
| HH raised or owned livestock                    | 0.03                                     | -0.05                                    | -0.03                                    | 0.01                                     | -0.01                          |
| Sole ownership of largest field                | -0.09**                                  | 0.03                                     | -0.07***                                 | 0.02                                     | 0.05                           |
| Total field area under agro-wells (acres)      | -0.01                                    | -0.00                                    | 0.01*                                    | -0.00                                    | -0.05***                       |
| Off-farm head's primary employment             | -0.05                                    | -0.05                                    | 0.04                                     | 0.01                                     | 0.13                           |
| Subsidy for fertilizers or other input         | 0.02                                     | -0.19***                                 | 0.01                                     | -0.05***                                 | 0.05                           |
| HH received food aid                           | -0.08*                                   | 0.04                                     | -0.01                                    | 0.02*                                    | 0.11                           |
| HH received a loan for ag. activity            | -0.07*                                   | 0.04                                     | -0.05**                                  | 0.01                                     | 0.04                           |
| Crop insurance scheme                          | 0.07*                                    | -0.08*                                   | -0.05**                                  | -0.00                                    | 0.02                           |
| Input from commercial sources                  | -0.04                                    | 0.05                                     | 0.05                                     | 0.02                                     | 0.78***                        |
| Log. distance (km) to ASC                      | 0.03                                     | -0.01                                    | -0.03*                                   | 0.01                                     | 0.03                           |
| Log. distance (km) to marketplace               | 0.02                                     | 0.02                                     | -0.01                                    | 0.01                                     | 0.01                           |
| Log. distance (km) to fertilizers retailer     | -0.05**                                  | 0.02                                     | 0.03*                                    | -0.00                                    | 0.01                           |
| Share of land that is irrigated                | 0.29***                                  | -0.09                                    | -0.00                                    | 0.02                                     | -0.11                          |
| Irrigation: Major                              | 1.99***                                  | -0.09                                    | -0.08                                    | -0.01                                    | -0.07                          |
| Irrigation: Minor                              | 2.11***                                  | -0.19                                    | -0.08                                    | 0.02                                     | -0.01                          |
| Irrigation: Mahaweli                           | 2.13***                                  | -0.14                                    | -0.02                                    | -                      | 0.19                           |
| HH received info on improved seeds (1=yes)      | 0.02                                     | -0.08*                                   | 0.02                                     | 0.02                                     | 0.15**                         |
| HH received info on new cultivation technologies (1=yes) | 0.08 | 0.08  | -0.02 | -0.00 | -0.01 |
| FO leave-out mean of adoption                  | 0.31***                                  | 0.46***                                  | -0.33**                                  | 0.06**                                   | 1.08***                        |
| Observations                                   | 427                                      | 427                                      | 707                                      | 498                                      | 513                            |

Notes: Levels of significance are * p<0.10; ** p<0.05; ***p<0.01.
### Table A6. Sample design

| Cluster (DS)                  | Number of farm family | Sample of farmer organization |
|------------------------------|-----------------------|-------------------------------|
|                              | Major | Minor | Rain-fed | Mahaweli | Major | Minor | Rain-fed | Mahaweli |
| Padaviya                     | 2,392 | 2,649 | 30       | 0        | 5,071 | 5     | 5        | 0        |
| Medawachchiya                | 0     | 9,067 | 0        | 0        | 9,067 | 0     | 10       | 0        |
| Nuwargam Palatha Central     | 76    | 4,997 | 0        | 0        | 5,073 | 1     | 9        | 0        |
| Kahatagasdigiliya            | 0     | 10,209| 0        | 0        | 10,209| 0     | 10       | 0        |
| Galenbidunuwewa              | 2,993 | 8,308 | 0        | 0        | 11,301| 3     | 7        | 0        |
| Nuwargam Palatha eastern     | 417   | 1,029 | 301      | 0        | 17,470| 2     | 6        | 2        |
| Nochchiyagama                | 0     | 5,467 | 0        | 6,125    | 11,592| 0     | 5        | 0        |
| Thabuththevama               | 0     | 0     | 0        | 4,150    | 4,150 | 0     | 0        | 10       |
| Thirappane                   | 312   | 2,728 | 161      | 0        | 3,201 | 1     | 8        | 1        |
| Palugaswewa                  | 0     | 3,170 | 0        | 0        | 0     | 0     | 10       | 0        |
| Galnewa                      | 110   | 5,336 | 0        | 1,994    | 7,440 | 0     | 7        | 0        |
| **Total**                    |       |       |          |          |       |       |          |          |
|                              | **12** | **77** |           | **3**    | **18** |       |          |          |

*Note:* DS: Divisional Secretariat.

*Source:* HARTI elaboration from District Statistical Branch, Anuradhapura, Department of Census and Statistics.

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**Figure A1.** Geographic location of households sampled within the Anuradhapura district at Grama Niladari (GND) levels (red polygons).

*Source:* Authors’ elaboration on sampled households.
Figure A2. Propensity Score probability distribution by treatment variable.
Figure A3. Balancing test of covariates distribution before and after the propensity model.
Figure A4. Density function of treatment probability before and after the propensity model.
## Appendix C

### Table A7. Adoption determinants of selected practices by type of land during the *maha* season

| List of Variables                                                                 | Lowlands   | Uplands   | Lowlands   | Uplands   | Lowlands   | Uplands   |
|----------------------------------------------------------------------------------|------------|-----------|------------|-----------|------------|-----------|
| Gender of HH head (1=female)                                                     | -0.16      | 0.04      | -0.04*     | -0.13     | 0.01       | -0.15     |
| Age of HH head                                                                   | -0.00      | -0.00     | -0.00*     | -0.00     | 0.00       | 0.00      |
| Highest education of HH head                                                     | -0.01      | -0.00     | 0.00*      | 0.01      | 0.01       | 0.01*     |
| HH family size                                                                   | 0.00       | -0.01     | 0.00       | 0.01      | -0.01      | 0.02      |
| Field area                                                                       | -0.00      | -0.00     | 0.01***    | 0.01      | -0.01*     | -0.00     |
| Normalized ag asset wealth index (0-1)                                            | 0.05       | -0.08     | -0.08**    | -0.05     | 0.10       | -0.12     |
| HH raised or owned livestock                                                     | 0.04       | -0.03     | 0.01       | -0.01     | -0.00      | 0.03      |
| Sole ownership of largest field                                                  | -0.04      | -0.07***  | 0.02       | 0.05      | 0.05       | -0.01     |
| Total field area under agro-wells (acres)                                        | -0.00      | 0.01*     | -0.00      | -0.05***  | 0.01       | 0.01      |
| Off-farm head’s primary employment                                               | -0.02      | 0.04      | 0.01       | 0.13      | -0.02      | -0.16***  |
| Subsidy for fertilizers or other input                                           | -0.08      | 0.01      | -0.05***   | 0.05      | 0.03       | 0.01      |
| HH received food aid                                                             | -0.04      | -0.01     | 0.02*      | 0.11      | 0.03       | -0.02     |
| HH received a loan for ag. activity                                              | 0.08**     | -0.05**   | 0.01       | 0.04      | 0.04       | 0.03      |
| Crop insurance scheme                                                           | 0.03       | -0.05**   | -0.00      | 0.02      | -0.08*     | -0.09***  |
| Input from commercial sources                                                    | 0.05       | 0.05      | 0.02       | 0.78***   | -0.15*     | 0.01      |
| Log. distance (km) to ASC                                                         | 0.04       | -0.03*    | 0.01       | 0.03      | 0.00       | -0.04*    |
| Log. Distance (km) to marketplace                                                 | -0.01      | -0.01     | 0.01       | 0.01      | -0.01      | -0.02     |
| Log. Distance (km) to fertilizers retailer                                       | -0.04*     | 0.03*     | -0.00      | 0.01      | -0.05**    | 0.02      |
| Share of land that is irrigated                                                  | 0.07       | -0.00     | 0.02       | -0.11     | 0.10       | 0.12*     |
| Irrigation: Major                                                                | 0.07       | -0.08     | -0.01      | -0.07     | -0.08      | -0.04     |
| Irrigation: Minor                                                                | 0.11       | -0.08     | 0.02       | -0.01     | -0.00      | -0.07     |
| Irrigation: Mahaweli                                                             | 0.04       | -0.02     | 0.19       | -0.25     | -0.22      |           |
| HH received info on improved seeds (1=yes)                                       | 0.02       | 0.02      | 0.02       | 0.15**    | -0.13**    | 0.03      |
| HH received info on new cultivation technologies(1=yes)                          | 0.09       | -0.02     | -0.00      | -0.01     | 0.11*      | 0.04      |
| FO leave-out mean of adoption                                                    | 0.44***    | -0.33**   | 0.06**     | 1.08***   | -0.36***   | -0.16***  |
| Observations                                                                     | 707        | 707       | 498        | 513       | 513        | 513       |

*Notes: Levels of significance are * p<0.10; ** p<0.05; ***p<0.01. The dependent variables according to the specification number are (1) Short duration rice seeds; (2) Improved Residue retention; (3) Other crops in the field; (4) Cultivating maize; (5) Retaining trees; (6) Soil erosion barriers.*
| List of Variables                                           | 1     | 2     | 3     | 4     | 5     | 6     |
|------------------------------------------------------------|-------|-------|-------|-------|-------|-------|
| Gender of HH head (1=female)                               | 0.01  | -0.08 | 0.06  | 0.03  | -0.19 | -     |
| Age of HH head                                             | -0.00 | -0.00**| 0.00  | -0.00*| 0.00  | 0.00  |
| Highest education of HH head                               | -0.00 | 0.00  | 0.01  | -0.01***| 0.01  | 0.01  |
| HH family size                                             | 0.03**| 0.03* | 0.01  | -0.00 | 0.01  | 0.01  |
| Field area                                                 | 0.01  | -0.01 | -0.00 | -0.00 | -0.01**| -0.00 |
| Normalized ag asset wealth index (0-1)                     | -0.25 | 0.36**| 0.11  | -0.14 | 0.15  | -0.26 |
| HH raised or owned livestock                               | 0.03  | -0.05 | 0.02  | -0.00 | 0.04  | 0.07  |
| Sole ownership of largest field                            | -0.09**| 0.03  | -0.02 | -0.04 | -0.03 | 0.04  |
| Total field area under agro-wells (acres)                  | -0.01 | -0.00 | -0.01 | 0.01  | 0.00  | 0.02  |
| Off-farm head's primary employment                         | -0.05 | -0.05 | -0.06 | 0.02  | -0.02 | -0.21**|
| Subsidy for fertilizers or other input                     | 0.02  | -0.19***| 0.06  | 0.03  | 0.01  | -0.01 |
| HH received food aid                                       | -0.08*| 0.04  | -0.03 | -0.03 | 0.03  | -0.04 |
| HH received a loan for ag. activity                        | -0.07*| 0.04  | 0.03  | -0.08**| 0.06  | -0.04 |
| Crop insurance scheme                                      | 0.07* | -0.08*| -0.03 | -0.03 | -0.13***| -0.05 |
| Input from commercial sources                              | -0.04 | 0.05  | 0.00  | 0.09  | -0.23**| 0.08  |
| Log. distance (km) to ASC                                  | 0.03  | -0.01 | 0.05***| 0.00  | -0.11***| -0.03 |
| Log. Distance (km) to marketplace                          | 0.02  | 0.02  | 0.00  | -0.03 | -0.01  | -0.06**|
| Log. Distance (km) to fertilizers retailer                 | -0.05**| 0.02  | -0.03*| 0.05**| -0.02  | -0.02 |
| Share of land that is irrigated                             | 0.29***| -0.09 | 0.07  | 0.03  | 0.18  | 0.05  |
| Irrigation: Major                                          | 1.99***| -0.09 | -0.27***| 0.10  | 0.10  | -0.15 |
| Irrigation: Minor                                          | 2.11***| -0.19 | -0.25***| 0.02  | 0.15  | -0.00 |
| Irrigation: Mahaweli                                       | 2.13***| -0.14 | -0.22**| 0.06  | -     | -     |
| HH received info on improved seeds (1=yes)                 | 0.02  | -0.08*| -0.08**| 0.03  | -0.11 | 0.07  |
| HH received info on new cultivation technologies(1=yes)    | 0.08  | 0.08  | 0.05  | -0.04 | 0.06  | -0.02 |
| FO leave-out mean of adoption                              | 0.31***| 0.46***| 0.05  | -0.36***| -0.38**| 0.16  |
| Observations                                               | 427   | 426   | 427   | 427   | 301   | 293   |

Notes: Levels of significance are * p<0.10; ** p<0.05; ***p<0.01. The dependent variables according to the specification number are: (1) Short duration rice seeds; (2) Other crops in the field; (3) Retaining trees; (4) Improved residue retention; (5) Retaining trees; (6) Soil erosion barriers.
Appendix D

Robustness Check I

In order to take into account the possibility of adopting multiple practices on the same field, we have implemented a robustness check to test the existence of complementarities among different practices. It is worth noting that with few relevant exceptions, in the Sri Lanka rice sector there is little evidence of the adoption of multiple practices on the same field during the same season (see table A9).

Table A9. Incidence of mutual exclusive package of practices by season/field type

| Season/Land type | Adaptive strategy                          | % of field |
|------------------|-------------------------------------------|------------|
| **MAHA LOW**     | No Practices                              | 55.74      |
|                  | Residue retention                          | 7.84       |
|                  | Short duration rice seed                   | 32.49      |
|                  | Short duration rice seed + Residue retention| 3.92       |
|                  | Total                                      | 100.00     |
|                  | No Practices                              | 7.95       |
|                  | Soil erosion barriers                      | 1.91       |
|                  | Retaining trees                            | 3.29       |
|                  | Soil erosion barriers + Retaining trees    | 0.42       |
|                  | Other crops in the field                   | 59.74      |
|                  | Other crops in the field + Soil erosion barriers| 6.97       |
|                  | Other crops in the field + Retaining trees | 13.92      |
|                  | Other crops in the field + Retaining trees + Soil erosion barriers| 5.79       |
|                  | Total                                      | 100.00     |
| **YALA LOW**     | No Practices                              | 42.77      |
|                  | Residue retention                          | 6.50       |
|                  | Retaining trees                            | 4.22       |
|                  | Residue retention + Retaining trees        | 0.28       |
|                  | Other crops in the field                   | 14.66      |
|                  | Other crops in the field + Residue retention| 1.51       |
|                  | Other crops in the field + Retaining trees | 2.95       |
|                  | Other crops in the field + Residue retention + Residue retention| 0.79       |
|                  | Short duration rice seed                   | 20.15      |
|                  | Short duration rice seed + Residue retention| 3.23       |
|                  | Short duration rice seed + Retaining trees | 1.73       |
|                  | Short duration rice seed + Retaining trees + Residue retention| 0.20       |
|                  | Short duration rice seed + Other crops in the field | 0.84       |
|                  | Short duration rice seed + Other crops in the field + Retaining trees + Residue retention| 0.18       |
|                  | Total                                      | 100.00     |
| **YALA UP**      | No Practices                              | 66.40      |
|                  | Soil erosion barriers                      | 8.86       |
|                  | Retaining trees                            | 18.37      |
|                  | Soil erosion barriers + Retaining trees    | 6.36       |
|                  | Total                                      | 100.00     |

In this framework, we have created a set of variables (one for each season–land typology dyad) to categorize the mutually exclusive adoption of a specific combination (package) of practices. As the mutually exclusive categories are not equally populated, we have selected for the empirical estimation only those packages for which the number of fields allows an empirical estimation. Depending on the
number of plots available in each season-typology, the thresholds to include a category vary between 3-5 per cent of the sample.

In particular, the probability of the mutually exclusive adoption of a specific package, \( j \), of practices has been modelled using a multinomial logit function in the spirit of Di Falco and Veronesi (2013), on a categorical variable encompassing all the mutually exclusive combinations of practices:

\[
P(T_j = t | W^1) = \frac{\exp(\beta_0 j + W^1 \beta_j)}{1 + \sum_{j=1}^{M-1} \exp(\beta_0 j + W^1 \beta_j)} \text{ with } j = 1, \ldots, (M - 1),
\]

where \( W^1 \) is a vector of household and field characteristics corresponding to the vector \( W \) used for the main analysis but excluding the dummies for all the practices adopted in the same season/land type as they are directly modeled in the multinomial categories.

The balancing properties of the weighted sample have been tested using pairwise comparisons of the variables across the levels of factor variables using the Bonferroni method (the results are available upon request). The kernel densities of the unbalanced and balanced sample are reported in figure A5.

**Figure A5.** Density function of treatment probability before and after the multinomial propensity model.
The weights from the multinomial logit model have been subsequently used to estimate an Inverse Probability Weighting (IPW) model for each dyad season/land type. The results do not highlight strong complementarities, but it is worth noting that the coefficients related to certain packages have been estimated on a very small number of observations. The main results have been summarized in table A10 (complete results are available upon request).

Table A10. Summary table of the main results from the impact assessment of mutually exclusive practices

| List of Variables | Sensitivity | Direct welfare Total gross value of harvest | Indirect welfare Total net value of harvest | Net welfare | Direct welfare Gross total income |
|-------------------|-------------|---------------------------------------------|------------------------------------------|-------------|-----------------------------------|
| Residue retention | MAHA LOW    | -0.085*                                    | 0.295                                    | 0.144       | 0.439                             | -0.053                                    | 0.092                                     | 0.039                             | 0.095                     |
| Short duration rice seeds |             | -0.003                                    | 0.101                                    | 0.004       | 0.105                             | 0.038                                    | 0.003                                     | 0.040                             | 0.043                     |
| Short duration rice seeds + Residue retention | MAHA UP    | -0.268***                                 | 0.471                                    | 0.455       | 0.925                             | 0.401**                                  | 0.290**                                    | 0.690***                           | -0.176                   |
| Other crops in the field |             | -0.120                                    | -0.052                                   | 0.222       | 0.170                             | 0.058                                    | 0.100                                     | 0.158                             | 0.132                     |
| Other crops in the field + Soil erosion barriers |             | -0.085                                    | -0.647                                   | 0.158       | -0.488                            | 0.412                                    | 0.071                                     | 0.483                             | 0.200                     |
| Retaining trees Other crops in the field + Retaining trees |             | -0.078                                    | -0.073                                   | 0.145       | 0.072                             | -0.444*                                  | 0.065                                     | -0.379                            | 0.198                     |
| Soil erosion barriers |             | -0.036                                    | 0.446                                    | 0.066       | 0.512                             | 0.237                                    | 0.030                                     | 0.267                             | 0.877**                   |
| Retaining trees | MAHA UP    | -0.003                                    | 0.004                                    | 0.004       | 0.004                             | 0.594**                                  | 0.004                                     | 0.598***                           | 0.922                     |
| Residue retention |             | -0.124***                                 | -0.508                                   | -0.011      | -0.519                            | -1.900***                                | 1.614**                                   | -0.286                            | 0.329                     |
| Other crops in the field |             | -0.090***                                 | 0.121                                    | -0.008      | 0.113                             | -1.299**                                 | 1.180**                                   | -0.118                            | 0.292                     |
| Soil erosion barriers Retaining trees |             | -0.063                                    | 0.173                                    | 0.137       | 0.309                             | 0.233                                    | 0.156                                     | 0.389*                            | 0.084                     |
| Soil erosion barriers Retaining trees |             | -0.063                                    | -0.217                                   | -0.059      | -0.276                            | -0.115                                   | -0.107                                    | -0.221                            | -0.190                    |
| YALA UP    | Residue retention | 0.042                                     | 0.594**                                  | 0.004       | 0.598***                           | 0.922                                    | -0.566                                    | 0.356**                           | 0.191                     |
| Other crops in the field | -0.124***   | -0.508                                    | -0.011                                   | -0.519      | -1.900***                          | 1.614**                                   | -0.286                                    | 0.329                            | -0.293                   |
| Short duration rice seeds | -0.090***   | 0.121                                    | -0.008                                   | 0.113       | -1.299**                           | 1.180**                                   | -0.118                                    | 0.292                            | 0.085                     |
| Soil erosion barriers Retaining trees | -0.063      | 0.173                                    | 0.137                                   | 0.309       | 0.233                             | 0.156                                    | 0.389*                                   | 0.084                            | 0.075                    |
| YALA UP    | Retaining trees | -0.063                                    | -0.217                                   | -0.059      | -0.276                            | -0.115                                   | -0.107                                    | -0.221                            | -0.190                    |
| Retaining trees |             | -0.0054                                   | 0.135                                    | 0.081       | 0.060                             | -0.090                                   | 0.150                                     | 0.060                             | -0.178                    |

Notes: Levels of significance are * p<0.10; ** p<0.05; ***p<0.01.
**Robustness Check II**

Since the use of IPW has the unfortunate property of giving a very high weight to very unlikely observations, with the weight going to infinity as the probability goes to zero, this robustness check tests the same models included in the main text by excluding the treated households with low conditional probability (<5th percentile) of adoption and control household with high probability of adoption from the sample (>95th percentile). Table A11 summarizes the main results (complete results are available upon request).

**Table A11.** Summary table of the main results obtained excluding extreme weights

| List of Variables | Sensitivity | Direct effect | Indirect effect | Net effect | Direct effect | Indirect effect | Net effect | Direct effect | Indirect effect | Net effect |
|-------------------|-------------|---------------|----------------|------------|---------------|----------------|------------|---------------|----------------|------------|
| **MAHA LOW**      |             |               |                |            |               |                |            |               |                |            |
| Short duration rice seeds | -0.005      | 0.030         | 0.011          | 0.041      | 0.055         | 0.004          | 0.060      | 0.007         | 0.002          | 0.009      |
| Residue retention [+Syrs & wat/urea] | -0.151***   | 0.256         | 0.318*         | 0.574***   | 0.139         | 0.110          | 0.249**    | -0.134        | 0.191*         | 0.057      |
| Other crops in the field | -0.267***   | -0.137        | 0.361***       | 0.224      | -0.275        | 0.164**        | -0.111     | 0.228         | 0.039          | 0.266      |
| Cultivating maize    | 0.158***    | 0.073         | -0.315***      | -0.242     | -0.106        | -0.172***      | -0.279**   | 0.084         | 0.118***       | -0.034     |
| Retaining trees      | 0.047       | -0.259        | -0.066         | -0.325*    | -0.421***     | -0.025         | -0.446***  | 0.021         | -0.027         | -0.006     |
| Soil erosion barriers | 0.023       | -0.114        | -0.047         | -0.161     | 0.269**       | -0.015         | 0.255*     | 0.103         | -0.010         | 0.094      |
| **YALA LOW**        |             |               |                |            |               |                |            |               |                |            |
| Short duration rice seeds | -0.055**    | 0.064         | 0.255          | 0.319***   | -0.317        | 0.472          | 0.155      | 0.085         | 0.037          | 0.122      |
| Other crops in the field | -0.092***   | 0.056         | -0.282         | -0.226     | -1.024        | 1.018          | -0.006     | 0.277         | -0.229         | 0.047      |
| Retaining trees      | -0.016      | -0.114        | 0.184          | 0.069      | 0.256         | -0.341         | -0.085     | 0.006         | -0.153         | -0.147     |
| Residue retention [+Syrs & wat/urea] | 0.056       | 0.546***      | -0.079         | 0.467***   | 0.506***      | -0.103         | 0.402***   | 0.189*        | -0.025         | 0.165*     |
| **YALA UP**         |             |               |                |            |               |                |            |               |                |            |
| Retaining trees      | -0.035      | -0.209        | 0.053          | -0.155     | -0.310**      | 0.048          | -0.262*    | -0.076        | 0.043          | -0.033     |
| Soil erosion barriers | -0.060      | 0.187         | 0.106          | 0.293**    | 0.146         | 0.130          | 0.276**    | -0.048        | 0.077          | 0.029      |

*Notes: Levels of significance are * p<0.10; ** p<0.05; *** p<0.01.*
Robustness Check III

The outcome variables considered for the main analysis are total household values. However, the size of the field cultivated has been included both in the propensity score and in the IPW model as controls. This robustness check estimates the specification in the main text considering the ratio between the total outcome variable and the land size as dependent variables. The main results have been summarized in table A12 (complete results are available upon request).

Table A12. Summary table of the main results obtained considering the ratio of the outcome variable to the land size as dependent variable

| List of Variables                  | Sensitivity | Direct effect | Indirect effect | Net effect | Direct effect | Indirect effect | Net effect | Direct effect | Indirect effect | Net effect |
|-----------------------------------|-------------|---------------|-----------------|------------|---------------|-----------------|------------|---------------|-----------------|------------|
| MAHA LOW Short duration rice seeds | -0.017      | 0.019         | 0.047           | 0.066      | 0.062         | 0.032           | 0.094      | -0.010        | 0.026           | 0.016      |
| MAHA LOW Residue retention[+Syrs&wat/urea] | -0.148*** | 0.098         | 0.323*          | 0.421***   | -0.033        | 0.199*          | 0.166*     | -0.270**      | 0.258**         | -0.012     |
| MAHA UP Other crops in the field  | -0.186***   | -0.026        | 0.294**         | 0.268      | -0.200        | 0.203**         | 0.003      | 0.045         | 0.076           | 0.121      |
| MAHA UP Cultivating maize         | 0.165***    | -0.161        | -0.340***       | -0.501**   | -0.326***     | -0.197***       | -0.522***  | -0.082        | -0.143***       | -0.226***  |
| MAHA UP Retaining trees           | 0.027       | -0.054        | -0.042          | -0.096     | -0.260**      | -0.018          | -0.278**   | 0.122         | -0.020          | 0.102      |
| MAHA UP Soil erosion barriers     | 0.020       | -0.192        | -0.043          | -0.235     | 0.174*        | -0.015          | 0.160      | 0.082         | -0.010          | 0.072      |
| YALA LOW Short duration rice seeds | -0.051*     | -0.112        | 0.445           | 0.333***   | -0.072        | 0.257           | 0.184      | 0.724         | -0.540          | 0.183*     |
| YALA LOW Other crops in the field | -0.093***   | 0.278         | -0.540          | -0.263     | -1.223        | 1.159           | -0.065     | 0.199         | -0.228          | -0.029     |
| YALA LOW Retaining trees          | -0.021      | -0.115        | 0.163           | 0.049      | -0.316        | 0.206           | -0.109     | -0.077        | -0.069          | -0.146     |
| YALA LOW Residue retention[+Syrs&wat/urea] | 0.035 | 0.349**        | -0.063          | 0.286**    | 0.348**       | -0.084          | 0.264***   | 0.057         | -0.022          | 0.035      |
| YALA UP Retaining trees           | -0.027      | -0.099        | 0.046           | -0.053     | -0.185        | 0.039           | -0.147     | 0.013         | 0.036           | 0.049      |
| YALA UP Soil erosion barriers     | -0.058      | 0.133         | 0.122           | 0.256**    | 0.103         | 0.146           | 0.248**    | -0.072        | 0.092           | 0.020      |

Note: Levels of significance are * p<0.10; ** p<0.05; *** p<0.01.
**Robustness Check IV**

The identification strategy in the main text is based on observable characteristics. However, this strategy does not allow us to rule out the presence of selection bias due to unobservable characteristics as well as the reverse causality between the adoption of a particular practice/technology and the latent sensitivity to water stresses. In order to relax these empirical concerns, this robustness check endogenizes the choice of each practice/technology by including another regression to the structural model. In doing so the model has been identified by means of two further exclusion restrictions: the leave-out mean of the adoption of each specific practice at the farmer organization level and leave-out mean of the cost of labour in each specific season at Grama Niladhari Divisions level (ADM4).

The assumption on which the validity of the strategy relies is that these variables are correlated with the adoption choice at the household level but, conditional on the other covariates, they are not directly linked to the household outcomes. Being the leave-out mean assigned to each household an average calculated at a higher level of aggregation and by excluding its own observed value the specific household considered, this assumption is economically and empirically plausible. It is worth noting that in our empirical framework aimed at estimating the mediating role of the sustainable practices, the three structural equations have been estimated simultaneously by means of a maximum likelihood estimator that is expected to produce consistent results that are more efficient relative to a two-stage procedure. The results from this alternative identification strategy largely support the robustness of those obtained with the doubly robust model used in the main text. The main results have been summarized in table A13 (complete results are available upon request).
### Table A13. Summary table of the main results obtained using an IV identification strategy

| List of Variables                      | Sensitivity | Direct effect | Indirect effect | Net effect | Direct effect | Indirect effect | Net effect | Direct effect | Indirect effect | Net effect |
|---------------------------------------|-------------|---------------|-----------------|------------|---------------|-----------------|------------|---------------|-----------------|------------|
|                                       |             | Total gross value of harvest | Total net value of harvest | Gross total income |
| MAHA LOW                              |             |               |                  |            |               |                 |            |               |                 |            |
| Short duration rice seeds             | -0.056      | -0.096        | 0.073           | -0.023     | 0.001         | 0.058           | 0.060      | 0.011         | 0.025           | 0.036      |
| Residue retention[+Syrs&wat/urea]     | -0.232***   | 0.508         | 0.312           | 0.820***   | 0.492**       | 0.176           | 0.668***   | 0.160         | 0.114           | 0.274**    |
| Other crops in the field              | -0.235***   | -0.254        | 0.387***        | 0.133      | -0.285        | 0.256***        | -0.029     | 0.009         | 0.148***        | 0.157      |
| Cultivating maize                     | 0.122***    | -0.061        | -0.201**        | -0.262     | -0.215*       | -0.096**        | -0.311**   | 0.056         | -0.076**        | -0.019     |
| Retaining trees                       | 0.055       | -0.054        | -0.091          | -0.144     | -0.241*       | -0.040          | -0.281**   | 0.062         | -0.035           | 0.027      |
| Soil erosion barriers                 | 0.028       | 0.126         | -0.047          | 0.080      | 0.351**       | -0.027          | 0.324**    | 0.256**       | -0.021          | 0.235**    |
| YALA LOW                              |             |               |                  |            |               |                 |            |               |                 |            |
| Short duration rice seeds             | -0.106***   | -1.187***     | 0.157           | -1.030***  | -1.011***     | 0.374           | -0.638***  | -0.029        | -0.037           | -0.066     |
| Other crops in the field              | -0.178***   | -0.902*       | 0.169           | -0.733***  | -1.297*       | 0.959           | -0.338**   | 0.037         | -0.071           | -0.033     |
| Retaining trees                       | -0.041      | 0.250         | 0.062           | 0.312      | -0.157        | 0.066           | -0.091     | 0.097         | 0.000           | 0.097      |
| Residue retention[+Syrs&wat/urea]     | 0.011       | 1.564***      | -0.017          | 1.547***   | 0.762**       | -0.023          | 0.740***   | 0.326*        | -0.001          | 0.325*     |
| YALA UP                               |             |               |                  |            |               |                 |            |               |                 |            |
| Retaining trees                       | 0.064       | 0.041         | -0.100          | -0.059     | 0.216         | -0.081          | 0.135      | 0.146         | -0.070           | 0.075      |
| Soil erosion barriers                 | -0.049      | 0.247         | 0.077           | 0.325*     | 0.102         | 0.063           | 0.166      | 0.038         | 0.039           | 0.077      |

*Note: Levels of significance are * p<0.10; ** p<0.05; ***p<0.01.*

### References

Di Falco S and Veronesi M (2013). How can African agriculture adapt to climate change? A counterfactual analysis from Ethiopia. *Land Economics* **89**, 743–766.