

**AGRIDE-c, a conceptual model for the estimation
of flood damage to crops:
development and implementation**

SUPPLEMENT

D. Molinari, A.R. Scorzini, A. Gallazzi, F. Ballio

1. Structure of the Supplement

The Supplement includes, for each principal crops in the Po Plain:

- average yield and price in the Province of Lodi over the last five years;
- distribution of production costs over the year in the case that no flood occurs (i.e. Scenario 0);
- implemented physical model;
- yield reduction and change in production costs on the basis of damage alleviation strategies;
- relative damage for the different combinations of times of flood occurrence (i.e. month), flood intensities (i.e. water depth and flood duration) and damage alleviation strategies.

in case of conventional and minimum tillage, when both techniques are possible. Concerning maize crops, only data related to conventional tillage are reported, being those related to minimum tillage included in the main manuscript.

2. Maize crops

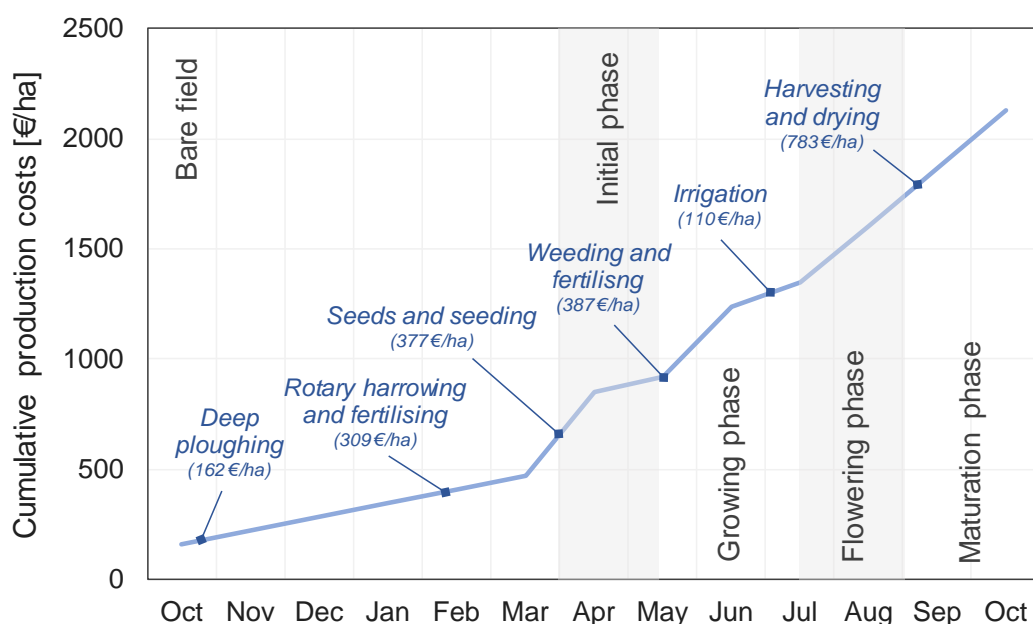


Figure S.1. Distribution of production costs over the year in the Scenario 0 for maize crops, in the case of conventional tillage

Table S.1. Yield reduction and change in production costs on the basis of damage alleviation strategies for maize crops, in case of conventional tillage

| Time of the flood | Vegetative stage | Alleviation strategy | Yield reduction [%] | Additional costs | €/ha | Avoided costs | €/ha |
|---------------------|------------------|----------------------|-------------------------|---|------|-------------------------|------|
| November - March | Bare field | Continuation | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | Deep ploughing | 162 | | |
| April - May | Initial phase | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Weeding and fertilising | 387 |
| | | | | Irrigation | 110 | | |
| | | | | Harvesting and drying | 783 | | |
| | | Reseeding | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | Rotary harrowing and fertilising | 309 | | |
| | | | | Seeds and reseeding | 377 | | |
| June | Growing phase | Continuation | see Fig. 4 of the paper | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | Soil restoring (sediment removal and terrain levelling) | 500 | Irrigation | 110 |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Harvesting and drying | 783 |
| | | | | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Reseeding | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | Rotary harrowing and fertilising | 309 | | |
| Seeds and reseeding | 377 | | | | | | |
| July - August | Flowering phase | Continuation | see Fig. 4 of the paper | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | Soil restoring (sediment removal and terrain levelling) | 500 | Irrigation | 55 |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Harvesting and drying | 783 |
| September - October | Maturation phase | Continuation | see Fig. 4 of the paper | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | Soil restoring (sediment removal and terrain levelling) | 500 | Harvesting and drying | 783 |

| Water depth < 130 cm | Strategy | Flood duration [days] | | | | | | | | | | |
|-------------------------|----------|-----------------------|------|------|------|------|------|------|------|------|---|--|
| | | <5 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | >11 | | |
| Bare field | Jan | c | 60% | | | | | | | | | |
| | | r | - | | | | | | | | | |
| | | a | - | | | | | | | | | |
| | Feb | c | 60% | | | | | | | | | |
| | | r | - | | | | | | | | | |
| | | a | - | | | | | | | | | |
| | Mar | c | 60% | | | | | | | | | |
| | | r | - | | | | | | | | | |
| | | a | - | | | | | | | | | |
| Initial phase | Apr | c | - | | | | | | | | | |
| | | r | 129% | | | | | | | | | |
| | | a | 261% | | | | | | | | | |
| | May | c | - | | | | | | | | | |
| | | r | 129% | | | | | | | | | |
| | | a | 261% | | | | | | | | | |
| Growing | Jun | c | 60% | 104% | 149% | 193% | 237% | 282% | 326% | 371% | - | |
| | | r | 129% | | | | | | | | | |
| | | a | - | 308% | | | | | | | | |
| Flowering | Jul | c | 60% | 149% | 237% | 326% | - | | | | | |
| | | r | - | | | | | | | | | |
| | | a | - | 314% | | | | | | | | |
| | Aug | c | 60% | 149% | 237% | 326% | - | | | | | |
| | | r | - | | | | | | | | | |
| | | a | - | 314% | | | | | | | | |
| Maturation | Sep | c | 60% | | | | | | | | | |
| | | r | - | | | | | | | | | |
| | | a | - | | | | | | | | | |
| | Oct | c | 60% | | | | | | | | | |
| | | r | - | | | | | | | | | |
| | | a | - | | | | | | | | | |
| Bare field | Nov | c | 60% | | | | | | | | | |
| | | r | - | | | | | | | | | |
| | | a | - | | | | | | | | | |
| | Dec | c | 60% | | | | | | | | | |
| | | r | - | | | | | | | | | |
| | | a | - | | | | | | | | | |

| Water depth ≥ 130 cm | Strategy | Flood duration [days] | | | | | | | | | | |
|-------------------------|----------|-----------------------|------|------|------|------|------|------|------|------|------|------|
| | | < 5 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | >11 | | |
| Bare field | Jan | c | 60% | | | | | | | | | |
| | | r | - | | | | | | | | | |
| | | a | - | | | | | | | | | |
| | Feb | c | 60% | | | | | | | | | |
| | | r | - | | | | | | | | | |
| | | a | - | | | | | | | | | |
| | Mar | c | 60% | | | | | | | | | |
| | | r | - | | | | | | | | | |
| | | a | - | | | | | | | | | |
| Initial phase | Apr | c | - | | | | | | | | | |
| | | r | 129% | | | | | | | | | |
| | | a | 261% | | | | | | | | | |
| | May | c | - | | | | | | | | | |
| | | r | 129% | | | | | | | | | |
| | | a | 261% | | | | | | | | | |
| Growing | Jun | c | 60% | 104% | 149% | 193% | 237% | 282% | 326% | 371% | - | |
| | | r | 129% | | | | | | | | | |
| | | a | - | 308% | | | | | | | | |
| Flowering | Jul | c | - | | | | | | | | | |
| | | r | - | | | | | | | | | |
| | | a | 314% | | | | | | | | | |
| | Aug | c | - | | | | | | | | | |
| | | r | - | | | | | | | | | |
| | | a | 314% | 314% | 314% | 314% | 314% | 314% | 314% | 314% | 314% | 314% |
| Maturation | Sep | c | 60% | | | | | | 149% | 237% | 326% | - |
| | | r | - | | | | | | | | | |
| | | a | - | | | | | | 321% | | | |
| | Oct | c | 60% | | | | | | 149% | 237% | 326% | - |
| | | r | - | | | | | | | | | |
| | | a | - | | | | | | 321% | | | |
| Bare field | Nov | c | 60% | | | | | | | | | |
| | | r | - | | | | | | | | | |
| | | a | - | | | | | | | | | |
| | Dec | c | 60% | | | | | | | | | |
| | | r | - | | | | | | | | | |
| | | a | - | | | | | | | | | |

Figure S.2. Relative damage to maize crops (in case of conventional tillage) for different combinations of times of flood occurrence (i.e. month), flood intensities (i.e. water depth and flood duration) and damage alleviation strategies ("c"=continuation; "r"=reseeding; "a"=abandoning)

3. Wheat crops

Table S.2. Average yield and price for wheat in the Province of Lodi over the last five years

| | |
|---------------------|----|
| Yield [q/ha] | 75 |
| Price [€/q] | 23 |

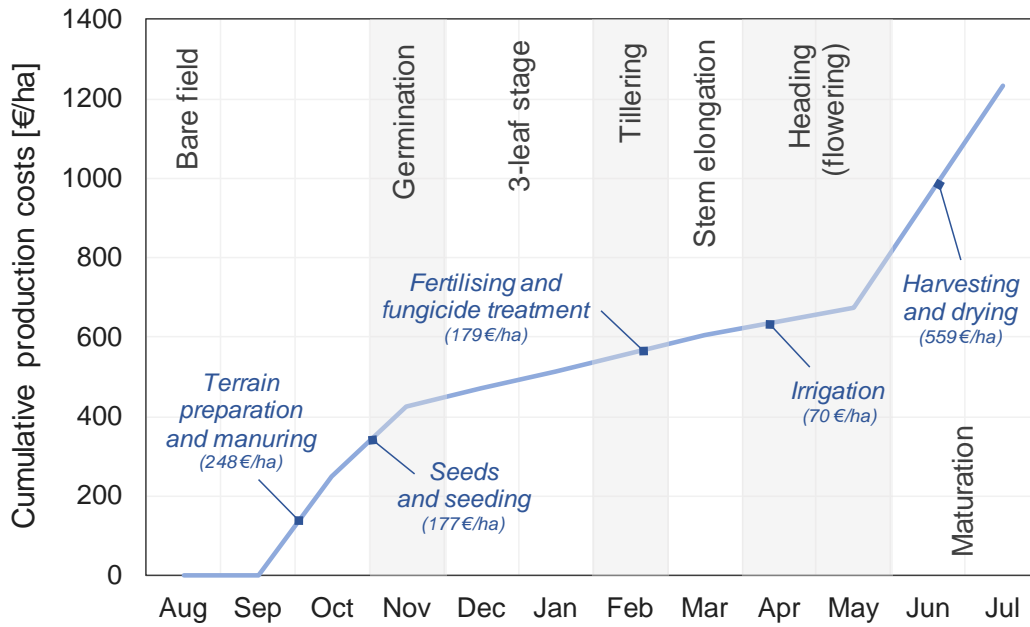


Figure S.3. Distribution of production costs over the year in the Scenario 0 for wheat crops, in case of minimum tillage

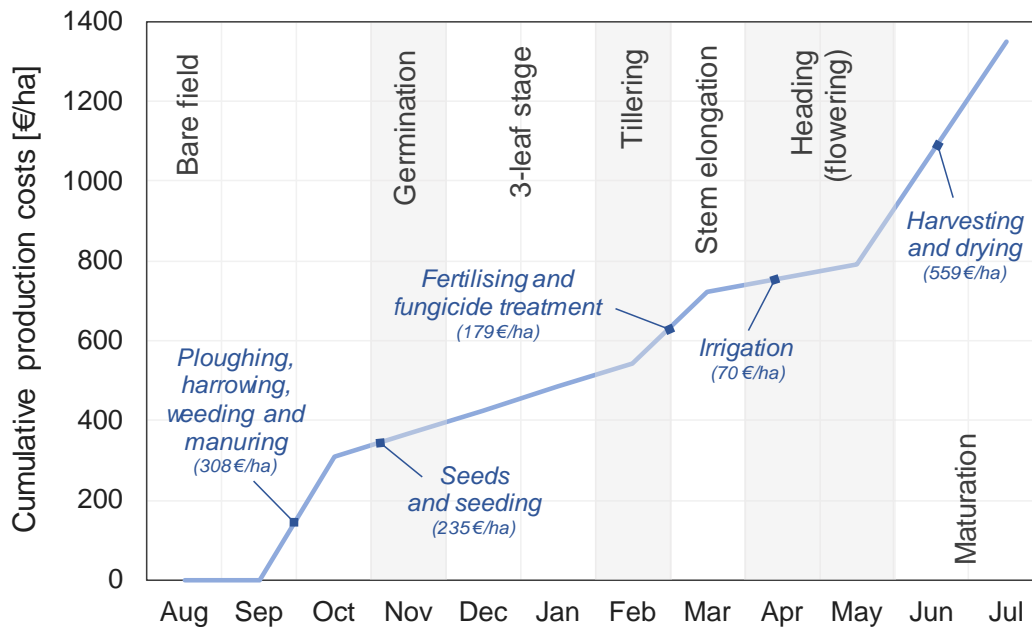


Figure S.4. Distribution of production costs over the year in the Scenario 0 for wheat crops, in case of conventional tillage

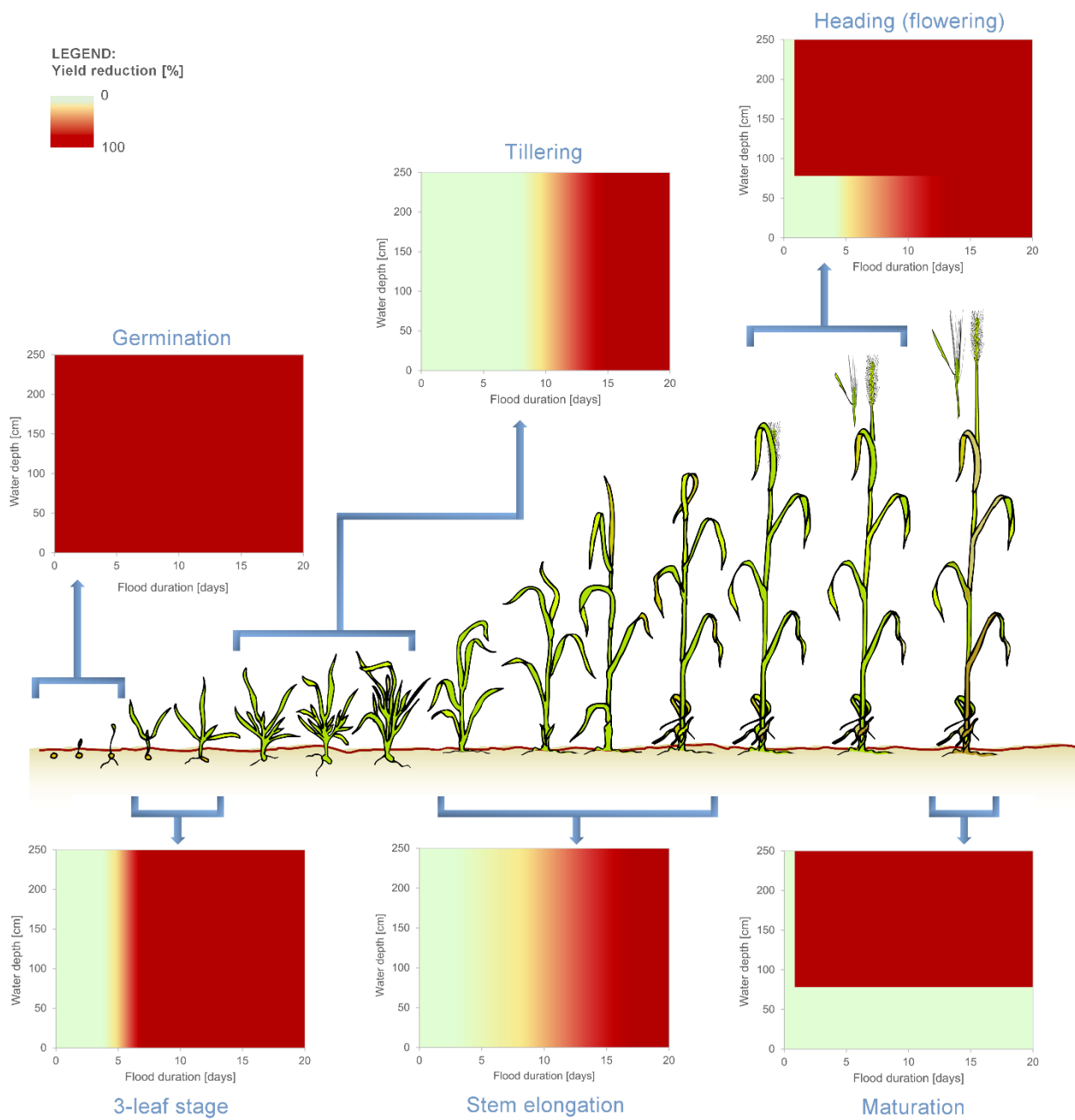


Figure S.5. Physical damage to wheat and barley as a function of vegetative stage, flood depth and duration (adapted from Agenais et al., 2013)

Table S.3. Yield reduction and change in production costs on the basis of damage alleviation strategies for wheat crops, in the case of minimum tillage

| Time of the flood | Vegetative stage | Alleviation strategy | Yield reduction [%] | Additional costs | €/ha | Avoided costs | €/ha |
|--------------------|---------------------|----------------------|---------------------|---|------|-------------------------------------|------|
| August - October | Bare field | Continuation | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| November | Germination | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Fertilising and fungicide treatment | 179 |
| | | | | | | Irrigation | 70 |
| | | | | | | Harvesting and drying | 559 |
| | | Reseeding | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | Seeds and reseeding | 177 | | |
| December - January | 3-leaf stage | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Fertilising and fungicide treatment | 179 |
| | | | | | | Irrigation | 70 |
| | | | | | | Harvesting and drying | 559 |
| | | Reseeding | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | | | Seeds and reseeding | 177 |
| February | Tillering | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Fertilising and fungicide treatment | 179 |
| | | | | | | Irrigation | 70 |
| | | | | | | Harvesting and drying | 559 |
| | | Reseeding | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | | | Seeds and reseeding | 177 |
| March | Stem elongation | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Irrigation | 70 |
| | | | | | | Harvesting and drying | 559 |
| April - May | Heading (flowering) | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Harvesting and drying | 559 |
| June - July | Maturation phase | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Harvesting and drying | 559 |

Table S.4. Yield reduction and change in production costs on the basis of damage alleviation strategies for wheat crops, in the case of conventional tillage

| Time of the flood | Vegetative stage | Alleviation strategy | Yield reduction [%] | Additional costs | €/ha | Avoided costs | €/ha |
|--------------------|---------------------|----------------------|---------------------|---|------|-------------------------------------|------|
| August - October | Bare field | Continuation | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| November | Germination | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Fertilising and fungicide treatment | 179 |
| | | | | | | Irrigation | 70 |
| | | | | | | Harvesting and drying | 559 |
| | | Reseeding | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | Seeds and reseeded | 235 | | |
| December - January | 3-leaf stage | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Fertilising and fungicide treatment | 179 |
| | | | | | | Irrigation | 70 |
| | | | | | | Harvesting and drying | 559 |
| | | Reseeding | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | | | Seeds and reseeded | 235 |
| February | Tillering | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Fertilising and fungicide treatment | 179 |
| | | | | | | Irrigation | 70 |
| | | | | | | Harvesting and drying | 559 |
| | | Reseeding | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | | | Seeds and reseeded | 235 |
| March | Stem elongation | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Irrigation | 70 |
| | | | | | | Harvesting and drying | 559 |
| April - May | Heading (flowering) | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Harvesting and drying | 559 |
| June - July | Maturation phase | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Harvesting and drying | 559 |

| Water depth < 60 cm | Strategy | Flood duration [days] | | | | | | | | | | | | | | | |
|------------------------|----------|-----------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|---|--|
| | | <5 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | >16 | | |
| 3-leaf | Jan | c | 59% | 109% | 240% | | | | | | | | | | | - | |
| | | r | 79% | | | | | | | | | | | | | | |
| | | a | 166% | | | | | | | | | | | | | | |
| Tillering | Feb | c | 59% | | | | | | 109% | 144% | 180% | 215% | 250% | - | | | |
| | | r | 79% | | | | | | | | | | | | | | |
| | | a | 166% | | | | | | | | | | | | | | |
| Stem el. | Mar | c | 59% | 84% | 99% | 114% | 129% | 144% | 159% | 175% | 190% | 205% | 220% | 235% | 250% | - | |
| | | r | 187% | | | | | | | | | | | | | | |
| | | a | 187% | | | | | | | | | | | | | | |
| Flowering | Apr | c | 59% | 84% | 106% | 128% | 151% | 173% | 195% | 218% | 240% | - | | | | | |
| | | r | - | | | | | | | | | | | | | | |
| | | a | 195% | | | | | | | | | | | | | | |
| | May | c | 59% | 84% | 106% | 128% | 151% | 173% | 195% | 218% | 240% | - | | | | | |
| | | r | - | | | | | | | | | | | | | | |
| | | a | 195% | | | | | | | | | | | | | | |
| Maturation | Jun | c | 59% | | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | | |
| | Jul | c | 59% | | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | | |
| Bare field | Aug | c | 59% | | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | | |
| | Sep | c | 59% | | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | | |
| Oct | c | 59% | | | | | | | | | | | | | | | |
| | r | - | | | | | | | | | | | | | | | |
| | a | - | | | | | | | | | | | | | | | |
| Germin. | Nov | c | - | | | | | | | | | | | | | | |
| | | r | 79% | | | | | | | | | | | | | | |
| | | a | 166% | | | | | | | | | | | | | | |
| 3-leaf | Dec | c | 59% | 109% | 240% | | | | | | | | | | | - | |
| | | r | 79% | | | | | | | | | | | | | | |
| | | a | 166% | | | | | | | | | | | | | | |

| Water depth ≥ 60 cm | Strategy | Flood duration [days] | | | | | | | | | | | | | | | |
|------------------------|----------|-----------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|---|--|
| | | < 5 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | >16 | | |
| 3-leaf | Jan | c | 59% | 109% | 240% | | | | | | | | | | | - | |
| | | r | 79% | | | | | | | | | | | | | | |
| | | a | 166% | | | | | | | | | | | | | | |
| Tillering | Feb | c | 59% | | | | | | 109% | 144% | 180% | 215% | 250% | - | | | |
| | | r | 79% | | | | | | | | | | | | | | |
| | | a | 166% | | | | | | | | | | | | | | |
| Stem el. | Mar | c | 59% | 84% | 99% | 114% | 129% | 144% | 159% | 175% | 190% | 205% | 220% | 235% | 250% | - | |
| | | r | 187% | | | | | | | | | | | | | | |
| | | a | 187% | | | | | | | | | | | | | | |
| Flowering | Apr | c | - | | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | | |
| | | a | 195% | | | | | | | | | | | | | | |
| | May | c | - | | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | | |
| | | a | 195% | | | | | | | | | | | | | | |
| Maturation | Jun | c | - | | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | | |
| | | a | 195% | | | | | | | | | | | | | | |
| | Jul | c | - | | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | | |
| | | a | 195% | | | | | | | | | | | | | | |
| Bare field | Aug | c | 59% | | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | | |
| | Sep | c | 59% | | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | | |
| Oct | c | 59% | | | | | | | | | | | | | | | |
| | r | - | | | | | | | | | | | | | | | |
| | a | - | | | | | | | | | | | | | | | |
| Germin. | Nov | c | - | | | | | | | | | | | | | | |
| | | r | 79% | | | | | | | | | | | | | | |
| | | a | 166% | | | | | | | | | | | | | | |
| 3-leaf | Dec | c | 59% | 109% | 240% | | | | | | | | | | | - | |
| | | r | 79% | | | | | | | | | | | | | | |
| | | a | 166% | | | | | | | | | | | | | | |

Figure S.6. Relative damage to wheat crops (in case of minimum tillage) for different combinations of times of flood occurrence (i.e. month), flood intensities (i.e. water depth and flood duration) and damage alleviation strategies ("c"=continuation; "r"=reseeding; "a"=abandoning)

| Water depth < 60 cm | Strategy | Flood duration [days] | | | | | | | | | | | | | | |
|------------------------|----------|-----------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|---|
| | | <5 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | >16 | |
| 3-leaf | Jan | c | 114% | 213% | 470% | | | | | | | | | | | |
| | | r | 168% | | | | | | | | | | | | | |
| | | a | 324% | | | | | | | | | | | | | |
| Tillering | Feb | c | 114% | | | | | 213% | 282% | 351% | 421% | 490% | | | | |
| | | r | 168% | | | | | | | | | | | | | |
| | | a | 324% | | | | | | | | | | | | | |
| Stem el. | Mar | c | 114% | 164% | 193% | 223% | 253% | 282% | 312% | 342% | 371% | 401% | 430% | 460% | 490% | - |
| | | r | - | | | | | | | | | | | | | |
| | | a | 365% | | | | | | | | | | | | | |
| Flowering | Apr | c | 114% | 164% | 208% | 251% | 295% | 338% | 382% | 426% | 470% | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | 381% | | | | | | | | | | | | | |
| | May | c | 114% | 164% | 208% | 251% | 295% | 338% | 382% | 426% | 470% | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | 381% | | | | | | | | | | | | | |
| Maturation | Jun | c | 114% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| | Jul | c | 114% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| Bare field | Aug | c | 114% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| | Sep | c | 114% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| Oct | c | 114% | | | | | | | | | | | | | | |
| | r | - | | | | | | | | | | | | | | |
| | a | - | | | | | | | | | | | | | | |
| Germin. | Nov | c | - | | | | | | | | | | | | | |
| | | r | 168% | | | | | | | | | | | | | |
| | | a | 324% | | | | | | | | | | | | | |
| 3-leaf | Dec | c | 114% | 213% | 470% | | | | | | | | | | | |
| | | r | 168% | | | | | | | | | | | | | |
| | | a | 324% | | | | | | | | | | | | | |

| Water depth ≥ 60 cm | Strategy | Flood duration [days] | | | | | | | | | | | | | | |
|------------------------|----------|-----------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|---|
| | | < 5 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | >16 | |
| 3-leaf | Jan | c | 114% | 213% | 470% | | | | | | | | | | | |
| | | r | 168% | | | | | | | | | | | | | |
| | | a | 324% | | | | | | | | | | | | | |
| Tillering | Feb | c | 114% | | | | | 213% | 282% | 351% | 421% | 490% | | | | |
| | | r | 168% | | | | | | | | | | | | | |
| | | a | 324% | | | | | | | | | | | | | |
| Stem el. | Mar | c | 114% | 164% | 193% | 223% | 253% | 282% | 312% | 342% | 371% | 401% | 430% | 460% | 490% | - |
| | | r | - | | | | | | | | | | | | | |
| | | a | 365% | | | | | | | | | | | | | |
| Flowering | Apr | c | - | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | 381% | | | | | | | | | | | | | |
| | May | c | - | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | 381% | | | | | | | | | | | | | |
| Maturation | Jun | c | - | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | 381% | | | | | | | | | | | | | |
| | Jul | c | - | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | 381% | | | | | | | | | | | | | |
| Bare field | Aug | c | 114% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| | Sep | c | 114% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| Oct | c | 114% | | | | | | | | | | | | | | |
| | r | - | | | | | | | | | | | | | | |
| | a | - | | | | | | | | | | | | | | |
| Germin. | Nov | c | - | | | | | | | | | | | | | |
| | | r | 168% | | | | | | | | | | | | | |
| | | a | 324% | | | | | | | | | | | | | |
| 3-leaf | Dec | c | 114% | 213% | 470% | | | | | | | | | | | |
| | | r | 168% | | | | | | | | | | | | | |
| | | a | 324% | | | | | | | | | | | | | |

Figure S.7. Relative damage to wheat crops (in case of conventional tillage) for different combinations of times of flood occurrence (i.e. month), flood intensities (i.e. water depth and flood duration) and damage alleviation strategies ("c"=continuation; "r"=reseeding; "a"=abandoning)

4. Barley crops

Table S.5. Average yield and price for barley in the Province of Lodi over the last five years

| | |
|---------------------|----|
| Yield [q/ha] | 70 |
| Price [€/q] | 19 |

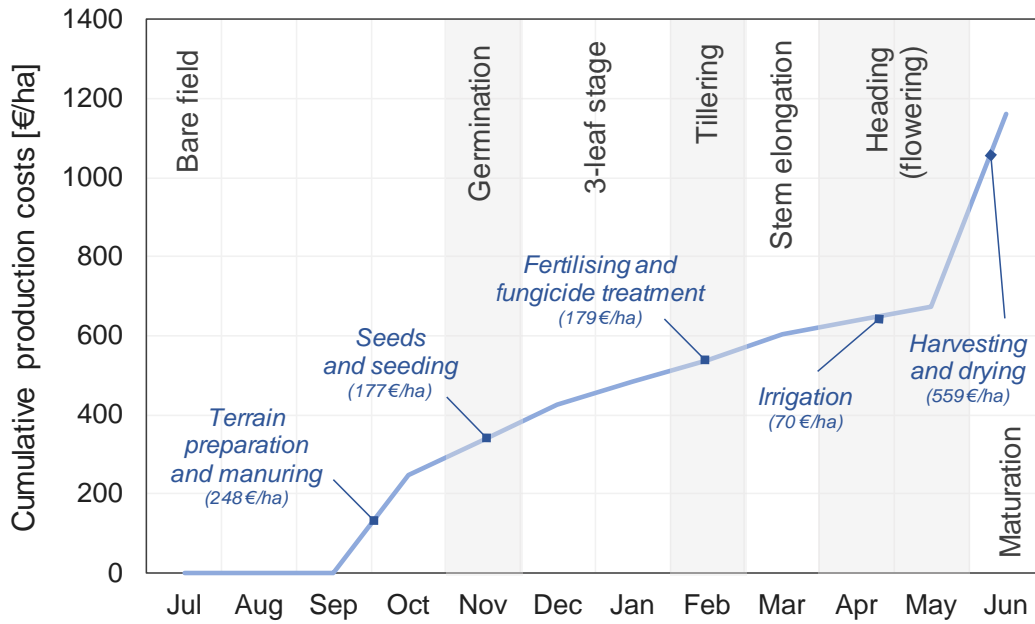


Figure S.8. Distribution of production costs over the year in the Scenario 0 for barley crops, in case of minimum tillage

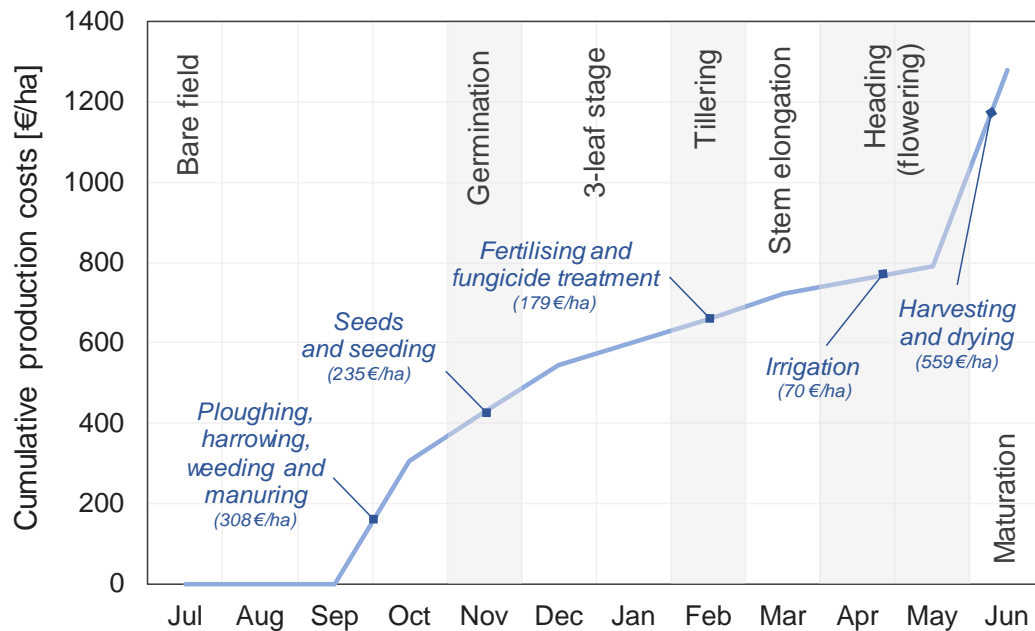


Figure S.9. Distribution of production costs over the year in the Scenario 0 for barley crops, in case of conventional tillage

Table S.6. Yield reduction and change in production costs on the basis of damage alleviation strategies for barley crops, in the case of minimum tillage

| Time of the flood | Vegetative stage | Alleviation strategy | Yield reduction [%] | Additional costs | €/ha | Avoided costs | €/ha |
|-----------------------|---------------------|----------------------|---------------------|---|------|-------------------------------------|------|
| July - October | Bare field | Continuation | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| November | Germination | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Fertilising and fungicide treatment | 179 |
| | | | | | | Irrigation | 70 |
| Harvesting and drying | 559 | | | | | | |
| | | Reseeding | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | | | Seeds and reseeding | 177 |
| December - January | 3-leaf stage | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Fertilising and fungicide treatment | 179 |
| | | | | | | Irrigation | 70 |
| Harvesting and drying | 559 | | | | | | |
| | | Reseeding | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | | | Seeds and reseeding | 177 |
| February | Tillering | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Fertilising and fungicide treatment | 179 |
| | | | | | | Irrigation | 70 |
| Harvesting and drying | 559 | | | | | | |
| | | Reseeding | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | | | Seeds and reseeding | 177 |
| March | Stem elongation | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Irrigation | 70 |
| Harvesting and drying | 559 | | | | | | |
| April - May | Heading (flowering) | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Harvesting and drying | 559 |
| June | Maturation phase | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Harvesting and drying | 559 |

Table S.7. Yield reduction and change in production costs on the basis of damage alleviation strategies for barley crops, in the case of conventional tillage

| Time of the flood | Vegetative stage | Alleviation strategy | Yield reduction [%] | Additional costs | €/ha | Avoided costs | €/ha |
|--------------------|---------------------|----------------------|---------------------|---|------|-------------------------------------|------|
| July - October | Bare field | Continuation | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| November | Germination | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Fertilising and fungicide treatment | 179 |
| | | | | | | Irrigation | 70 |
| | | | | | | Harvesting and drying | 559 |
| | | Reseeding | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | Seeds and reseeded | 235 | | |
| December - January | 3-leaf stage | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Fertilising and fungicide treatment | 179 |
| | | | | | | Irrigation | 70 |
| | | | | | | Harvesting and drying | 559 |
| | | Reseeding | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | Seeds and reseeded | 235 | | |
| February | Tillering | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Fertilising and fungicide treatment | 179 |
| | | | | | | Irrigation | 70 |
| | | | | | | Harvesting and drying | 559 |
| | | Reseeding | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | Seeds and reseeded | 235 | | |
| March | Stem elongation | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Irrigation | 70 |
| | | | | | | Harvesting and drying | 559 |
| April - May | Heading (flowering) | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Harvesting and drying | 559 |
| June | Maturation phase | Continuation | see Fig. A.5 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Abandoning | 100 | Soil restoring (sediment removal and terrain levelling) | 500 | Harvesting and drying | 559 |

| Water depth < 60 cm | Strategy | Flood duration [days] | | | | | | | | | | | | | | |
|------------------------|----------|-----------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|---|
| | | <5 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | >16 | |
| 3-leaf | Jan | c | 91% | 151% | 307% | | | | | | | | | | | - |
| | | r | 91% | | | | | | | | | | | | | |
| | | a | 219% | | | | | | | | | | | | | |
| Tillering | Feb | c | 91% | | | | | | 151% | 193% | 235% | 277% | 319% | - | | |
| | | r | 123% | | | | | | | | | | | | | |
| | | a | 219% | | | | | | | | | | | | | |
| Stem el. | Mar | c | 91% | 121% | 139% | 157% | 175% | 193% | 211% | 229% | 247% | 265% | 283% | 301% | 319% | - |
| | | r | - | | | | | | | | | | | | | |
| | | a | 231% | | | | | | | | | | | | | |
| Flowering | Apr | c | 91% | 121% | 147% | 174% | 201% | 227% | 254% | 280% | 307% | - | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | 243% | | | | | | | | | | | | | |
| | May | c | 91% | 121% | 147% | 174% | 201% | 227% | 254% | 280% | 307% | - | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | 243% | | | | | | | | | | | | | |
| Matur. | Jun | c | 91% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| Bare field | Jul | c | 91% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| | Aug | c | 91% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| | Sep | c | 91% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| | Oct | c | 91% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| Germin. | Nov | c | - | | | | | | | | | | | | | |
| | | r | 123% | | | | | | | | | | | | | |
| | | a | 198% | | | | | | | | | | | | | |
| 3-leaf | Dec | c | 91% | 151% | 307% | | | | | | | | | | | - |
| | | r | 91% | | | | | | | | | | | | | |
| | | a | 219% | | | | | | | | | | | | | |

| Water depth ≥ 60 cm | Strategy | Flood duration [days] | | | | | | | | | | | | | | |
|------------------------|----------|-----------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|---|
| | | < 5 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | >16 | |
| 3-leaf | Jan | c | 91% | 151% | 307% | | | | | | | | | | | - |
| | | r | 91% | | | | | | | | | | | | | |
| | | a | 219% | | | | | | | | | | | | | |
| Tillering | Feb | c | 91% | | | | | | 151% | 193% | 235% | 277% | 319% | - | | |
| | | r | 123% | | | | | | | | | | | | | |
| | | a | 219% | | | | | | | | | | | | | |
| Stem el. | Mar | c | 91% | 121% | 139% | 157% | 175% | 193% | 211% | 229% | 247% | 265% | 283% | 301% | 319% | - |
| | | r | - | | | | | | | | | | | | | |
| | | a | 231% | | | | | | | | | | | | | |
| Flowering | Apr | c | - | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | 243% | | | | | | | | | | | | | |
| | May | c | - | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | 243% | | | | | | | | | | | | | |
| Matur. | Jun | c | - | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | 243% | | | | | | | | | | | | | |
| Bare field | Jul | c | 91% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| | Aug | c | 91% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| | Sep | c | 91% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| | Oct | c | 91% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| Germin. | Nov | c | - | | | | | | | | | | | | | |
| | | r | 123% | | | | | | | | | | | | | |
| | | a | 198% | | | | | | | | | | | | | |
| 3-leaf | Dec | c | 91% | 151% | 307% | | | | | | | | | | | - |
| | | r | 91% | | | | | | | | | | | | | |
| | | a | 219% | | | | | | | | | | | | | |

Figure S.10. Relative damage to barley crops (in case of minimum tillage) for different combinations of times of flood occurrence (i.e. month), flood intensities (i.e. water depth and flood duration) and damage alleviation strategies ("c"=continuation; "r"=reseeding; "a"=abandoning)

| Water depth < 60 cm | Strategy | Flood duration [days] | | | | | | | | | | | | | | |
|------------------------|----------|-----------------------|------|------|-------|------|------|------|-------|-------|-------|-------|-------|-------|-------|---|
| | | <5 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | >16 | |
| 3-leaf | Jan | c | 371% | 619% | 1261% | | | | | | | | | | | - |
| | | r | 546% | | | | | | | | | | | | | |
| | | a | 898% | | | | | | | | | | | | | |
| Tillering | Feb | c | 371% | 371% | 371% | 371% | 371% | 371% | 618% | 791% | 964% | 1137% | 1310% | - | | |
| | | r | 546% | | | | | | | | | | | | | |
| | | a | 898% | | | | | | | | | | | | | |
| Stem el. | Mar | c | 371% | 495% | 569% | 643% | 717% | 791% | 866% | 940% | 1014% | 1088% | 1162% | 1236% | 1310% | - |
| | | r | 946% | | | | | | | | | | | | | |
| | | a | 946% | | | | | | | | | | | | | |
| Flowering | Apr | c | 371% | 495% | 605% | 713% | 823% | 932% | 1041% | 1151% | 1261% | - | | | | |
| | | r | 998% | | | | | | | | | | | | | |
| | | a | 998% | | | | | | | | | | | | | |
| | May | c | 371% | 495% | 605% | 713% | 823% | 932% | 1041% | 1151% | 1261% | - | | | | |
| | | r | 998% | | | | | | | | | | | | | |
| | | a | 998% | | | | | | | | | | | | | |
| Matur. | Jun | c | 371% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| Bare field | Jul | c | 371% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| | Aug | c | 371% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| | Sep | c | 371% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| | Oct | c | 371% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| Germin. | Nov | c | - | | | | | | | | | | | | | |
| | | r | 546% | | | | | | | | | | | | | |
| | | a | 813% | | | | | | | | | | | | | |
| 3-leaf | Dec | c | 371% | 619% | 1261% | | | | | | | | | | | - |
| | | r | 546% | | | | | | | | | | | | | |
| | | a | 898% | | | | | | | | | | | | | |

| Water depth ≥ 60 cm | Strategy | Flood duration [days] | | | | | | | | | | | | | | |
|------------------------|----------|-----------------------|------|------|-------|------|------|------|------|------|-------|-------|-------|-------|-------|---|
| | | < 5 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | >16 | |
| 3-leaf | Jan | c | 371% | 619% | 1261% | | | | | | | | | | | - |
| | | r | 546% | | | | | | | | | | | | | |
| | | a | 898% | | | | | | | | | | | | | |
| Tillering | Feb | c | 371% | 371% | 371% | 371% | 371% | 371% | 371% | 618% | 791% | 964% | 1137% | 1310% | - | |
| | | r | 546% | | | | | | | | | | | | | |
| | | a | 898% | | | | | | | | | | | | | |
| Stem el. | Mar | c | 371% | 495% | 569% | 643% | 717% | 791% | 866% | 940% | 1014% | 1088% | 1162% | 1236% | 1310% | - |
| | | r | 946% | | | | | | | | | | | | | |
| | | a | 946% | | | | | | | | | | | | | |
| Flowering | Apr | c | - | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | 998% | | | | | | | | | | | | | |
| | May | c | - | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | 998% | | | | | | | | | | | | | |
| Matur. | Jun | c | - | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | 998% | | | | | | | | | | | | | |
| Bare field | Jul | c | 371% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| | Aug | c | 371% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| | Sep | c | 371% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| | Oct | c | 371% | | | | | | | | | | | | | |
| | | r | - | | | | | | | | | | | | | |
| | | a | - | | | | | | | | | | | | | |
| Germin. | Nov | c | - | | | | | | | | | | | | | |
| | | r | 546% | | | | | | | | | | | | | |
| | | a | 813% | | | | | | | | | | | | | |
| 3-leaf | Dec | c | 371% | 619% | 1261% | | | | | | | | | | | - |
| | | r | 546% | | | | | | | | | | | | | |
| | | a | 898% | | | | | | | | | | | | | |

Figure S.11. Relative damage to barley crops (in case of conventional tillage) for different combinations of times of occurrence of the flood (i.e. month), flood intensities (i.e. water depth and flood duration) and damage alleviation strategies ("c"=continuation; "r"=reseeding; "a"=abandoning)

5. Grassland

Table S.8. Average yield and price for grassland in the Province of Lodi over the last five years

| | <i>Tot.</i> | <i>I mow.</i> | <i>II mow.</i> | <i>III mow.</i> | <i>IV mow.</i> |
|---------------------|-------------|---------------|----------------|-----------------|----------------|
| Yield [q/ha] | 120 | 60 | 20 | 20 | 20 |
| Price [€/q] | 15.4 | | | | |

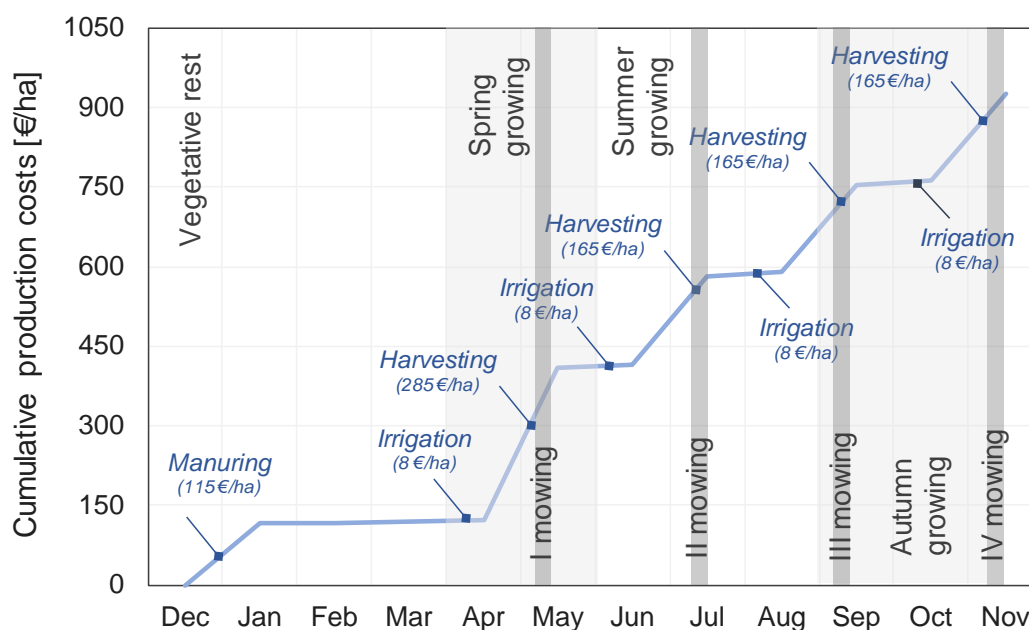


Figure S.12. Distribution of production costs over the year in the Scenario 0 for grassland

Assumptions for calculation of flood damage to grassland:

- Abandoning is not considered among the different alleviation strategies, as grassland is a perennial crop (i.e., if production is abandoned, the flood will impact on farmer's revenues also in the following years);
- The impact of the flood has influence only on the forthcoming harvest and not on successive ones;
- In case of flood, a reduction in the selling price is expected due to a lower quality harvest, as a function of flood duration and days remaining to the forthcoming harvest (see Figure A.14).

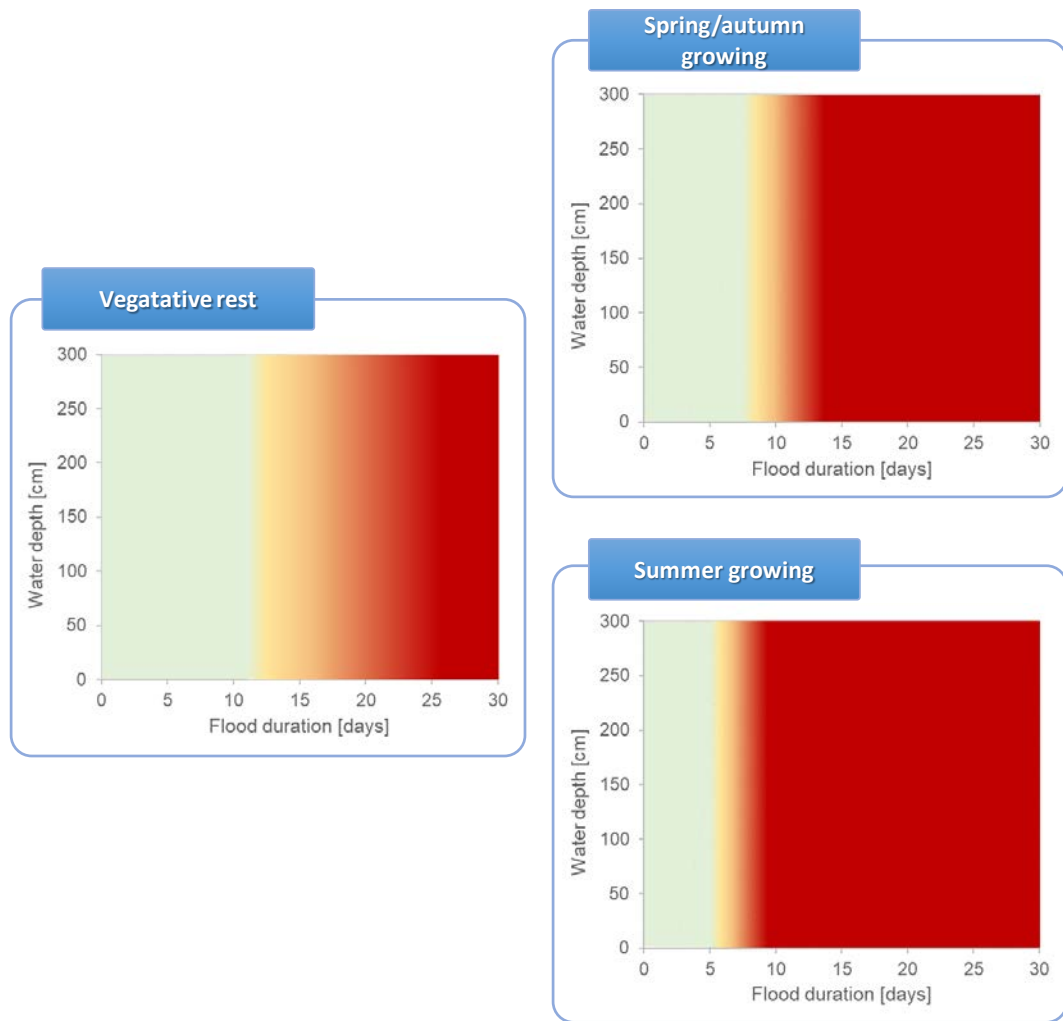


Figure S.13. Physical damage to grassland as a function of vegetative stage, flood depth and duration (adapted from Agenais et al., 2013)

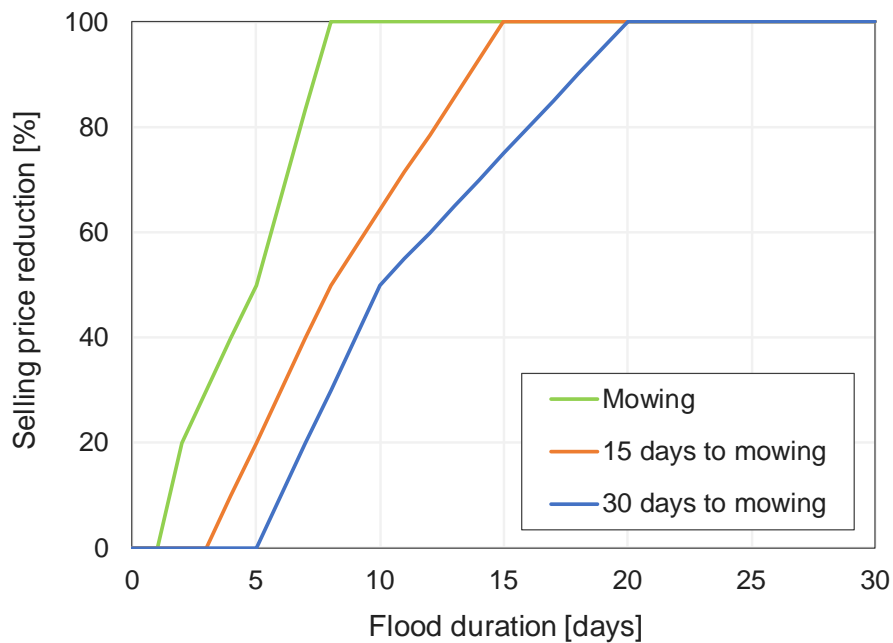


Figure S.14. Selling price reduction for different times of flood occurrence: mowing, 15 days to mowing and 30 days to mowing (adapted from Agenais et al., 2013)

Table S.11. Yield reduction and change in production costs on the basis of damage alleviation strategies for grassland

| Time of the flood | Vegetative stage | Alleviation strategy | Yield reduction [%] | Additional costs | €/ha | Avoided costs | €/ha |
|---------------------|------------------|----------------------|---|---|------|--|------|
| November - March | Vegetative rest | Continuation | see Fig. A.13 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | Reseeding | 0 | Soil restoring (sediment removal and terrain levelling) | 500 | | |
| | | | | Seeds and reseeding | 89 | | |
| April - May | Spring growing | Continuation | see Fig. A.13 | | | | |
| | | Reseeding | Only 1 st harvest lost | Soil restoring (sediment removal and terrain levelling) | 500 | I mowing (if the flood occurs before it) | 285 |
| | | | | Seeds and reseeding | 89 | | |
| June - August | Summer growing | Continuation | see Fig. A.13 | | | | |
| | | Reseeding | 2 nd or 3 rd harvest lost | Soil restoring (sediment removal and terrain levelling) | 500 | II mowing (if the flood occurs before it) or III mowing (if the flood occurs before it) | 165 |
| | | | | Seeds and reseeding | 89 | | |
| September - October | Autumn growing | Continuation | see Fig. A.13 | | | | |
| | | Reseeding | Only 4 th harvest lost | Soil restoring (sediment removal and terrain levelling) | 500 | IV mowing (if the flood occurs before it) | 165 |
| | | | | Seeds and reseeding | 89 | | |

Figure S.15. Relative damage to grassland for different combinations of times of flood occurrence (i.e. month), flood intensities (flood duration) and damage alleviation strategies ("c"=continuation; "r"=reseeding). Results refer to a flood occurring before harvest has been made (under the hypothesis of 15 days remaining to mowing).

| | | Strategy | Flood duration [days] | | | | | | | | | | |
|-----------------|-----|----------|-----------------------|-----|-----|-----|------|------|------|------|------|------|-----|
| | | | <5 | 7 | 9 | 11 | 13 | 15 | 17 | 19 | 21 | 23 | >25 |
| Vegetative rest | Jan | c | 60% | | | 67% | 82% | 96% | 110% | 124% | 139% | 153% | - |
| | | r | - | | | -* | | | | | | | 71% |
| | Feb | c | 60% | | | 67% | 82% | 96% | 110% | 124% | 139% | 153% | - |
| | | r | - | | | -* | | | | | | | 71% |
| | Mar | c | 60% | | | 67% | 82% | 96% | 110% | 124% | 139% | 153% | - |
| | | r | - | | | -* | | | | | | | 71% |
| Spring grow | Apr | c | 45% | | 71% | 93% | 107% | - | | | | | |
| | | r | - | | -* | | | 148% | | | | | |
| | May | c | 45% | | 71% | 93% | 107% | - | | | | | |
| | | r | - | | -* | | | 148% | | | | | |
| Summer growing | Jun | c | 4% | 24% | 34% | - | | | | | | | |
| | | r | - | -* | | 88% | | | | | | | |
| | Jul | c | 4% | 24% | 34% | - | | | | | | | |
| | | r | - | -* | | 88% | | | | | | | |
| | Aug | c | 4% | 24% | 34% | - | | | | | | | |
| | | r | - | -* | | 88% | | | | | | | |
| Aut. grow. | Sep | c | 4% | 15% | 23% | 31% | 36% | - | | | | | |
| | | r | - | -* | | | | 88% | | | | | |
| | Oct | c | 4% | 15% | 23% | 31% | 36% | - | | | | | |
| | | r | - | -* | | | | 88% | | | | | |
| Veget. rest | Nov | c | 60% | | | 67% | 82% | 96% | 110% | 124% | 139% | 153% | - |
| | | r | - | | | -* | | | | | | | 71% |
| | Dec | c | 60% | | | 67% | 82% | 96% | 110% | 124% | 139% | 153% | - |
| | | r | - | | | -* | | | | | | | 71% |

- Strategy not possible

-* Reseeding is considered only in case of a 100% physical damage