

Manuscript nhes-2019-61 “AGRIDE-c, a conceptual model for the estimation of flood damage to crops: development and implementation” – Final response to referee comment 2

We would like to thank the referee both for appreciation of our work and for carefully reading our manuscript; we greatly appreciate the insightful comments as they may contribute to increase the manuscript robustness and, in general, to improve its quality and readability. In the following, we supply a point by point reply to the general and specific comments raised by the referee.

General comments:

RC1: There is scope to improve the structure of the paper:

- by separating the introduction of context and rationale, including statement of research objectives, and statement of methods to cover literature search, review of knowledge and construction of the analytical framework.
- There should be a critique of the approach.
- The case study then becomes results (reordering some results that currently occur in discussion).
- Discussion can then follow on both the case and the validity or otherwise of generic framework.

Some items currently in the conclusion, particularly on gaps/further development, can go in discussion (they appear to be recommendations). Conclusion on what has gone before can focus whether the objectives (regarding the tool, its application and its prospects) have been met, rather than introducing new elements into discussion.

Answer: We would try to address at our best the suggestions provided by the referee, especially regarding a better re-organisation of the contents of the introduction/literature review/methodological part, and discussion/conclusions. Still we think that the present organisation of the sections is appropriate for the explanation of the conceptual model and its exemplification. Of course, if the editor thinks that a change in the structure of the paper is required to better meet the journal standards, we will re-organise the paper as suggested.

RC2: It probably would be best to be more cautious and modest about the claims made about the comprehensiveness and novelty of the approach, and its suitability to all circumstances and contexts.

Answer: After reading the referee comment, we realised that the “scope of use” of our model was not well specified in the original version of the paper, which could lead to incorrect interpretations of our work. Indeed, without such specifications our claims appear as too wide, and we will be more specific in the revised version of the manuscript. In fact, the conceptual model has been designed to supply an estimation of flood damage:

- to annual crops (i.e. not including perennial plants)
- by considering one single culture (i.e. by not considering replacement of one culture with another one)
- by limiting the time frame of the analysis to one “productive year” (i.e. not considering long term damages, e.g. loss of soil productivity in the following years);
- for infrequent flooding (i.e. effect of two, or more, consecutive floods is not considered)

Nonetheless, as specified at page 9 line 11-19, AGRIDE-c do not consider damage to other components/elements of the farm that may induce additional damage to crops, as, for instance, damage to machineries and equipment (e.g. the irrigation plant) that may prevent cultivation for a while. Only damage to soil is considered from the evidence that, during a flood, damage to soil and plants occurs always at the same time, differently from damage to the other components which can occur or not,

independently from the damage to plants; as a consequence, damage to soil and plants is modelled together, while damage to the other components could be modelled as separated factors, not included in the conceptual model.

We will specify all these aspects in the new version of the paper, by hopefully clarifying what we mean with “generality” and “transferability” of the approach. We never referred in the paper to “novelty” or “comprehensiveness” of the approach, but we highlighted the fact that we are trying to encapsulate and systematise the available knowledge on damage mechanisms (to annual crops) triggered by inundation phenomena, as well as on their consequences in terms of income for the farmers.

RC3: Further clarity on its potential application, either in cost benefit analysis of (publically funded) investments at the landscape scale in flood risk management, or in guiding individual farm-scale responses would be appropriate. The two applications are different in purpose and detail of approach. There is a difference between, for example, economic and financial appraisals. There is also a difference between ex ante appraisal and ex post evaluation, which is implied. This will support the important point made that insufficient ex post evaluation is undertaken to provide sound ex ante decisions

Answer: The CBA of flood risk mitigation strategies would require a comprehensive estimation of benefits linked to the different strategies, i.e. of the avoided loss to all exposed sectors and at different temporal scales (i.e. direct and indirect/long term damages). Present damage modelling capacity prevents comprehensive flood damage assessments, which usually include only direct damage to people and some of the exposed assets (typically residential buildings). In such a context, by allowing the estimation of the expected loss to crops in a specific flood scenario, AGRIDE-c may support more comprehensive CBAs of public risk mitigation strategies. Of course, to meet such an objective, the tool must be critically used, e.g. by considering possible transfers of losses/gains between farmers in an economic perspective, according to the temporal and spatial scales of the analysis. Regarding individual responses, by supplying the expected damage for different types of crops and alleviation strategies (according to the expected yield reduction for different flood intensities and period of occurrence), AGRIDE-c may support individual farmers exposed to flood risk in preventing losses by supporting: the choice of the most appropriate crops to be cultivated, the choice of the best alleviation strategy to be followed once flooded, the evaluation of the opportunity to ask for a flood insurance scheme and the definition of the premium. The model was not designed to be used ex-post. This explanation will be added in the revised version of the manuscript.

RC4: One particular issue requires attention, namely the importance, especially in temperate climates, of agricultural land drainage. The control of water levels in the soil, and particularly the removal of excess water and below surface ‘flooding’, including during the post flood phase before field return to ‘normal’ is an important aspect of agricultural flood risk management and assessment. Impacts and land management responses are often driven by seasonal waterlogging and drainage problems as much as they are by surface flooding. This is certainly the case in northern Europe and North America. There should be coverage of this aspect, and the implications of not explicitly allowing for it in this model framework. Many areas of strategic importance are pump drained.

Answer: We thank the referee for highlighting these important aspects for flood risk/damage assessment and management (that were erroneously not included in the original version of the paper), and for supplying some of the related literature. In the new version of the manuscript, the conceptual model will be modified in order to take into account of the effect of waterlogging and prolonged soil saturation on both the yield and the soil, as well as on the corresponding effect on the revenue and costs for the farmer, and then on the final flood damage. Still, these aspects will not be considered in the

application of the model to the Po Valley because, according to experts' opinion, phenomena like waterlogging and prolonged soil saturation after floods are not common in the area.

RC5: Saline flooding, a major issue in coastal and tidal areas, should be referred to with implications for costs, especially regarding remediation and subsequent year impacts

Answer: The conceptual model was not conceived to cover coastal floods but we have decided to extend the context of applicability of the model in the revised version. However, the model will still be focused on "one" productive year. We will discuss limitations of this hypothesis in the discussion section.

RC6: Surprising the authors do not mention climate change as a driver of concern or a factor affecting damage costs and responses. This seems an omission given the topic.

Answer: Given that the model is focused on "one" productive year, long term effects of climate change are not considered in the model. Anyway, we will add a sentence in the introduction on the importance of climate change in exacerbating future flood damage to agriculture.

RC7: Further clarity is required regarding the definition of measurements of damage. A more detailed listing, upfront, of the revenue and cost related parameters would help: these emerge in the case application later on.

Answer: A comprehensive list of all revenue and cost related parameters cannot be compiled in the framework of the conceptual model, as most of them, especially those related to costs, are context-specific. Still, we will add examples of such parameters in the description of the conceptual model

RC8: A table would be good to summarise the main elements of cost estimation processes /assumptions/ algorithms and where they come from. In the main, the methods draws on published data from Sub-sector models of crop damage or additional costs, such as Agenias et al. What other ones are used to transfers changes in yield, revenue and cost responses?

Answer: a table will be added summarising the main elements and sources of revenue and cost estimation processes

RC9: Further clarity would help regarding the use of the terms 'turnover' and 'gross profit', ie exactly what is in these terms? They are not universally applied in farm business accounting, where the terms gross output (or gross revenue), gross margin and net margin are often used. (Turnover can for example include sales from previous production periods – just to be clear). And the definition of gross profit may or may not include elements of farm level fixed costs, such as machinery and buildings costs (again to be clear, so that the methods can be generally applied). The use of 'relative' Gross profit measured at negative % values is difficult to interpret and doesn't mean a lot.

Answer: we really thank the referee for the suggestion. According to the literature suggested, we will change the terms "gross profit" and "turnover" in "net margin" and "gross output", respectively, by also specifying what is included in production costs.

RC10: On flood scenarios, the treatment presumably here is for one-off relatively infrequent flooding on a land use that is not hitherto constrained by flood exposure. An increase in flood frequency, associated with climate change for example, or withdrawal of flood defences, could lead to increased flooding with a range of outcomes, permanent abandonment, repeat annual losses or a switch to more flood tolerant land use. How are these to be handled by the model?

Answer: As explained before (RC2) the model considers damage to one productive year for infrequent floods. Limits of these assumptions will be discussed in the new version of the paper.

RC11: The paper refers to spreadsheets and supplementary data containing both data and estimation methods. I had difficulty locating these and understanding them when I did. This is probably my fault. It would be good to explain what is in them and how they can be reliably accessed.

Answer: We will ask the NHESS editorial support office whether the spreadsheet can be added as supplement material; otherwise, we will upload it in a repository with an easier access We will also develop a user manual for it.

RC12: There is a need to strengthen the treatment of inherent variation and uncertainty in the estimates.

Answer: We will include a deeper discussion on model uncertainty in the discussion section.

RC13: there is a need to provide a more systematic critique of the model and the resultant damage estimates, and implications for use and improvements

Answer: see answer to RC2, RC3 and RC12

RC14: The authors report that their work draws on systematic review of multiple sources, including expert judgement. This aspect, especially the latter, is under reported. Did the research approach follow a particular methodology that can be supported by literature, especially engaging experts?

Answer: Experts were involved with two main objectives. The first one is to support the definition, and validate the quality, of the conceptual model. The second one is to give suggestions/information on the implementation of the model in the Po Valley, above all regarding expected physical damage and costs. With respect to the first objective, an iterative process was followed. First, a semi-structured interview was conducted, by asking experts about the main damage mechanisms/phenomena in case of flood, possible interconnections among them, important explicative variables. In this phase, results from the literature review were proposed to experts for their judgment. In the following step, experts were asked to evaluate a draft version of the conceptual model we draw according to the literature review and results from first interviews. Then, there was an iterative revision process of improved versions of the model until an agreement on its final structure was reached.

With respect to the second objective, several individual meetings were organised with the aim of asking experts about context-specific information on: crops calendars, yields and prices, type, timing and costs of cultivation practices. In this phase, the transferability of the model by Agenais et al. was also discussed.

Three kinds of experts were involved. One representative of the Regional Authority responsible for agricultural damage management and compensation, with more than 20 years of expertise in the management and compensation of flood damage to farms in the Lombardy Region. Two agronomists of the local association of farmers (Coldiretti Lodi), with specific knowledge on the investigated context and with direct experience in managing floods in the last 20 years. During the work, the two agronomists asked for data/information also to individual local farmers that were flooded in the past years, including also their viewpoint in the process. Finally, an academic economist, with specific expertise in agriculture, has been involved in validating the final model.

A new sub-section will be added to the revised version of the paper explaining the whole process of experts' involvement.

Specific comments (we noted that for some comments the reviewer made a wrong reference to page/line number of the original manuscript; in the following, we made our best to locate the comments in the proper point of the paper)

RC15: Abstract. I think the abstract would better begin with a statement of context and purpose, and how the proposed model seeks to make a contribution to decision support. I think it best to avoid giving the paper an identity by using ‘this paper....’ as a writing style here and in the manuscript itself ; it is the authors who are reporting their work. As above, I think some cautious modesty would be advisable. CBA implies welfare assessment. Farmer decision support is something else.

Answer: We will revise the abstract according to reviewer’s suggestion. We would like to maintain the impersonal writing style within the paper as there are not specific indications about in the Journal guidelines, or a common trend in published articles. However, in this respect, we are available to follow editor’s suggestions, if any. See also reply to general comments RC2-RC3.

RC16 (P1.L20): What are flood risk management plans, and what is the implication of CBA ?. This implies public investment at the landscape scale, often funded through the public purse, as implied by CBA.

Answer: According to the EU Floods Directive, Flood Risk Management Plans are the operational/normative tools by which Member States (and in particular River District Authorities within each State) must implement flood risk management, including a blend of structural and non-structural risk mitigation strategies, to be implemented at different spatial and temporal scales. Such measures must be identified on the bases of a reliable and comprehensive assessment of costs and benefits associated to alternative strategies. We will better clarify this point in the revised manuscript.

RC17: I would avoid, ‘in this paper’, here and elsewhere.

Answer: See reply to RC15.

RC18 (P1.L25): River restoration usually implies rejoining the river to its floodplain and set back of (previously installed) flood defences in the conventional sense. See:

Morris J, Bailey AP, Lawson CS, Leeds-Harrison PB, Alsop D, Vivash R (2008) The economic dimensions of integrating flood management and agri-environment through washland creation: A case study from Somerset, England. J Environ Manage 88:372-381

Rouquette JR, Posthumus H, Morris J, Hess TM, Dawson, QL, Gowing DJG (2011) Synergies and trade-offs in the management of lowland rural floodplains: an ecosystem services approach. Hydrol Sci J 56(8):1566-1581

Is the context to justify of guide decisions in flood risk management infrastructure and operations made at the landscape/sub catchment/shoreline scale , with support from the public purse. This is the case in many parts of northern Europe and north America. Getting a handle on damage costs to agriculture is part of this ?

Answer: We thank the reviewer for the suggested references, which support our statement regarding the importance of including damage costs to agriculture when dealing with floodplains devoted to agricultural activities. The two references will be included in the revised version of the paper.

RC19 (P1.L29): I think this is partly reflecting a limitation of the use of selected key literature search terms and also confinement to formal academic, rather than grey literature and institution-based activities and outputs. There is a history here in this topic: Since the 1930s, and probably up to the mid1980s, the focus in this area in northern Europe was on ‘land drainage’ of which flood protection , (rather than ‘flood risk management’), was a part. Major investments, including large scale pumping

schemes, were made to control /remove excess soil water and simultaneously alleviate surface flood from river, tidal and shore line sources. Many of these investments were 'land reclamation (for agric projects)' often involving major river works (and not river restoration). Thus land drainage and flood control were and are inextricably integrated (just as irrigation and drainage are). The authors should in my view show an understanding of this nexus, and consider how, without undermining what they have done, it can be incorporated here. Including the terms agricultural/land drainage in the search would go some way towards this, as would 'flood risk'. Much of the work was carried out by research institutions as part of national programmes and is reported in sources that are not as easy to access.

A bit dated, but see for example, *Morris, J. 1992. Agricultural land drainage, land use change and economic performance: Experience in the UK. Land Use Policy Volume 9, Issue 3, July 1992, Pages 185-198.*

And for decision support: *See Chapter 9 Flood Risk Management for Agriculture, in: Penning-Rowsell, E., Priest, S., Parker, D., Morris, J., Tunstall, S., Viavattene, C., Chatterton, J. and Owen D. (2013) Flood and Coastal Erosion Risk Management: A Manual for Economic Appraisal, Routledge, Abingdon, Oxford*

Answer: Thank you. In the revised version of the manuscript we will try to expand the literature review, by including (both academic and grey) references dealing with the issue of land drainage.

RC20 (P2.L15): I think also there has been a policy shift, especially in Europe post 1980s when agricultural surpluses increased under EU CAP and the subsidies to agric were being challenged , and urban flood damage increased in absolute as well as relative importance. Also the drainage link is important here : the emphasis in Europe and N America was on drainage land and reclamation.

Answer: Thank you for this comment. We will include these points in the revised version of the manuscript.

RC21 (P2.L15): Some of the comments here seem premature: we haven't yet explained the approach and the model, but seem to be drawing conclusions , unless these are objectives . The authors might want to consider a clear statement of the objectives of the work reported here, and then subsequently review the extent to which they have been able to meet them

Answer: In the lines indicated by the reviewer we briefly introduced AGRIDE-c, the need for its model structure and its usefulness. In order to avoid ambiguity, we propose to rephrase P2.L17-19 as follows: "While the model structure aims to be generally valid, the analytical expression of its components must necessarily be specific to the local physical characteristics of the area as well as to the standards of the agricultural practices and to the type of crops under analysis, given the large variability characterising the agricultural sector".

RC22 (P2.L25): Should table 1 be part of methods ? What of 'flood risk' and 'drainage' as key search terms ? And using experts to identify sources ?

Answer: We will include "flood risk" and "drainage" as key search terms and modify the results in Table 1 accordingly. However, we think Table 1 should not be moved in the methodological section of the paper, as we used it only to support our preliminary statement on the need to improve damage modelling for the agricultural sector. Experts were not involved in this literature research (almost all of them were not academics), but they were interviewed for model development and assessment (see also response to RC14).

RC23 (P3): Would be good to clarify the perspective and purpose of the assessment of damage costs: ex ante or ex post, and the implications : the term ex post is used later without explanation.

Answer: In the Introduction of the revised version of the manuscript we will better explain that AGRIDE-c is a tool for an ex-ante (i.e. expected) estimation of flood damage to agriculture, while we will replace the term “ex-post” within the paper with “observed” or “empirical”.

RC24 (P3.L20): Agree there is paucity of data on actual flood impact costs , recorded during and post flood. This observation is not confined to the agricultural sector (Chatterton et al, for the English cases for example, including agricultural damage)

Chatterton, J; Clarke, C; Daly, E; Dawks, S; Elding, C; Fenn, T; Hick, E; Miller, J; Morris, J; Ogunyoye, F; Salado R. .2016. The costs and impacts of the winter 2013 to 2014 floods. Report SC140025/R1. Environment Agency, Bristol. http://rpaltd.co.uk/uploads/report_files/the-costs-and-impacts-of-the-winter-2013-to-2014-floods-report.pdf

There is a large, albeit now dated literature on drainage/water logging impacts on agricultural production that should be referred to, with modelling of the link between soil- water, crop growth and yields, and particularly linked to water level management in the context of land drainage and associated flood control measures.

Answer: Thank you. We will add the suggested reference in the revised version of the manuscript. In addition, we will include aspects related to drainage and waterlogging impacts in an enhanced version of the conceptual model represented in Figure 2. See also answer to comment RC4

RC25: See Chapter 9, section 9.5, p336 in Penning-Rowssel, opcit. For FLOODFARM, that assesses the cost of flooding at the farm scale Where FLOODFARM = (costs associated with flood impacts on) ARABLE+GRASS+LIVESTOCK+OTHER.

See also: *Dunderdale J A L and Morris J. 1997. The Benefit: Cost Analysis of River Maintenance. Water and Environment Journal. Volume11, Issue 6 Pages 423-430 <https://doi.org/10.1111/j.1747-6593.1997.tb01375.x>*

Answer: We thank the referee for the suggested literature that we will include in the new version of the manuscript. Still, our model is only focused on the crops component of flood damage to farms as explained in answer to RC2.

RC26 (p.3, L25): I am not sure the assumption of full loss is true here. The Posthumus, and the Morris and Brewin examples, based on farmers reported assessment of damages, incorporated ‘partial’ losses, and also losses in the following years. And also on farms adapting to flood risk:

Pivot J.M., Josien E. & Martin P. Farms adaptation to changes in flood risk: a management approach. J Hydrol 2002, 267, 12–25.

The ex-ante estimation methods described in Penning Rowsel above, for use in the appraisal of flood investments for agriculture, explicitly build in allowance for seasonal variation in yield loss between different crops (including grass) and livestock.

Answer: Thank you. In the revised version of the paper, we will include a comment based on the suggested references.

RC27 (P7.L29): Should define Gross profit as gross output minus direct costs. The term Gross Margin is widely used in agricultural /farm business accounting circles. (there is an interesting accounting challenge here: what is considered a direct, avoidable cost in the context of flood impacts, especially when lots of field operations are carried out by contractors)

Answer: See reply to comment RC9. All agricultural operations have been considered as direct, avoidable costs and priced based on contractors' price lists for the different operations (experts told us that in Lodi province most of field operations are carried out by contractors). This point will be made clearer in the revision of the manuscript and reference to the price books will be included.

RC28 (P9.L7): Is this a tautology ?

Answer: The sentence "the first provides information on the physical damage, while the second converts the physical effects of the flood into monetary terms" will be deleted in the revised manuscript.

RC29 (P9.L9): Should this be 'and/or': with respect to data source, estimation and valuation methods: eg some models have both physical quantities and unit monetary values.

Answer: We will replace "and" with "and/or" in the revised paper.

RC30 (P9.L10): Implies that this would be good idea? Again need to set in context of the purpose of the 'modelling', high level or detailed assessment ? A number of Environmental bodies use very high level 'cost calculators' to derive quick assessments of flood impacts at the large scale , eg using 'standardised' damage costs \$/ha, for example to respond to immediate questions by politicians post flood. There is guidance on this > The UK Environment Agency use a Flood Cost Calculator, European Commission are promoting a standard approach to disaster observation, see for example http://publications.jrc.ec.europa.eu/repository/bitstream/JRC110489/loss-database-architecture_jrc110489.pdf

Answer: We agree with the reviewer that the required level of detail of a model depends on the context and use. So, not always an ultra-detailed, multi-parameter model can be the best option. We think however that it is not appropriate to comment on this point in the methodological part of the paper, but we will include some comments on this in the discussion section of the revised paper.

RC31 (P12.L12): Says Agenais model is physically, presumably yield based , but then says it uses gross profit (gross output (turnover) less direct costs : isn't this monetary (cost) based. Some further clarity of the distinction between physical and monetary estimation would be useful with definition of terms used

Answer: We will better explain the Agenais model in the revised version of the manuscript.

RC32 (P12.L15): They both imply that duration is probably more important than depth ?

Answer: Yes, for the crop under investigation (maize). But this depends on crop type.

RC33 (P13.L5): Some more detail on the methods used to define the boundary of investigation, and the methods used to elicit important parameters and values from experts and other sources. Was a formal research method used? Was the research review for example formally a 'systematic' review, and were the experts 'systematically' engaged? Would be good explain how the research topic was framed and bounded , and the issues arising. What is the implication of an expert based approach here? This is an important methodological aspect, and liable to bias that needs to be managed ?

Answer: See response to comment RC14.

RC34: How is turnover defined . For the purpose here is it Gross Output (Q x P) specifically for the damage to crop outputs in a given period. Turnover in an accounting sense can be something else. Need to explain.

Answer: This will be better explained in the revised paper. See reply to comment RC9.

RC35 (P9.L32): Need to be explicit on definition of production costs here. Presumably the concern with a costs across the farm business (non revenue items), including replacement and remedial costs, net of savings in uncommitted costs Gross profit is usually after direct costs (or the cost of good sold) , but much depends on how overheads/fixed costs are categorized .How are changes in machinery operating costs, or ‘other’ damage costs to machinery, buildings and infrastructure being assessed, or are they not included here , given the implied focus on ‘field’ scale costs?

I think a table to support equation 1 should show the revenue and cost items that are used in the assessment : what is in and what is not ? Lots of jobs are done by contractors : how are these valued ? what of within season reseeded costs, reduction in gross output or profit associated with crop substitution , clean up and remedial works, following year impacts? A list would be good . I see these come later for the Po example, but a classification for the model would be useful; Elements are suggested in figure 1 , but it is not clear which are explicitly measured revenue and cost items

Answer: See reply to comment RC2, as AGRIDE-c assesses only damage to annual crops and not to other farm components (machinery, buildings, infrastructure), and RC7 regarding revenue and cost items. Prices of agricultural operations are based on contractors’ price lists (experts told us that in Lodi province most of field operations are carried out by contractors and that this would have been the most suitable option for pricing the different operations).

RC36 (Figure 2): Useful diagram. Where would salinity fit, and field flooding/waterlogging as it affects field access and timing of operations both within and beyond the immediate flood period? Not all elements are ‘valued’ in the model

Pri’c’es.

Answer: See response to RC2, RC4 and RC5. Figure 2 will be amended with the correct spelling of “prices”, thank you for noting that.

RC37: Does the model include grassland and associated grassland management and livestock systems? If so, how are flood impacts assessed?

Answer: No, AGRIDE-c only estimate damage to crops; this will be better clarified in the revised version of the manuscript (see response to RC2).

RC38: A summary of estimation parameters and algorithms would be helpful, possibly linked to the table of estimation items referred to earlier, summarizing the estimation basis . Presumably these are listing in the supporting spreadsheets: I tried but had difficulty accessing. See my comment on the Po case later : the approach is one of ‘estimation transfer’ . And there are some implicit criteria for transfer that could be made more explicit It would be good to say what is not in there : are damage costs to farm infrastructure, crops in store, included ?

Answer: Ok, a summary table will be included in the revised version of the manuscript. See also response to RC2.

RC38 (P13.L2): Are there thresholds for assumptions on crop switching/reseeding ?

Answer: Yes, this was implicitly reported in Table 3 (alleviation strategy vs month). We will better specify this point in the revised version of the manuscript.

RC39: So the scenario is for a single freshwater flood occurring in a given production year ?

Answer: Yes, this will be clarified in the revised manuscript (see response to comment RC2).

RC40 (P11.L5): Implications of grassland?

Answer: Only damage to crop are considered in AGRIDE-c. See response to RC2.

RC41 (P11.L10): What year price base is used ? Were annual price series inflation adjusted to a common year ? similarly with costs?

Answer: As stated in P11.L11 prices and costs were averaged over the last five years (2013-2017: this will be better specified in the revised paper) and were not adjusted for inflation (negligible change over the considered period).

RC42 (P11.L15): ‘annual EU contributions for agriculture as a further income for the farmer and, in detail, the subsidies given to agricultural activities in...’ Not clear how these are being treated. Presumably farmers get decoupled income support at the farm scale under CAP and these are unaffected by the flood, so can be left out for a single flood event. What of production subsidies: will not these also continue for the year of the flood, so from a farmers viewpoint costs (and cost savings) are net of subsidies?

Answer: Experts explained us that EU contributions do not depend on actual production. If a farmer abandons the production of a year due to a flood, he still receives the contribution.

RC43 (P11.L17): consultation of regional price books: reference?

Answer: Reference to regional price books will be added in the revised manuscript.

RC44 (P11): Is the assumption that all the costs shown in Fig 3 are direct costs (and therefore included in Gross profit as defined here) and are potentially ‘avoidable’ . This might be the case if farmers are using contractors , but if they are using own equipment and labour, how much of these are avoidable costs. Some explanation of the treatment of field operations and related costs would be useful. Some costs are more direct than others. The reference to fixed costs on the next page suggests that most costs are regarded as direct. The estimates are very sensitive to assumptions about the treatment and behaviour of costs : a tricky subject. I don’t quite follow: I got E927 using the numbers presented , but there may be other costs not shown. Even so, the gross profit as defined for maize seems high > maize farmers in the Po Valley are doing well.

Answer: Yes, all field operations are considered as direct costs and priced based on contractors’ price lists See also response to RC35. The reviewer is right in obtaining 927 Euro = $175 \times 16.92 + 150 + 400 - (175 \times 16.92) \times 0.05 - (\text{sum of production costs})$. The results in terms of gross profit reflect the ones observed in the Province, as also confirmed by interviewed local experts and farmers.

RC45 (P12.L10): This approach should be more fully explained in describing the model above , that algorithms are judiciously ‘transferred’ from research applications elsewhere according to suitability/relevance, and availability

Answer: In the original manuscript we already stated that “local agronomists expressed a favourable opinion on the suitability of this model in the examined region”. However, for more clarity, this point will be stressed in the new section regarding expert involvement in model development/validation (see also response to comment R14).

RC46 (P12.L16): Delete first ‘nor’

Answer: Ok, thanks.

RC47 (P12.L25): According to regional price books, restoration costs have been estimated to be equal to 500 €/ha (see Table 3). Would be good to reference these sources: Were contractors contacted? These seem very high unit costs . As for that matter do field operating costs , eg Harvesting at almost E800 /ha?

Answer: See previous response to comments regarding reference to contractors' price lists and experts' opinions.

RC48 (P12.L25): So the damage to soil box in Figure is aspirational?

Answer: Yes. See also response to RC1 of Reviewer 1.

RC49 (P14.L10): I am surprised that a yield (and possibly price) penalty is not included in the assessment of reseeded crops, given the importance of timing of operations. There are generic yield functions available for timeliness that would support a relative estimate of yield and gross output loss. This is one topic where local experts and farmers would have an empirically based view. The comment about variation and uncertainty in the estimates is valid for the modelling as a whole, and should be made as part of the method critique

Answer: In the original version of the manuscript we did not consider a yield reduction for late planting in case of reseeded, because interviewed experts told us that this is very variable and dependent on many factors (among others, type of late hybrids used) and difficult to estimate based on few parameters. However, in the revised version of the paper and of the model, we will comment on this point and we will also include simplified functions for yield reduction (possible range, max and min) based on experimental results reported in the literature, as in Tsimba et al. (2013), in order to take into the possible effect of yield reduction on the results.

Tsimba, R., Edmeades, G. O., Millner, J. P., & Kemp, P. D. (2013). The effect of planting date on maize grain yields and yield components. Field Crops Research, 150, 135-144.

RC49 (P15.L16): Break stage? There is no crop in the field? Presumably also depends on crop rotation .

Answer: Yes, we are considering only a single crop type in field. This will be better explained in the revised version of the manuscript (see also response to comment RC2).

RC50 (P15.L22): In my view gross output or gross revenue would be a better term than turnover, throughout . (Turnover refers to total sales in a period, sales may include items from other production periods)

Answer: Ok. See response to RC9.

RC51 (P15.L25): Seems unlikely that there would be no yield penalty for delayed planting Furthermore, reseeded would probably not be feasible immediately post flood because of field conditions . Penalty delay functions could be used .

Answer: See response to comment RC49.

RC52 (P15.L30): Finally?

Answer: Ok, thanks.

RC53 (P16. Figure5): Would be good to make the axes consistent amongst the graphs , and for cost and turnover estimates. Would also be good to indicate net margin (or gross profit) , although this might complicate the graph. If a read it correctly, for a june flood, reseeding will not make sense , especially if there is (likely) yield penalty: I note for this graph the two 'y' scales are common

Answer: Figure 5 will be amended in the revised manuscript by taking into consideration reviewer's suggestions.

RC54 (P17.L9): This raises the question about likely average annual damaged according to the likelihood of a flood occurring within given months: where information is available on annul flood probability, and seasonal distribution, and to complicate further, whether seasonal distributions vary according the severity of the flood ? I see this is raised later

Answer: Yes. The importance of knowing "seasonal" return periods of floods is commented in the Discussion section.

RC55 (P16. Figure5): Is this really a table. The title does not explain that it is relative gross profit : this is difficult to interpret when the preceding assessment was made with respect to turnover ad costs, so some clear explanation is required. Is a relative loss of gross profit greater than 100% a helpful measure?

Answer: In the revised manuscript, the caption and the text referring to Figure 5 will be more explicative.

RC56 (P17.L15): The use of the term CBA needs explanation: it implies public choice and assessment of welfare change associated with public investments .

Answer: See response to comment RC3.

RC57 (P17.L16): Quite consolidated practices. Meaning

Answer: We mean that cost assessment in CBA is not very problematic, as all cost data can be easily determined. We will better explain this in the revised paper.

RC58 (P17.L18): limited to the direct avoided damage to people and some exposed items . this is not clear

Answer: We will change this sentence as follows: "CBAs currently consider only direct avoided damage to people and some exposed sectors as benefit of a flood mitigation measure".

RC59 (P17.L24):The points here are not clear. I suggest the whole paragraph might be recrafted to advantage, with some examples to support the argument

Answer: This will be better explained in the revised manuscript, by also including references supporting the statement of the necessity of using different sets of damage models for more reliable CBAs (e.g. Jongman et al. 2012).

RC60 (P17.L30): I am not convinced Figure 6 does this. What does the greater than 100% refer to: is this the gross profit estimate in Figure 6. Assumption of no yield loss with (delayed) reseeding probably underestimates losses . There may be opportunities for reseeding with a different crop, especially between winter sown and spring sown crops

Answer: See reply to comment RC9 and RC49.

RC61 (P17.L30): Apart from EU contributions? Not clear

Answer: With “apart from EU contributions” we meant “if excluding the EU contributions” (which will still be obtained by the farmer). We will make this point clearer in the revised version of the paper.

RC62 (P17.L30): Sustained? Already committed/incurred

Answer: Ok. This will be fixed in the revised manuscript.

RC63 (P19.L0-10): These are valid and critical points, and fundamentally concern the underlying variation and uncertainty in the estimates (that have been single values so far). In my view it would be more appropriate to include the treatment of variation and uncertainty in the description of methods and the presentation of results of the case, rather than raise it for the first time here in discussion, where the purpose is to critical discuss the methods and results.

Answer: See reply to general comments regarding the reorganization of the paper. In our opinion, this specific point on variability and uncertainty of estimations should remain in the Discussion section of the paper, as here, after the presentation of model structure, description of input parameters and data, we make comments of strengths and weaknesses of the adopted approach.

RC64 (P19.Fig7): This is results and should go there above. The figure is presumably for the Po case? The likely effect of a 10% penalty that would most likely arise due to (delayed) planting is apparent : negative gross profit. A figure showing absolute changes in gross profit (as defined here) might be useful in the results section.

Answer: See reply to general comments regarding the reorganisation of the paper.

Yes, the results in the Figure refer to the Po case: this will be better clarified in the figure caption. See also response to comment RC49. Figure 7 will be amended in order to show also changes in gross profit (i.e. net margin in the revised paper, after reviewer’s indication).

RC65 (P19.L16) : Rather than saying ‘must’ it would be better to say why, identifying the advantage of doing so.

Answer: We explained the need of developing rapid approximate methods just in previous lines of the original manuscript (P19.L11-16): “The development of AGRIDE-c highlighted some challenges for the hydrology and the hydraulic community. In fact, application of the model requires a relatively detailed set of hazard input variables which are often not supplied in existing flood hazard maps (de Moel et al., 2009). Such knowledge would require a shift from traditional 1D steady hydraulic models to 2D unsteady hydraulic models - coupled with suitable sediment and contaminant transport models - in all flood prone areas, which is not easily achievable in a short time, both for technical and economic constraints”.

RC66 (P19.L18): Perhaps rather than ‘no more’ , ‘not only.... but also’ seasonal probabilities Is the Morris and Hess ref 1988?

Answer: The reviewer is right. The sentence and year of Morris and Hess paper will be fixed in the revised manuscript.

C67: This paper? The reference to the spreadsheet and to supplementary data needs further support : these are mentioned in passing

Answer: “This paper”: it is a writing style preference, as already discussed in replies to previous comments. In revising the paper, we will better emphasize reference to the spreadsheet and supplementary data.

RC68 (P20.L5): It depends how far the Authors have looked, and with the information presented here it is difficult to judge whether they can substantiate the claim. It might be fair to say they see advantage in developing a generic framework that can potentially be applied across different geographical and economic contexts , and they have made progress in this respect. For example, in more temperate part of Europe, land drainage is a particularly critical component of the land use: flooding nexus, and is particularly critical during post flood periods .

Answer: We will revise the sentence according to reviewer's suggestion. The issue of land drainage will be discussed as well (see reply to general comments).

RC69: It would be useful to have a description of the sub models used , as referred to earlier. A summary table showing the estimation methods and sources would be particularly helpful, linked to supplementary data.

Answer: See answer to RC8.

RC70: Damage mechanisms- Meaning ? Drainage and soils might be important also. And also salinity issues in coastal areas, as referred earlier.

Answer: With damage mechanisms we mean the interaction between damage influencing factors and characteristics of exposed elements leading to a loss. We will better clarify the sentence in the revised manuscript. Issues related to soil drainage and salinity will also be included (see answer to general comment RC4-RC5).