Specificity of damage to agriculture due to storms: first recommendations to produce flood damage functions

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Pauline Brémond[1], Frédéric Grelot[1] and Daphné Durant[2]

1. Background

1.1 Storm Xynthia, 2010

French littoral and particularly Vendée and Charente-Maritime departments have been seriously impacted by storm Xynthia which occured on the 28th of February 2010 .

32 000 ha of agricultural lands representing 956 farms were flooded with saline water. 55% of farms impacted had more than 50% of their land plots impacted by saline submersion. The main crops impacted by Xynthia were cereal crops or mixed crop-livestock farming systems and viticulture.

French littoral is protected by dykes: first rank dykes protect mainly agricultural areas whereas urban areas are rather enclosed by second rank dykes. A lot of infrastructures, in particular first rank dykes have been destroyed by Xynthia.

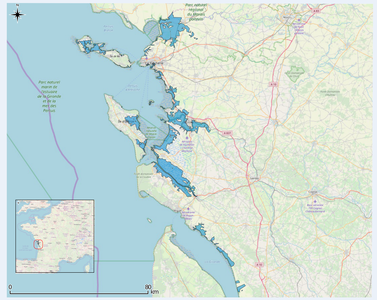

Figure 1: French littoral impacted by Xynhtia storm in 2010

1.2 Reconstruction of new protections / Cost Benefit Analysis

After Xynthia, local communities asked for fundings to reconstruct and implement new protections. In France, funding from the State need to be asked through the procedure PAPI (Programs of Actions to Prevent Floodings). In this PAPI, Cost Benefit Analysis (CBA) is mandatory.

As a consequence, to conduct CBA, Avoided Damage need to be evaluated. In France, National Flood Damage Functions have been elaborated for non saline floodings and for every category of assets (dwelings, economic activities, agriculture and public infrastructures).

The adapatation of Flood Damage Functions have been proposed for saline floodings for dwelling and economic activities but not yet for agriculture.

Figure 2: Ile de Ré during Xynthia, 2010

1.3 Evaluation of agricultural damage

French National Damage Functions for non saline context have been developed by IRSTEA (Agenais et al, 2013). The approach relies on a conceptual model developed by Bremond et al. (2013) which suggests to distinguish damage to plots (crops, vegetal material, soil and equipment) and damage to farm buildings (building and equipment).

French National Damage functions include damage to plots by considering loss of added value induced by the flood on crops (loss of yield and technical operations required after flooding), vegetal material and soil. All the information collected on loss of yield and recovery actions after flooding have been collected from surveys with agricultural experts (30). Focus groups by category of crop have been organised to validate the Damage Functions. floodam-agri ® is the model developed by IRSTEA to simulate agricultural damage due to non saline flooding (fig. 3).

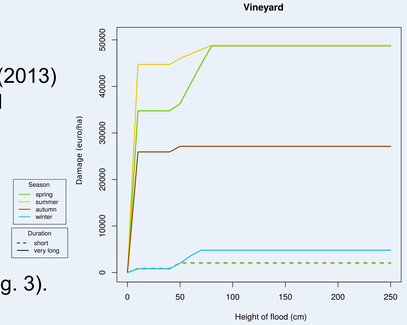

Figure 3: Example of flood damage function

2. Research and operationnal issues

1. To what extend the mechanisms that induce damage due to saline flooding are specific?
2. To what extent mid and long term effects should be considered?
3. How long is the recovery of farm after submersion?
4. Which adaptations of the damage functions to agriculture should be done?

3. Method to analyze specifity of saline floodings

We conducted interviews with 8 farmers, 8 agricultural experts and 2 cooperatives in Vendée and Charente-Maritime that have been impacted by Xynthia or have supported farmers recovery after Xynthia. Those interviews conducted 8 years after Xynthia allowed us to consider **short, mid and long term effects** as well as the **duration of recovery.** Two interview guides have been used: one for the farmers and one for the agricultural experts. All the interviews were transcribed and analysed.

4. Results

4.1 General result

No consolidated expertise on mid and long term effects of storm Xynthia on agriculture have been carried out. Only one precise feedback experience has been found on the INRA experimental farm of Saint-Laurent-de-la-Prée (Durant et al, 2018). The only other submersion that occurred in this area is Martin (December, 1999) . With this only two events, it is difficult to analyze potential effects on crops for every season.

Figure 4: Fields in Saint Laurent de la Prée

4.2 Specificity of damage, specific actions and duration of the recovery

Figure 5: Impact of salinity on soil structure

Figure 6: Mud deposit on soil

Damage to soil are specific due to salinization (fig. 5) and mud deposit composed of sand and algae (fig. 6). To evacuate salt, gypsum has been applied on fields (fig. 7). From our interviews, 20t / ha of gypsum during 3 years have been applied which represents a total cost of 990 €/ha. Efficacity of gypsum also depended on wether rain occured after treatment.

On vineyard, gypsum could not be applied due to technical constraints and organic matter has been applied.

Figure 7: Gypsum application

Figure 8: Drainage equipment in Saint Laurent de la Prée

Damage to drainage equipment (fig. 8) is also specific. Crops along the littoral are equiped with a system of drainage which relies on pump engines and canals. Reparation costs should be considered in damage functions.

Figure 9: Crops after Xynthia

Damage to cereals / leguminous plants

Crop losses on winter durum wheat after Xynthia was 100%. Depending on crop type, crop losses varied between 50% and 100% the year Xynthia occured.

Contrarily to what happens after a non saline flooding, crop losses were endured the years after Xynthia. Effects on yield have been observed between five to seven years after Xynthia due to soil salinity.

Figure 10: Grassland flooded after Xynthia

Damage to grassland / livestock feeding

Fatallities of cattle have been observed. However, most of barns were out of the area flooded by Xynthia. The main effect on livestock farms was due to flood impacts on grassland. The shortfall induced for feeding cattle has been compensated by buyng fodder. The duration of recovery of grassland fields was about three years. Specific damage functions which take into account this linkage should be developped.

Figure 11: Vinegrowers in their field after Xynthia

Damage to vineyard (fig. 11)

Vineyard mortality due to saline water differs from mortality observed with non saline water. In non saline context, except in spring, mortality is very low. After Xynthia, vineyard mortality occured and was high and delayed in time (sometimes two years after). The factors that influenced vineyard mortality were : the age of the vineyard, the type of soil and duration of submersion. The duration of the recovery varies between two and seven years.

Damage to potatoes . Potato crop is often coupled with viticulture in this area. After Xynthia, crop loss were 100%. However, no effect was observed the year after on crops.

6. Conclusions / Key messages

1. Lack of data on other submersion events to produce damage functions for every season
2. Need to introduce long term effects for non perenial crops whereas long term effects existed only for perenial crops
3. Need to introduce higher rate of vineyard mortality
4. Need to develop damage functions for mix crop livestock farming systems (do not existing yet for non saline flooding)

Vienna | Austria | 7–12 April 2019

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This work benefited from fundings of the French Ministry of Environment (CGDD convention n° 2201138418)

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