G-Eau Working Paper/Rapport de Recherche No. 6

Characterization and evaluation of farm vulnerability to flooding using EVA methodology: Comparison of two case studies in the South of France and Saxony

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1 MuldEVA project

1.1 Introduction

1.1.1 Scientific collaboration

This project has been carried out in the framework of PEER network in which IRSTEA and UFZ are involved. On the basis of this collaboration, Pauline Bremond, researcher at IRSTEA Montpellier, has been doing six months of mobility at UFZ within the Department of Economics (division of social sciences) from March to August 2012.

Common research interests in the field of ’economics of natural hazards’ with regard to methodologies developed and objects studied, have been identified between researchers of IRSTEA (Pauline Brémond, Frédéric Grelot, Katrin Erdlenbruch) and of UFZ (Volker Meyer, Reimund Schwarze). This common interest relies mainly in the analysis and evaluation of natural hazard effects on social systems in a context of climate change. This collaboration was intended to strengthen the collaboration and mutualize the efforts carried both by UFZ and IRSTEA to improve the economic assessment of natural hazards.

On the one hand, the work carried out by Pauline Brémond, who achieved a Ph.D. in economics on the evaluation of farm vulnerability to flooding, closes some gaps, at the micro scale, in the systemic analysis of effects of natural hazard on assets. On the other hand, the UFZ group coordinates several projects on the topic of cost evaluation of natural hazards that aim at improving the assessment of natural hazard effects on society based on a systemic approach of looking at social systems vulnerability and resilience like for example the MEDIS, Floodsite project and CONHAZ project (Costs of Natural Hazards).

This project, called thereafter MuldEVA, aimed at enhancing exchange on the methodologies to assess the costs of natural hazard. Specifically, within the six months, three main objectives were tackled:

1. to determine the possibility and conditions to transfer the model developed by BremondP2011a to appraise flood damage on agricultural areas to a case study in Saxony;
2. to better understand vulnerability to flooding in a case study in Germany, the Mulde River area;
3. to compare farm vulnerability to flooding on the two case studies i.e. the Rhône River downstream and the Mulde River.

1.1.2 Presentation of EVA model

The farm vulnerability model, called thereafter EVA (Evaluation of the Vulnerability of Agriculture), has been applied in France, on the Rhône River downstream on typical farms. The following section gives a brief description of the EVA model. For more details, see BremondP2011a and BremondP2012a.

1.1.2.1 <u>Purpose and links with other models</u>

The purpose of the model EVA is to evaluate flood consequences on farms with quantitative indicators in order to assess their vulnerability. In particular, EVA aims at evaluating impacts of a change in flood parameters and/or asset vulnerability. Concerning flood scenarios, EVA uses as inputs flood parameters such as duration, height, occurrence period and speed arising from hydrologic and hydraulic modelling. Concerning changes in asset vulnerability, EVA uses as inputs modified farm’s characteristics.

1.1.2.2 Spatial and temporal scales

The system considered is a farm represented as a collection of physical components: on the one hand, buildings containing machinery and stocks of inputs; on the other hand, land plots containing crop production and orchard or vineyard. During and after the flood, these components are characterized by their usability which is a combination of their accessibility and state (normal, damaged, destroyed). The usability defines if the component can be involved in the production process. As an example, as long as a machinery is unusable, it cannot be used to achieve a production task which requires its use. EVA model crosses farm and flood temporalities. Without flooding, farm task planning relies on the crop management sequence defined as a parameter of farm. When a flood is simulated, task planning is reorganized at the weekly time step until the end of the production cycle. Production tasks can be delayed or partially achieved and recovery tasks (cleaning) are added to the list of tasks to do.

1.1.2.3 Outputs of EVA

This model aims at describing the flood effects on farms with several indicators. Three main indicators are produced by EVA:

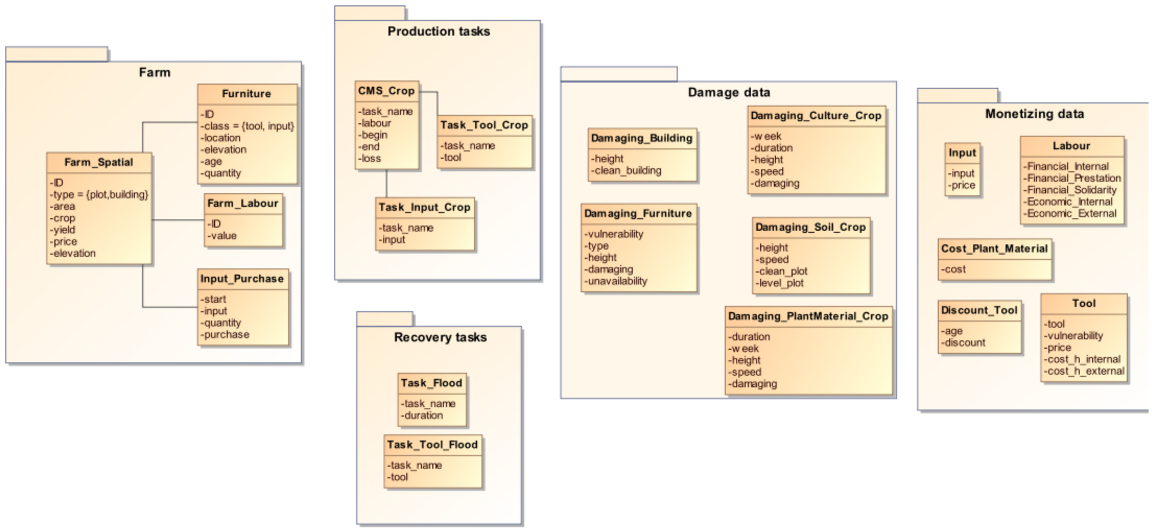
1. the chronology of the usability of every farm physical component;
2. a quantification of changes induced in needs and availability of production factors , mainly workforce and machinery, required to carry on production and recovery tasks, at the same time ;
3. a quantification of induced damage, in monetary terms, by the achievement using external resources or the undoing of some production tasks depending on farmer’s capacity to access to external resources.

1.1.2.4 Data requirement

EVA finally models the consequences of flooding on farm components and on farm functioning. This modelling approach requires data that can be classified into five types as presented on Figure 1.

1. data related to farm description;
2. data on field operation achievement;
3. data on recovery task achievement;
4. data on direct damage assessment (damage functions);
5. data required to monetize damage.

Figure 1: Data needed to feed EVA model



1.1.3 Conceptual framework for EVA model

The definition of risk which is adopted in this approach is based pn the Global Assessment Report (GAR) of the United Nations Office for Disaster Risk Reduction (UNISDR, 2011a) and the SREX report of the Intergovernmental Panel on Climate Change (IPCC, 2012a).

According to this, risk, or mean annual damage, is a function of hazard, exposure and vulnerability.

Hazard refers to the flood probability and characteristics and exposure refers to the number (and value) of people or assets in the hazard-prone area. Vulnerability can be distinguished into susceptibility (or sensitivity) and coping capacity as suggested by Gallopin (2006a). Susceptibility/sensitivity refers to the potential of elements at risk to suffer harm or loss while coping capacity describes their potential to cope with these losses and to recover afterwards. All these risk components can be altered by mitigation/adaptation measures (i.e. explicit risk management measures).

In the case of farm vulnerability to flooding,

- the hazard characteristics that are critical to consider are the period of occurrence, the height, the velocity and the duration;
- the exposure depends on the spatial configuration of the farm i.e. area and type of land plots as well as type and number of buildings flooded;
- the sensitivity of several physical elements has to be considered i.e. crops, cattle, soil, perennial vegetal material, buildings and contents (machinery, stocks of inputs or forage)
- the coping capacity as showed by Bremond (2011a), mainly depends on the availability of internal resources (workforce, machinery) and the capacity to access external ones (solidarity, service providers).

1.1.4 Research questions

Two mains research questions have been addressed in for the MuldEVA project:

1. Knowing that the EVA model is highly data demanding, which are the conditions and difficulties to transfer EVA model to a case study in Saxony?

2. Can different patterns of vulnerability to flooding be identified between the farms on the Rhône River downstream and on the Mulde River?

2 Presentation of the case studies

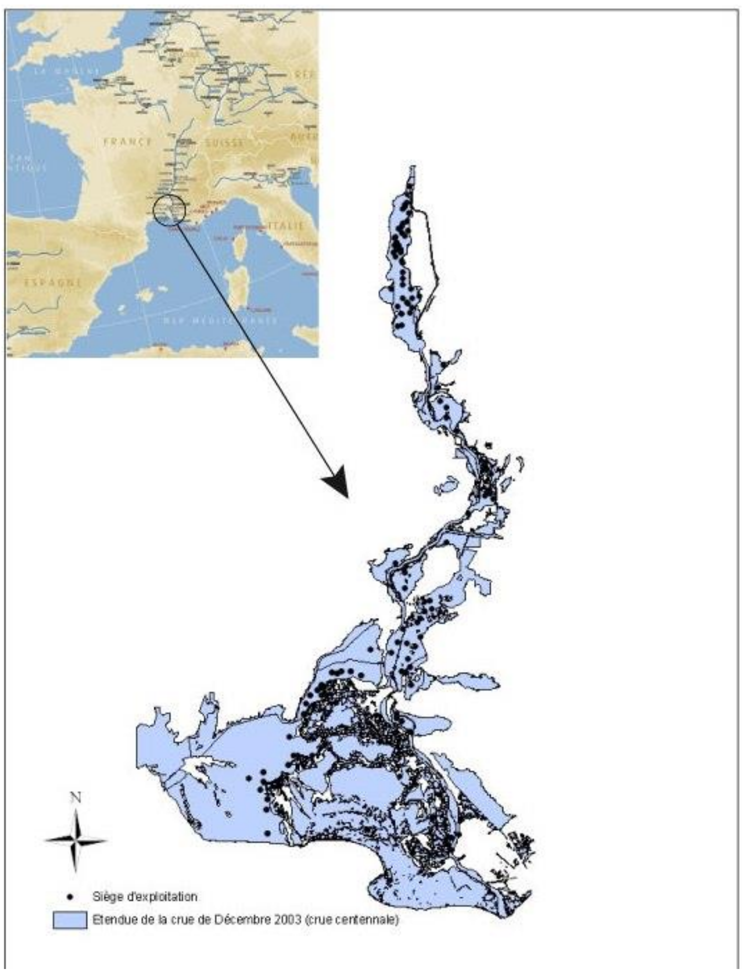
2.1 Case study area on the Rhône River downstream

The French case study is located on the Rhône River downstream. It is briefly described in this section. The description is much more detailed in Bremond (2011a) since this area was the case study for the application of EVA model.

2.1.1 Localization

The Rhône River with 812 km, is one of the main river in France (Figure 2). It has been frequently impacted by severe floods. The flood of reference occurred in May 1856 and caused huge impacts on cities such as Lyon and agricultural areas.

Figure 2: Localization of the Rhone River downstream case study

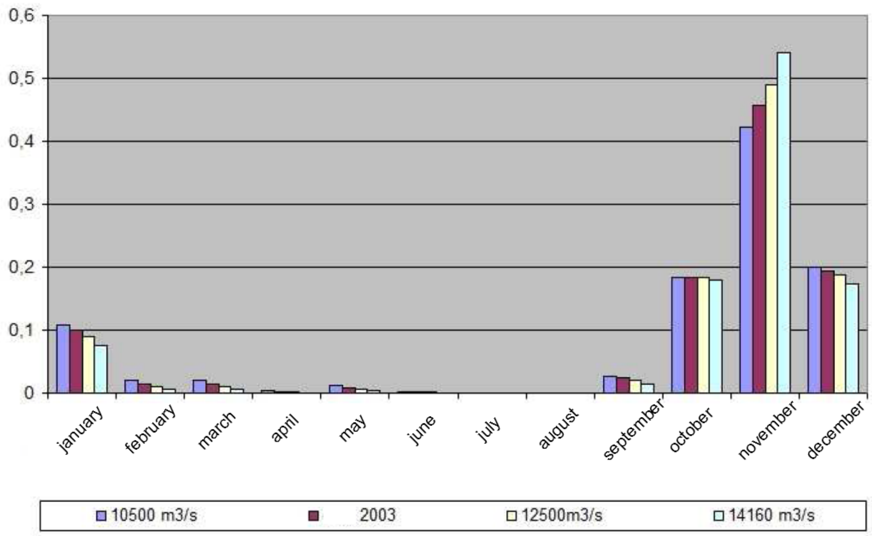


2.1.2 Flood characteristics

2.1.2.1 <u>Period of occurrence</u>

The analysis of hydrologic data on the Rhône River downstream between 1920 and 2005 (ISL, 2010a) shows the following probabilities of occurrence in function of the year (Figure3).

Figure 3: Monthly probability of occurence



In function of their period of occurrence, three types of floods with different consequences on assets, particularly agricultural ones, can be distinguished:

- autumn floods (September to November);
- winter floods (December to February)
- spring floods (April to June).

On the Rhône River downstream, the last extreme flood occurred in December 2003. Most of the impacts have resulted from dike failures.

According to the Figure 3, the highest probability of for flooding is between October and January (autumn and winter floods).

2.1.3 Flood damages

In 2003, the total amount of damage on the Rhone River downstream has been estimated to 850 millions € among which 76,8 millions € i.e. 9%, correspond to agricultural activities (SIEE, 2005c).

2.1.4 Flood management and place of agriculture

Extreme events combined with dike failures on the Rhône River in 1993, 2002 and 2003 have shown limits of flood management policies relying only on dyke protection: worsening of flood impacts downstream, increased damage by dyke rupture. The Rhône River program is a contract of objectives signed between French Government and local authorities which aims at promoting an integrated management of the watershed on several points: environment, flood, culture... In 2003, the part concerning flooding has been implemented after the last extreme flood. New orientations to mitigate flood exposure are promoted, in particular, floodplain restoration and vulnerability mitigation. These new orientations may have significant impacts on agricultural areas. Concerning floodplain restoration, the assets mainly concerned are agricultural ones, because they are more frequently located in existing or former floodplains and the potential damage on these areas is expected to be less important than urban or industrial areas. As a consequence, agricultural sector is also particularly concerned by planned actions to mitigate asset vulnerability, an important part of the program (15 out of 310 millions € for the period 2007-2013). Mitigation of agricultural assets vulnerability reveals particularly interesting for the local authorities for the two following reasons. Firstly, it is a way to maintain agricultural activities in floodplains, without promoting new flood protections. Secondly, in case of floodplain restoration, vulnerability mitigation is a way for local authorities to compensate additional flood impacts. In practice, local authorities may financially support farmers for implementing measures to mitigate their farm vulnerability. Some studies have been carried out funded by the Rhône River program, to characterize farm vulnerability to flooding and propose measures to mitigate it (CRAM-R1-2006). More than 3 000 farms exposed to flood risk have been identified representing 88 690 ha of agricultural areas. Moreover, 70 % of the farms exposed to flooding have their buildings in the flood plain.

2.2 Case study area in Saxony

2.2.1 Localization

Research carried out by the UFZ group dealing with flood vulnerability and resilience has mainly been focussed on the Mulde River catchment. More specifically, on the Vereinigte Mulde River which was heavily affected by the flood in August 2002, causing high damages in many towns and villages along the river (RiskMap, 2011a). The Mulde River is one of the main tributaries of the Elbe River (Figure 4). The 124 km long course of the Vereinigte Mulde is formed by a Western branch, the Zwickauer Mulde, and an Eastern branch, the Freiberger Mulde.

2.2.2 Flood characteristics

2.2.2.1 Period of occurrence

Considering agricultural damage, particular attention has to be paid to the period of occurrence of the flood. The table 1 (LfULG2009b) summarizes some characteristics of the main flood events that occurred on the Mulde watershed area. The flood height is measured in a city located in the Vereinigte Mulde area (Grimma). The extreme floods mainly occur in summer (July, August) but even if it is less frequent some can also occur in winter (December).

2.2.2.2 The 2002 flood

Last extreme flood that impacted the Elbe catchment, including the Mulde area, occurred in mid-August 2002. The areas in red in the Figure 4 correspond to the flooded areas in 2002. This flood has begun on the 12th of August at the smaller catchments in the Ore mountains (Erzgebirge) and has lasted until the 22nd of August at the Elbe river (Staatregierung, 2002a). Depending on the area, the return period of this flood was between a 50-year and 500-year return period as depicted on Figure 5. At the Vereinigte Mulde, where the case study is located, the return period for the 2002 flood was defined as in between a 200 and 300-year flood.

Figure 4: Localization of the case study in Saxony

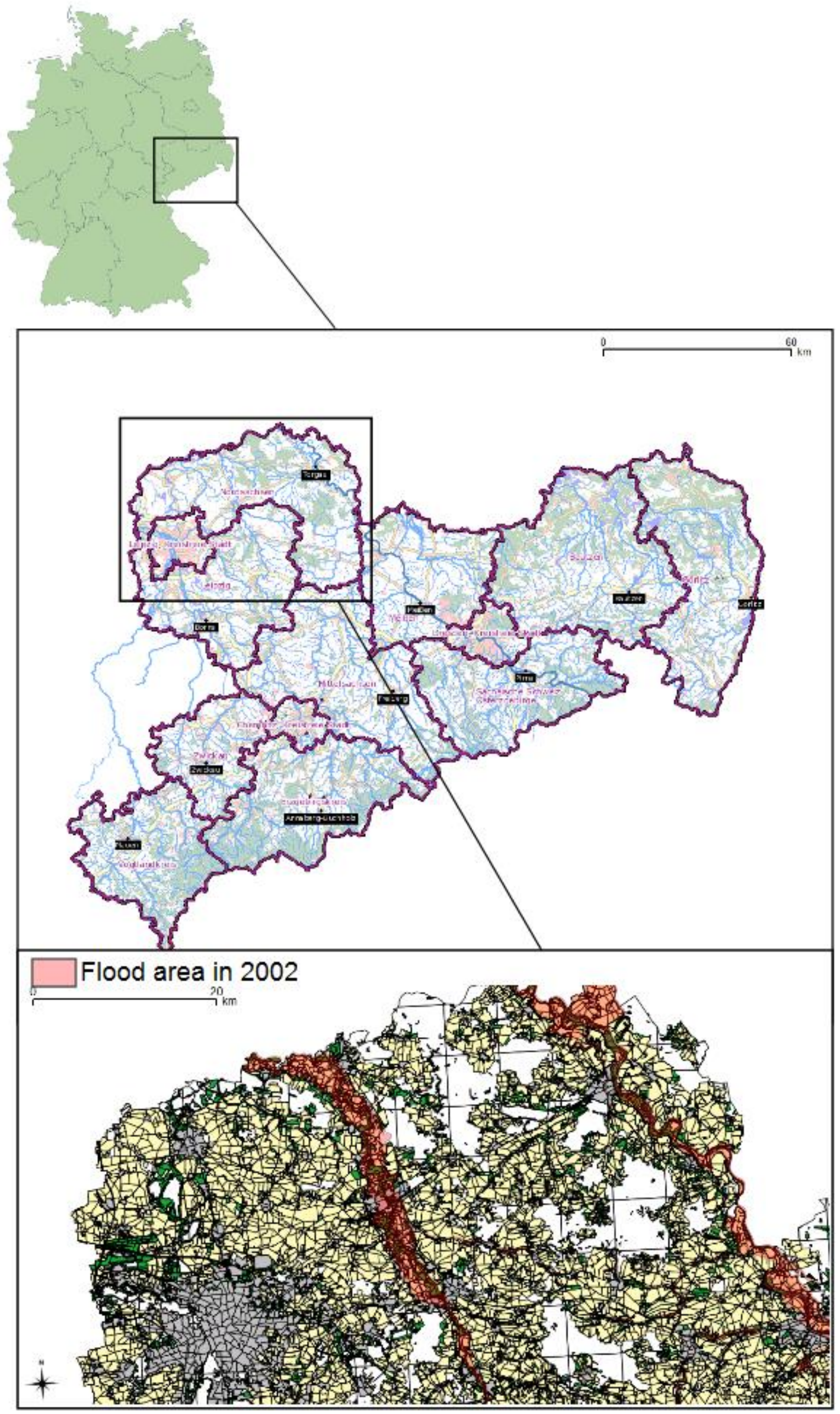
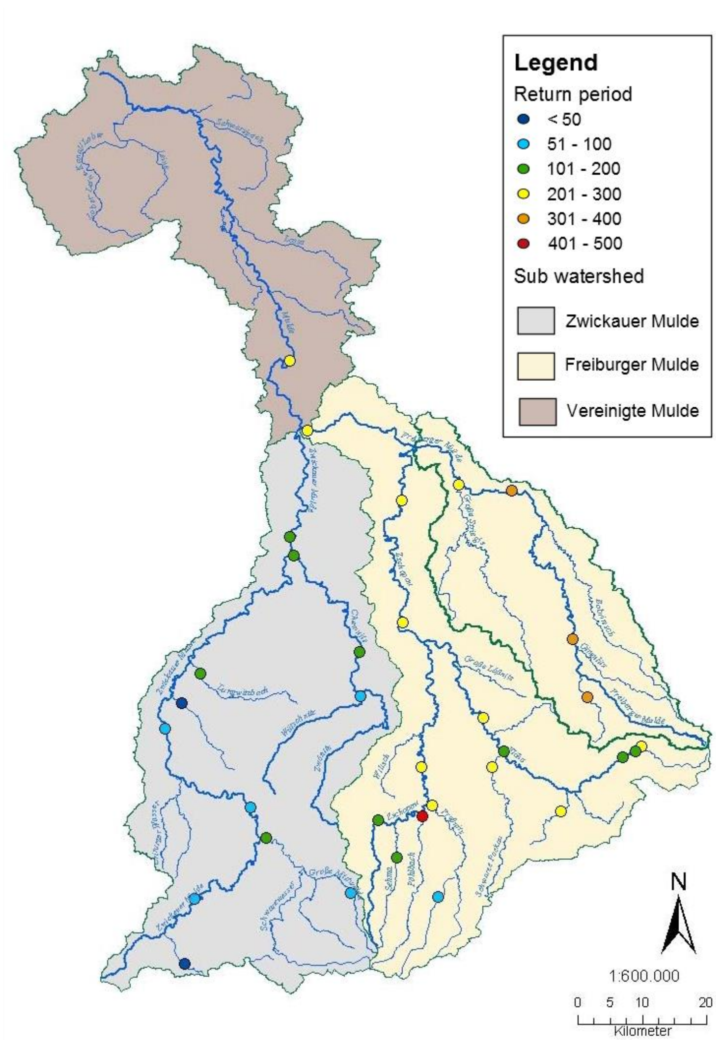


Table 1: Past floods on the Mulde watershed (LfULG, 2009b)

Date	Period of occurrence	Height (cm)
1573	August	636
1771	June/July	598
1858	August	481
1897	July	490
1932	January	455
1954	July	508
1958	July	414
1974	December	464
2002	August	752

Figure 5: Return period of the 2002 flood on the Mulde River watershed (LfULG, 2009b)



2.2.3 Flood damages

2.2.3.1 Flood damages in 2002

The 2002 flood caused huge damages in Saxony. 21 persons died and 110 were injured (Staatregierung, 2002a). In terms of economic damages, the report from the Sächsischen Staatsregierung (Saxon federal government), which is in charge of the management of claims and compensation after 2002, mentions a total amount of damage of more than € 6 billions, for the economic sectors as described in the Table 2.

This amount does not include structural damage and loss of profitability after the flood. For example, concerning buildings, induced damage due to the flood occurred after the frost period. For economic activities, the induced damage due to the loss of profitability has not been estimated (Staatregierung, 2002a).

Table 2: Distribution of flood damage after 2002 (Staatregierung, 2002a)

	Million €	%
Residential building	1 706	27,5
Industry	1 420	22,9
Municipal infrastructure	1 287	20,8
National infrastructure	928	15,0
Furniture	529	8,5
Emergency costs	136	2,2
Other infrastructure	111	1,8
Agriculture and forestry	79	1,3
Total	6 196	100

2.2.3.2 Focus on agricultural damage from 2002 flood

The total amount of damage has been estimated to 79 millions € and divided per agricultural activity as depicted in Table 3. A total of 1 375 farms have been affected in Saxony. The damage assessment is based on surveys of the Offices of Agriculture and experts.

Table 3: Distribution of agricultural flood damage after 2002 (Staatregierung, 2002a)

	Million	%
Agricultural assets	36	45,6
Field inventory	24	30,4
Clean-up and evacuation costs	15	19,0
Timber losses and damage to forestry sector	4	5,1
Total	79	100

2.2.3.3 Analysis of the damage distribution for the 2002 flood

The damage to agriculture represents only 1,3 % of the total damage. This flood was an extreme event and has impacted areas that are not used to be impacted by more frequent flooding. That could partly explain why the share of agricultural damage is particularly low.

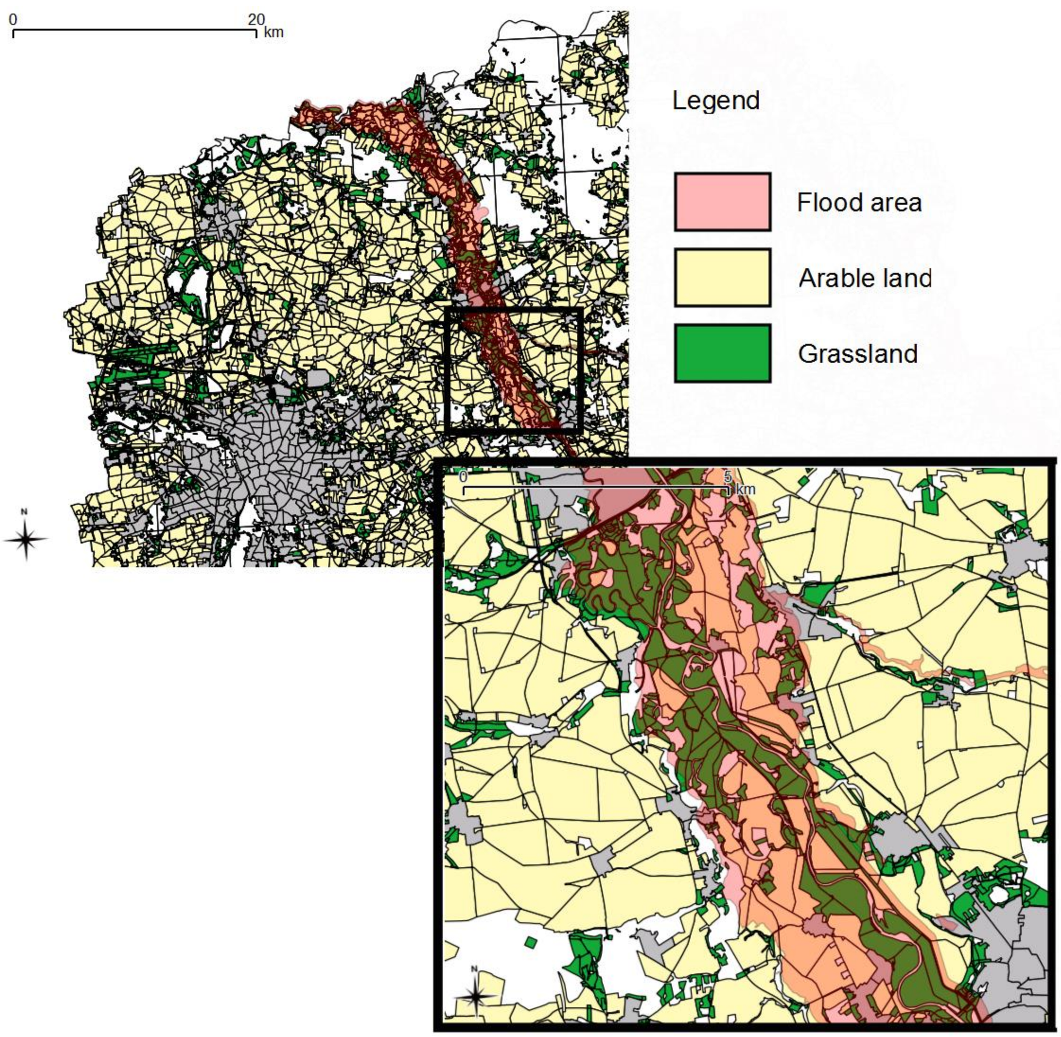
2.2.3.4 Land use in the flood plain

The total flood area on the Mulde River represents 13 381 ha of which:

- 1 558 ha on the Freiberger Mulde,
- 229 ha on the Zwickauer Mulde,
- 11 594 ha on the Vereinigte Mulde.

The analysis of the land use provides some insights on the type of assets impacted by the flood. Figure 6 shows a focus on an area flooded in 2002 at the Vereinigte Mulde. Most of the areas impacted are agricultural ones and mainly grassland. However, arable land is also located in the floodplain.

Figure 6: Land use in the flood plain area



For extreme events, some assets such as cities, industries can also be impacted. Then, the share of damage related to those sectors is high. However, agricultural assets are the most represented in the floodplain and may be more frequently impacted. In this case, the share of agricultural damage in the Mean Annual Damage (MAD) at regional level, may provide another insight in flood impacts. If agriculture is more frequently impacted, the share of agricultural damage in the MAD may be higher than expected. However, no literature was found on this topic.

2.2.4 Flood management and place of agriculture [1]

2.2.4.1 Institutions and responsibilities

The competencies of flood and water policy in Germany lie mostly with the German Federal States (Länder), whereas the central government is entitled to frame the legislation. In Saxony, the Saxon State Ministry of the Environment and Agriculture (Sächsisches Staatsministerium für Umwelt und Landwirtschaft, SMUL) is the main decision authority for flood management and is supported by the State Office for the Environment, Agriculture and Geology (Landesamt für Umwelt, Landwirtschaft und Geologie, LfULG).

The Saxon Flood Center (Landeshochwasserzentrum, LHWZ), within the LfULG, is also a main actor for flood information and early warning, particularly since 2002. It provides relevant flood information directly to each authority with flood defence responsibilities.

The local representative of farmers in flood management decision processes are the regional farmers' associations (Regionalbauernverband). These associations are the local level of the national association, der Deutsche Bauernverband.

2.2.4.2 Role of agriculture in flood management

After 2002, the potential role of agriculture in helping to prevent flood risk has been questioned. Several options were considered (Stahl, 2005a, LfULG, 2007a):

- to lower or relocate dikes which protect agricultural areas,
- to create some areas of controlled flooding (polder) on agricultural areas,
- to prevent water run-off by adapting farmers' practices in the upstream watershed.

To also understand which of these options have been implemented since 2002 and how, was part of the interviews we carried out in the case study of the Mulde River region.

2.3 Focus on agriculture

In this section, we compare data at the regional level which does not correspond to the scale of the both case studies. The French case study on the Rhone River downstream located on two political regions i.e. Languedoc-Roussillon (LR) and Provence Alpes Côte d'Azur (PACA). The German case study is entirely located in the Federal State of Saxony. This section provides some general information on agriculture characteristics in these regions.

[1] For a more detailed presentation of flood management in Saxony see the report of the project RISKMAP from which this section is derived RiskMap (2011a).

2.3.1 Agriculture and employment

The proportion of people working in the agricultural sector in Saxony is close to the proportion in Languedoc Roussillon and Provence Alpes Côtes d'Azur (Table 4).

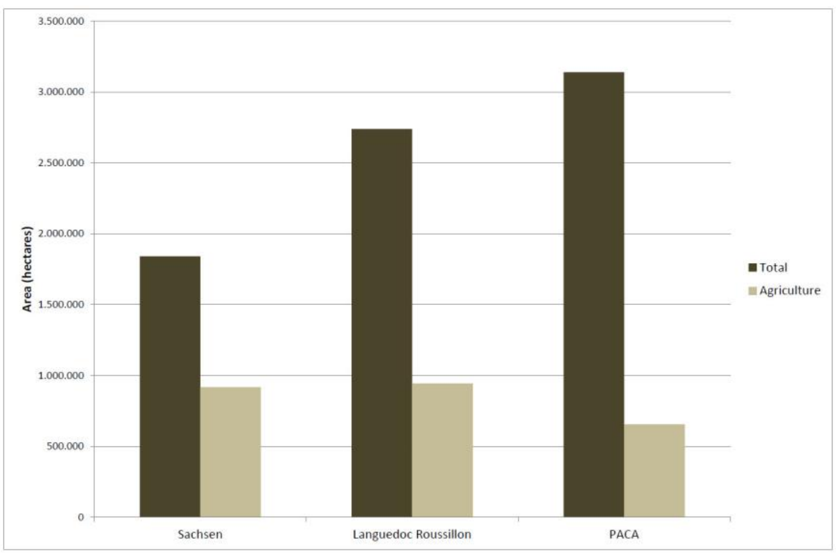
Table 4: Employment in the agricultural sector

	Active population	Agriculture (number)	Agriculture (%)
Saxony	2 000 000	40 000	2 %
LR	932 000	41 400	4 %
PACA	1 616 000	15 000	1 %

2.3.2 Agriculture and land use

Agricultural areas in Saxony represent 55 % of the total area, exceeding the national average for which agricultural areas represent 50 % of the total area. The proportion of agricultural areas in Saxony (Figure 7) is higher than in the two regions of France.

Figure 7: Comparison of agricultural area in Saxony, Languedoc-Roussillon and Provence Alpes Cotes d'Azur (PACA)[2]

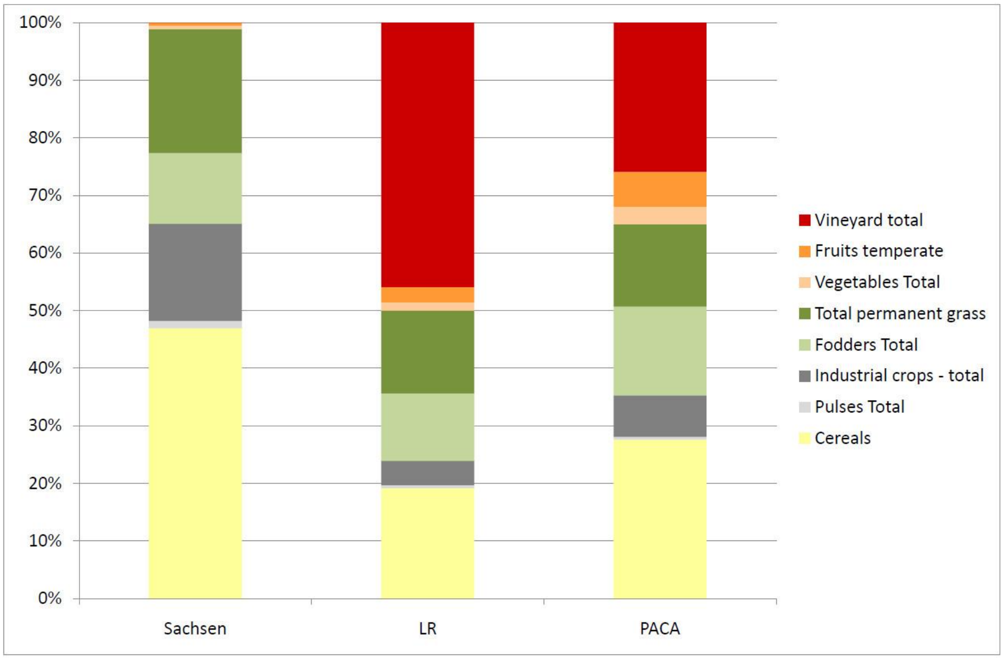


Prevalent crop types differ a lot for the two case studies (Figure 8).

[2]Eurostat 2007

[3]Eurostat 2007

Figure 8: Proportion of crop type in Saxony, Languedoc-Roussillon and Provence Alpes Cotes d'Azur (PACA)[4]



In Saxony, most of the arable land is cultivated with cereals (wheat, barley, oat, rye), followed by pulses and industrial crops among which production of oil seed such as rape. The grassland represents also a large share of agricultural land (20 %) and is part of the grazing system for animal production (milk cows).

Comparatively, in LR and PACA, the proportion of vineyard, orchard and market gardening is much higher. Crop types in Saxony are much more capital extensive.

Specifically, on the Rhone River downstream, some information exists on the characterization of agriculture in the floodplain (CRAM-R1-2006). The highest numbers of farms in the floodplain are farm specialized in arboriculture, market gardening and vineyard (Figure 8). In terms of areas, cereals, livestock farming then arboriculture represent the most important areas within the floodplain (Figure 8).

2.3.3 Farm size

In Saxony, farm structure is still very influenced by the reform implemented during the GDR (German Democratic Republic) system (collectivization). Mainly two types of farms coexist: the big entrepreneurial structures and the familial farms which can be full time or part time activity.

The size of the farms can be diverse (Figure 9) but in general, many of the farms are bigger than on the French case study.

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[4]Eurostat 2007

[5]Eurostat 2007

Figure 9: Number of farm by crop type in the floodplain area of the Rhone River downstream

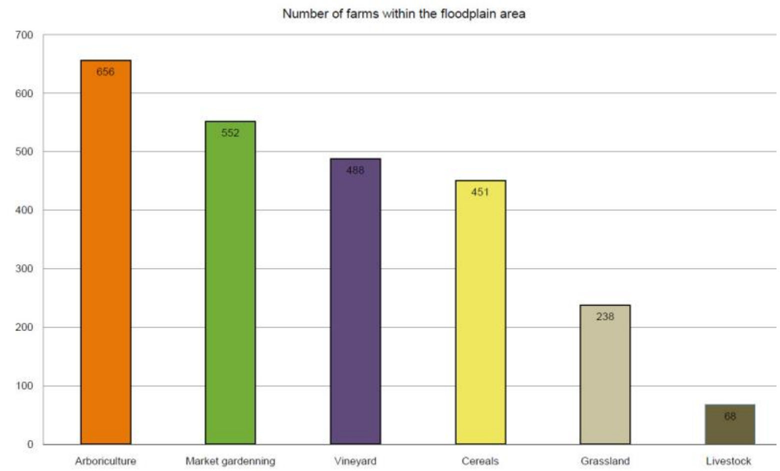


Figure 10: Crop type areas in the floodplain area of the Rhone River downstream

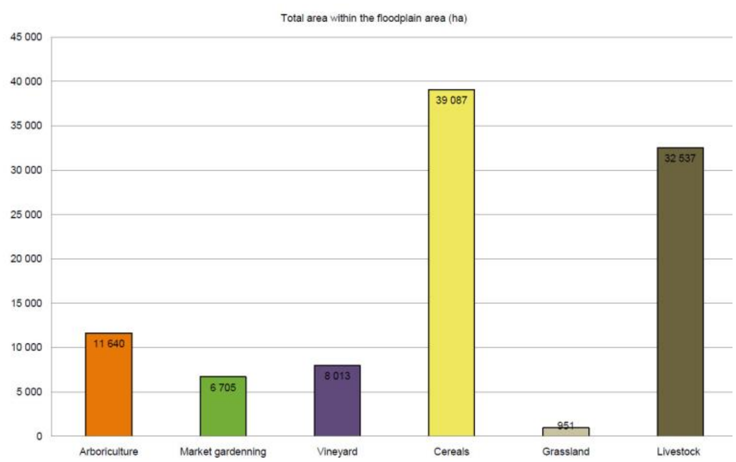
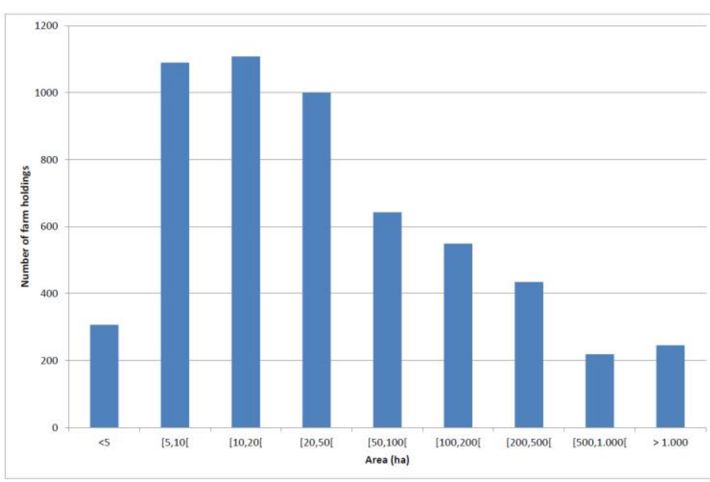


Figure 11: Distribution of the number of Saxon farms in function of their area in hectares SMUL2010b



On the Rhone River downstream, farm size is generally smaller. As for examples:

• 4 300 farms are specialized in arboriculture in the five departments of the Rhone River downstream. Among them, 2 031 farms have less than 15 ha (average UAA is 8 ha) and 2 266 farms have more than 15 ha (average UAA is 38 ha).

• The size of farms specialized in viticulture ranges from 12 to 42 ha on the case study area and the average farm size is 22 ha.

2.3.4 Legal forms of the farms

German farms' legal form are either corporate bodies or natural persons. Among corporate bodies, the most common forms are (Dieckhoff, 2008a):

- registered co-operatives (eingetragene Genossenschaft, e.G.) which are constituted by at least 7 co-operators,
- Ltds and similar (GmbH and AG).
- Natural persons can be (Dieckhoff, 2008a):
- partnership (GdBr),
- individual farmers.

Farm distribution within these categories is given in the Table 5.

Table 5: Distribution of farm legal form (SMUL, 2010b)

	Saxony	Germany
Corporate bodies	610	5 000
Registered co-operatives	197	1 100
Ltd's and similar	289	2.800
Natural persons	4 987	295 600
Partnerships	372	21 000
Individual farmers (total)	4 615	274 600
Individual farmers (main activity)	1 803	137 400

2.3.5 Existing studies on farm vulnerability to flooding

Few works have been carried out on flood vulnerability of German farms. Mainly, three studies deal with this topic:

- ForsterS2008a wrote an article dedicated to the evaluation of the efficiency of a retention area on agricultural land,
- BMBF2004a published a book on the potential development of polder,
- ThiekenA2010a published a book summarizing works on flood damage.

The most detailed work on the characterization of flood impacts on farms, results from BMBF2004a. They recommend to consider the following damage categories:

- surface damage on crops (loss of harvest, fodder) and soil (recovery costs),
- damage to buildings and contents (inputs, machinery),

- fatalities to cattle.

3 Methodology

The project has been structured around the following steps:

1. Literature review in English and German concerning the case study area, flood damage and agricultural context
2. Identification of existing data sources (English and German) and analysis of their importance for the study
3. Selection of contacts for interviews
4. Preparation of interview guides (German and English)
5. Interviews with representatives from administrative bodies and transcription
6. Identification of contacts to farmers
7. Preparation of interview guides and data collection framework for farms
8. Interviews with farmers and transcription
9. Data collection and formatting
10. Synthesis

3.1 Interviews with representatives from administrative bodies

3.1.1 Presentation of the contacts

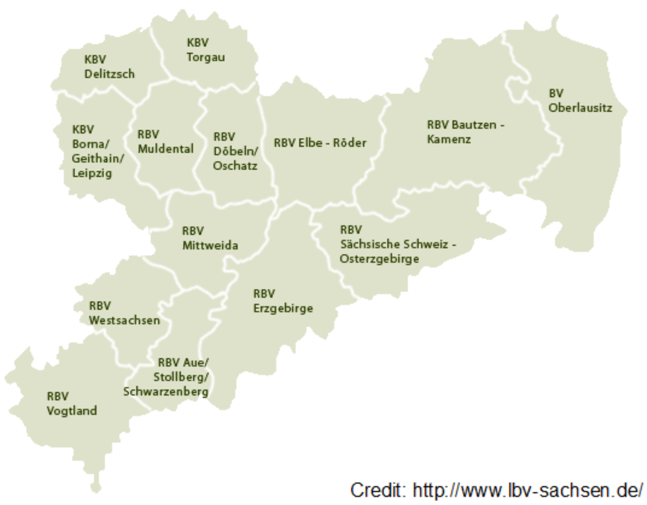
We carried out 6 interviews with representatives from administrative bodies (Table 6). These include the three main institutions involved in flood management and the farmers' associations of the regions mostly affected. In addition, we carried out an interview with an experimental farm which is located in the floodplain area on the Elbe river to contrast from qualitative interviews with administrative bodies and have more insights at farm level.

Within the farmers' assocation (Regionalbauernverband, RBV), we met Mr Eggert who was the representative of the Delitzch region and Mr Freiberg who was the representative of the Muldental region (Figure 12). These two regions were the most impacted ones during 2002 flood.

Table 6: Overview on the interviews carried out with representatives of institutions

	Institution	Date
Hening Stahl	LfULG Leipzig	09.05.12
Ulrich Henk	SMUL	04.05.12
Uwe Büttner	LHWZ	07.05.12
Reinhard Eggert	Farmers' assocation (Delitszch)	06.06.12
Frank Freiberg	Farmers' assocation (Muldental)	04.06.12
Heike Weiß and Ondrej Kunze	Experimental farm LfULG	19.07.12

Figure 12: Local sections of the Regionalbauernverband



3.1.2 Objectives of the interviews

The interviews focused on:

1. the description of agriculture and farm organization in the region,
2. the characteristics of the 2002 flood and its impacts on agriculture, recovery and role of the administration during this event,
3. the place of agriculture in flood management policies under discussion and their implementation since 2002,
4. the discussion about the exat location of the case study and the contacts with some farms which have been impacted by the 2002 flood.

3.2 Interviews with farm managers

3.2.1 *Selection of farms*

Four farms that have been impacted by the 2002 flood in the case study area have been identified and interviewed (Table 7)

Table 7: Interviews with farm managers

Farm	Structure	Date
Tilo Bishoff	Agrargenossenschaft eG	14.06.12
Ulrich Kröber	Agrargenossenschaft eG	18.06.12
Lutz Eilenberg	GmbH Co.KG	25.06.12
Matthias Hofmann	GmbH Co.KG	25.06.12

3.2.2 *Objectives of the interviews*

Interviews were organized around four topics:

1. presentation of the project and objectives of the interview,
2. general presentation of the farm (legal form, short history, crops, workforce),
3. collection of farm data (areas, crops, workforce, machinery, etc.);
4. data on damage and recovery after 2002 flood.

3.3 Methodology for data collection and organization

3.3.1 *Presentation of the data*

Due to the important number of data to be collected, we proceeded to a fine description of each data as presented on the next page. For each piece of data, we define:

- at which level and category, the data corresponds to (this level and category correspond to those of Figure 1),
- if the data is numeric or text,
- what the unit is,
- how this data has been collected in France and in Germany.

Every indicator described in the following table refers to EVA model components.

3.3.2 *Identification of existing data sources*

To identify which method should be used to collect data in Germany, we had an interview with researchers from IAMO (Leibniz-Institut für Agrarentwicklung in Mittel- und Osteuropa). It helped us to identify data bases such as the data produced in Germany by the KTBL (Kuratorium für Technik und Bauwesen in der Landwirtschaft) which provides data on production tasks (crop management sequence) giving the list of tasks and their timing on the year and the resources needed.

	Level	Category	Indicator	Description	unit / value	Method France	Method Germany
	Hazard	Hazard	ID	numeric			
	Hazard	Hazard	location	text			
	Hazard	Hazard	begin	numeric	week number		
	Hazard	Hazard	end	numeric	week number		
	Hazard	Hazard	height	numeric	cm		
	Hazard	Hazard	speed	numeric	{0,1,2} qualitative treshold		
	Farm	Farm_Spatial	ID	numeric		nn	nn
	Farm	Farm_Spatial	class	text	{plot, building}	nn	nn
F	Farm	Farm_Spatial	area	numeric	ha	expert interviews / agricultural census	farmer interview / validation Agricultural census
F	Farm	Farm_Spatial	crop	text		expert interviews / agricultural census	farmer interview / validation Agricultural census
L	Farm	Farm_Spatial	yield	numeric	x/ha	technological-economic manuals	farmer interview / KTBL
L	Farm	Farm_Spatial	price	numeric	y/x	technological manuals	farmer interview / KTBL
F	Farm	Farm_Spatial	elevation	numeric	cm	assumption elevation = 0	assumption elevation = 0 / farmer interviews
F	Farm	Furniture	name	text	{list of tool}	report CA30 expertise	farmer interview (/ KTBL ?)
F	Farm	Furniture	class	text	{tool, input}	nn	nn
F	Farm	Furniture	location	text	ID Farm_Spatial	expert interviews	farmer interview (/ KTBL ?)
F	Farm	Furniture	elevation	numeric	cm	assumption elevation = 0	assumption elevation = 0
F	Farm	Furniture	age	numeric	year	report CA30 expertise	farmer interview (/ KTBL ?)
F	Farm	Furniture	quantity	numeric	integer	report CA30 expertise	farmer interview (/ KTBL ?)
F	Farm	Farm_Labour	internal	numeric	number of worker	expert interviews / agricultural census	farmer interview (/ KTBL ?)
F	Farm	Farm_Labour	internal_hour	numeric	hour/week/worker	french regulation / expert	german regulation / farmers
F	Farm	Farm_Labour	internal_hour_crisis	numeric	hour/week/worker	interview with farmers	german regulation / farmers
L	Farm	Input_Purchase	start	text	{T}	expert interviews	nn
L	Farm	Input_Purchase	input	text	{list of input}	technological-economic manuals, expert interviews	KTBL
L	Farm	Input_Purchase	quantity	numeric	kg/farm	technological-economic manuals, expert interviews	KTBL
L	Farm	Input_Purchase	purchase	numeric	week number	expert interviews	Farmer interview
L	Production Tasks	CMS_Crop	task name	text		technological-economic manuals, expert interviews	KTBL
L	Production Tasks	CMS_Crop	labour	numeric	hour/ha	technological-economic manuals, expert interviews	KTBL
L	Production Tasks	CMS_Crop	begin	numeric	week number	technological-economic manuals, expert interviews	KTBL
L	Production Tasks	CMS_Crop	end	numeric	week number	technological-economic manuals, expert interviews	KTBL
L	Production Tasks	CMS_Crop	loss	numeric		expert interviews	use french data if possible
L	Production Tasks	Task Tool Crop	tool/task	numeric	ratio of labour	expert and farmer interview	KTBL
L	Production Tasks	Task input crop	input/task	numeric	ratio of total input quantity	expert interviews	KTBL
E / F	Recovery Tasks	Task flood	task name	text		expert and farmer interview	interview with farmers
E / F	Recovery Tasks	Task flood	duration	numeric	hour/ha	expert and farmer interview	interview with farmers
E / F	Recovery Tasks	Task flood	loss	numeric		assumption loss = 0	assumption loss = 0
E / F	Recovery Tasks	Task tool flood	tool/task	numeric		expert and farmer interview	Expert and farmer interview
E / F	Recovery Tasks	Task input Flood	input/task	numeric		expert and farmer interview	Expert and farmer interview
E	Damage Data	Damaging building	height	numeric	cm	expert and farmer interview	use french data if possible
E	Damage Data	Damaging building	clean building	numeric	hour/m²	expert and farmer interview	use french data if possible
E	Damage Data	Damaging furniture	vulnerability	text		expert interview / report CA30 expertise	use french data if possible
E	Damage Data	Damaging furniture	type	numeric	{number of vulnerability type}	expert interview / report CA30 expertise	use french data if possible
E	Damage Data	Damaging furniture	height	numeric	cm	expert interview / report CA30 expertise	use french data if possible
E	Damage Data	Damaging furniture	damaging	numeric	ratio	expert interview / report CA30 expertise	use french data if possible
E	Damage Data	Damaging furniture	unavailability	numeric	number of weeks	expert interview / report CA30 expertise	use french data if possible
E	Damage Data	Damaging culture crop	week	numeric	week number	expert interview / report CA30 expertise	use french data if possible
E	Damage Data	Damaging culture crop	duration	numeric	day	expert interview / report CA30 expertise	use french data if possible
E	Damage Data	Damaging culture crop	height	numeric	cm	expert interview / report CA30 expertise	use french data if possible
E	Damage Data	Damaging culture crop	speed	numeric	{0,1,2} qualitative treshold	expert interview / report CA30 expertise	use french data if possible
E	Damage Data	Damaging culture crop	damaging	numeric	ratio	expert interview / report CA30 expertise	use french data if possible
E / F	Damage Data	Damaging soil crop	height	numeric	cm	expert and farmer interview	use french data if possible
E / F	Damage Data	Damaging soil crop	speed	numeric	{0,1,2} qualitative treshold	expert and farmer interview	use french data if possible
E / F	Damage Data	Damaging soil crop	clean plot	numeric		expert and farmer interview	use french data if possible
E / F	Damage Data	Damaging soil crop	level plot	numeric		expert and farmer interview	use french data if possible
nn	Damage Data	Damaging plant material crop	duration	numeric	day	technological-economic manuals, expert interviews	nn
nn	Damage Data	Damaging plant material crop	week	numeric	week number	technological-economic manuals, expert interviews	nn
nn	Damage Data	Damaging plant material crop	height	numeric	cm	technological-economic manuals, expert interviews	nn
nn	Damage Data	Damaging plant material crop	speed	numeric	{0,1,2} qualitative treshold	technological-economic manuals, expert interviews	nn
nn	Damage Data	Damaging plant material crop	damaging	numeric	ratio	technological-economic manuals, expert interviews	nn
	Monetizing Data	Input	input	text		Technological-economic manuals	KTBL
	Monetizing Data	Input	price	numeric	€	nn	KTBL
	Monetizing Data	Labour	financial internal	numeric	€/hour	assumption = 0	assumption = 0 / check KTBL
	Monetizing Data	Labour	financial prestation	numeric	€/hour	assumption = 12	assumption = 12 / check KTBL
	Monetizing Data	Labour	financial solidarity	numeric	€/hour	assumption = 0	assumption = 0 / check KTBL
	Monetizing Data	Labour	economic internal	numeric	€/hour	assumption = 12	assumption = 12 / check KTBL
	Monetizing Data	Labour	economic external	numeric	€/hour	assumption = 12	assumption = 12 / check KTBL
nn	Monetizing Data	Cost plant material	cost	numeric	€/ha	Technological-economic manuals and expert inteviews	nn
	Monetizing Data	Discount tool	age	numeric	year	report CA30 expertise	use french data if possible
	Monetizing Data	Discount tool	discount	numeric	ratio	report CA30 expertise	use french data if possible
L	Monetizing Data	Tool	tool	text	{list of tool}	Interview with farmers	Maschinering (IAMO) / KTBL
	Monetizing Data	Tool	vulnerability	text		report CA30 expertise	
L	Monetizing Data	Tool	price	numeric	€/tool	Bareme d'entraide / BCMA	Maschinering (IAMO) / KTBL
	Monetizing Data	Tool	cost h internal	numeric	€/ha	Bareme d'entraide / BCMA / assumption cost internal = 0,5 cost external	same assumption as in France =0,5
L	Monetizing Data	Tool	cost h external	numeric	€/ha	Bareme d'entraide / BCMA	Maschinering (IAMO) / KTBL

(red)	to be collected
(green)	collected
F	to be collected by interview with farmers only
L	to be filled using literature
E	to be discussed with experts
nn	non necessary

3.3.3 *Data at farm level*

Besides the questionnaires, we used excel files to collect data with farm managers. Data concerning farm have been collected using 13 Excel sheets:

- *Farm-Spatial* corresponds to the list of plots (size, type of crops, area impacted in 2002), buildings (size, area impacted in 2002) and animals (number, location);
- *Labour* establishes the amount of internal and external workforce on farm required to achieve crop management sequences;
- *Machinery* gives the list and quantity of the pieces of machinery;
- *Stock* gives the list of inputs and their location;
- *Flood parameters* corresponds to the description in terms of height, period of occurrence and duration of flood events that have impacted the farm;
- *Crop damage* gives for each crop the area impacted and yet harvested for 2002 flood;
- *Soil damage* gives the list of recovery tasks that have been carried out after 2002 flood to restore soils;
- *Building damage* gives the list of recovery tasks that have been carried out after 2002 flood to restore buildings;
- *Animal damage* gives the list of fatalities endured by the farm after 2002 flood;
- *Input damage* gives damage on the stock of inputs;
- *Stock damage* gives damage on other stocks;
- *Machinery damage* gives damage on machinery;
- *Compensations* gives the list of compensations the farm has benefited after 2002 flood.

3.3.4 Methodological differences for data collection at farm level for the two case studies

Two different methods were used in the Rhône River downstream and in the Mulde River area. On the Rhône River downstream, typical farms have been constructed based on data from regional statistics and technical expertise. That means, data at farm level do not correspond to a real farm but to a standard farm. Table 8 gives a summary of the characteristics of these typical farms.

On the Mulde River, data has been collected directly at farm level during the interviews with farm managers. This choice was made for two reasons:

- From a research point of view, it was interesting to test if data collection of farm data was possible directly during the interviews.
- From a practical point of view, we could not identify the relevant database to construct typical farms and we found less expert studies on agriculture in the floodplain on the Mulde River area than on the Rhône River downstream area.

Table 8. Description of the typical farms on the Rhône River downstream

Farm type	UAA (ha)	AWU/ha	Crops	ha per crops	Product (k€)
A	8	0,25	Apple	8	155
V	22	0,01	Vine	22	123
MC	15	0,06	Melon/Salad	3	161
			Wheat	12	

4 Results

4.1 Data collection and formatting

4.1.1 Framework to collect data

Since most of the interviews had to be carried out in German, it was essential that the colleagues from UFZ know exactly which data and in which format the data needed to be collected. Efforts have been done to produce a framework to collect data and to make it as much transferable as possible.

4.1.2 Some learning from this experience

We present here some learnings from our experience about the transfer of a modelling approach and the data collection in two culturally different regions:

- A clear presentation of data is needed (name, explanation, units). This is the framework we presented earlier.
- The way the data is used in the model needs to be clearly explained so that the importance of the data to be collected is really understood. This point was made even more essential since the colleagues from UFZ had to carry out the interviews in German.
- Language presents a difficulty that should not be neglected to achieve the interviews and data collection. To overcome this, some time for discussions and exchange is needed to be sure that the data we are talking about are really the one needed.
- To identify existing data bases, a good way to proceed is to identify people specialized in the field. In our case, the challenge was data related to agriculture because the UFZ expertise does not focus on this field. It was really useful to speak with researchers at IAMO to better understand available data bases. Sufficient time need to be allotted for these discussions because there is also a need to discuss about the model to really ensure we are talking about the same concepts and data.

4.2 Qualitative analysis of interviews with representatives from administration

The representatives from administration were asked about:

- an overview of agriculture in Saxony and specifically in the Mulde area,
- flood management policies and the place of agriculture,
- flood impacts on agriculture mainly after 2002 flood.

4.2.1 Agriculture in Saxony

4.2.1.1 <u>Farm size</u>

As it was expected from statistics, experts suggested that farm size is in average very big.

- Big farms have 1.000 - 2.000 ha in average,
- Small professional farm would have 100 ha,
- An average cattle would be 100 cows for milking production.

4.2.1.2 <u>Purchase and storage of farm inputs</u>

Most of the farms buy inputs from private enterprises which store them. The consequence in terms of flood damage is that damage on inputs should be affected to the buildings of those companies rather than to farm buildings.

4.2.1.3 <u>Crop rotations</u>

- Rotation should alternate wheat, raps, corn and barley.
- The rape needs to be sowed before the end of August. This implies that the plots need to be prepared by this time.
- Winter crops have better yield and quality than summer crops but are more risky due to the winter kill and loss of yield due to pre-summer droughts.

4.2.2 Flood management and agriculture

4.2.2.1 <u>Agriculture in the flood plain</u>

- Areas in between the dikes and the river are usually used by farmers for arable crops or grassland, with the farmers bearing their own risk.
- Currently, there is more grassland than arable land in between dikes and the river.
- There is no difference in terms of crop management sequences between the flood plain and other areas.
- Organic farming can also be located in these areas.

4.2.2.2 <u>Conversion of arable land in the floodplain</u>

There is a will to incite farmers to convert arable land into grassland in the floodplain. From an ecological point of view, the opinion prevails to have only grassland in these areas. However, farmers do not agree and prefer to keep arable land even if, in that case, they bear themselves all the damage on crop (no insurance, no compensation). Farmers' representatives argue that the decision criteria which motivate farmers not to convert arable land into grassland is the economic one, above the risk aversion one. Farmers do not want to convert arable land into grassland because is not economically profitable to have more cattle. The economic market leads to the impossibility to increase the offer in cattle and as a consequence to the refusal of farmers to convert arable land into grassland in flood plain.

It could be interesting to test if the optimization criteria is still true considering flood damage.

4.2.2.3 <u>Land use regulation in the floodplain</u>

Contrarily to France, converting grassland into arable land in the flood plain is restricted by law.

4.2.2.4 <u>Controlled flooding and dike lowering</u>

There are two ways to give more room for water in flood management policies:

1. the so-called non controlled flooding policies, which consists in a complete removing or lowering of dikes;
2. the so-called controlled flooding or polder, which consists in the construction of new dikes to create a retention area.

After the 2002 flood, both of these options have been considered. Some cases of dike lowering have been discussed between farmers' association and water managers. LTV2003a is a guideline established at the federal level, to define the strategy for the flood protection concepts in Saxony after 2002 flood. According to this guideline, the indicative protection level for agricultural areas is only Hq5 (i.e. a 5-year flood event). In a footnote, it is further specified, that "For agricultural areas there is no or only minor entitlement for protection. Generally, a cultivation adapted to the situation has to be conducted." Generally, farmers' association have tried to limit the dike lowering but some compromises have been done.

Farmers' associations are generally in favour of the controlled flooding option which provides compensations to farmers in case of flood damage within the polder area.

4.2.2.5 Actual implementation of these policies

Finally, these policies were little implemented on the Mulde River. Currently, most of the dikes have been reconstructed. Depending on the land use, they have been reconstructed even higher than before as for example to protect cities. However, there are examples where the main dikes have been relocated and agricultural areas are only protected now by small dikes (e.g. the village of Erlln)

The contribution of agriculture to flood management has also been oriented towards upstream retention by the use of soil conservation practices (tillage). These measures can also be compensated by the means of Common Agriculture Policy which makes them much more attractive.

4.2.3 Flood impacts on agriculture

From the interviews with representatives from administration, we already collected some information on flood damage on agriculture.

4.2.3.1 Classification of flood damage by order of importance

From the point of view of experts from administration, main damages for the farmers have consisted in removing litter, mud and deposit from soil. Most of crop damages were compensated. Animals were, most of the time, evacuated. Damage on machinery was limited since few buildings were impacted and most of the machinery was evacuated. Some problems occurred also with oil tanks.

4.2.3.2 Variability of the loss of harvest

In 2002, due to heavy rain during summer, the harvest date had a huge variability depending on very local conditions. Theoretically, wheat should have been harvested everywhere but that was not the case. The variability induced in damage is huge (0 or 100%).

4.2.3.3 Flooding induces not always such negative impacts

Some experts related their experience of a plot of wheat flooded and frozen during more than a week in winter and on which, the wheat has not been destroyed but rather this event increased the yield.

4.2.3.4 Soil damage

Assuming expert knowledge, this type of damage is more dependent on the current than the height of water. In 2002, the flood reached generally high levels but it has induced less litter deposit since the current was higher. However, this remark is really local dependant because the deposit from flood has certainly occurred somewhere upstream or downstream.

4.2.3.5 Recovery and solidarity

Most important aspects concerning solidarity processes that have fostered recovery are the following ones:

- Districts have offered free recycling of garbage for farms.
- Most of solidarity was self organized in between the farmers. But, farmers' association contributed to networking for specific problems. For instance, difficulties to find straw and fodder have been encountered by farmers.
- Some low cost workforce from unemployment agency could be employed thanks to a specific system existing in Germany (Arbeitsbeschaffungsmaßnahme, ABM) and helped the recovery of farms.

4.2.4 Vulnerability to other risks related to water

During the interviews, farm vulnerability to other risks related to water has been mentioned. Main ideas are in this section briefly presented.

4.2.4.1 Consequences of pre-summer droughts

These phenomena mostly occurs during the stem elongation for which wheat requires water and nutrients. The pre-summer drought not only influences water uptake but also the one of nutrients. Even if the rest of the season is rainy, this loss of yield can never be recovered.

4.2.4.2 Irrigation

Some infrastructure to irrigate existed and was well developed in GDR times but now, few of these infrastructures have been maintained and are currently used mainly because of maintenance costs and questions of governance. However, it has been mentioned that it might become valuable again in the light of climate change.

4.2.4.3 Influence of energy policy on vulnerability

Due to the shift in energy policy, there is an increasing demand in crops used for bio-energy i.e. corn silage and rape. The increase of corn silage may have potential impacts on vulnerability to summer floods because the corn is harvested much later (September, October) than wheat. Concerning winter flood, in case of corn, there is no crop on the plot in winter. The increase in corn production may also lead to problem of water scarcity. Even more if considering that corn may need to be irrigated due to the increase of pre-summer drought.

4.3 Qualitative analysis of interviews with farm managers

4.3.1 General description of farms

4.3.1.1 Farm size

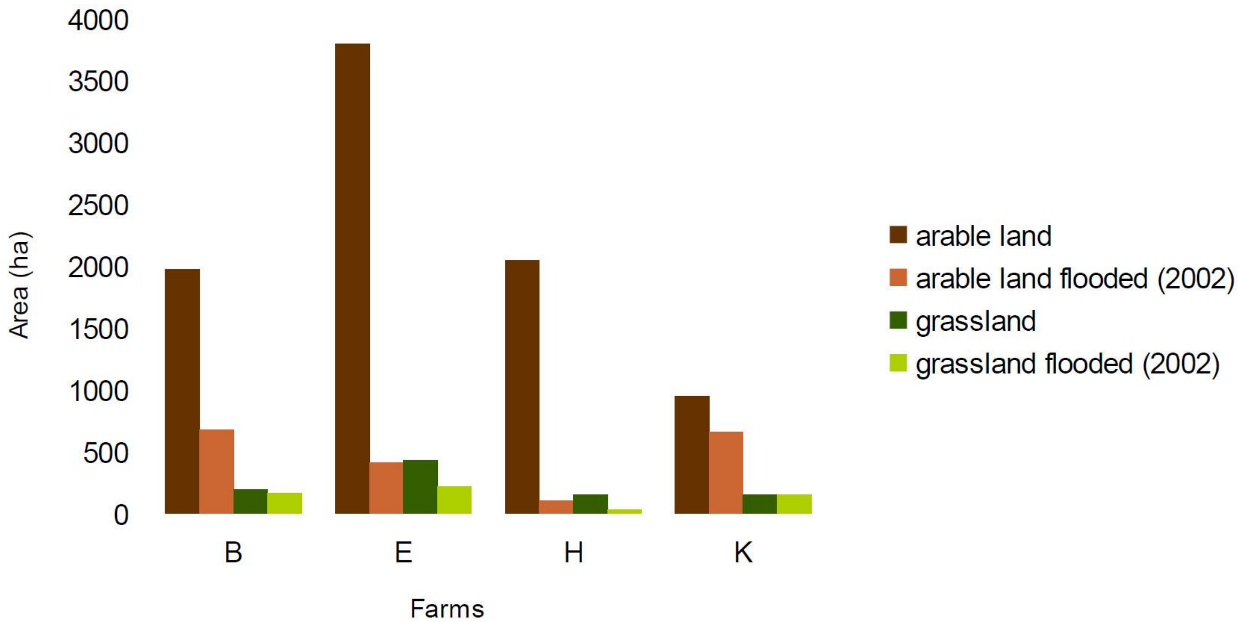
Table 9 gives the size of the farms where interviews have been carried out. Note that all are cooperatives and belong to several stakeholders. The smallest farm is 1 100 ha and the biggest 4 230 ha.

On Figure 13, the proportions of arable land (AL) and grassland (GL) flooded for each farm are given. Most of the time the grassland has been flooded by more than 80 % in 2002. For arable land, even if the areas flooded are huge (2 000 ha in average), this generally represents less than 30 % of the total arable land except for farm K which arable land was flooded by 70 % and grassland by 100 %.

Table 9. Farm area in hectares and exposure to ood

Farms	Total	Arable Land (AL)	AL flooded (2002)	Grassland (GL)	GL flooded (2002)
B	2 170	1 975	677	195	165
E	4 230	3 800	411	430	220
H	2 200	2 050	102	150	30
K	1 100	950	660	150	150
average	2 425	2194	462	231	141
ecart type	1 307	1 182	269	134	80

Figure 13: Farm areas and exposure to flood



4.3.1.2 Husbandry activity

Table 10 shows the number and type of animals for each farm. As expected from interviews with representatives from the administration, the size of cattle is high. All farms have cow cattle for milk production.

4.3.1.3 Shareholders and workforce

All farms have stakeholders (between 41 and 62). Concerning workforce, the number of employees vary between 29 and 70. As showed in Table 11, the ratio, in terms of employee per ha, varies between 0.01 and 0.03 Annual Working Units (AWU).

Table 10. Number and type of animals

Farms	cows	sheeps	bulls	calfs	pigs
B	200	850	0	0	0
E	450	1 200	100	200	0
H	430	0	150	460	690
K	120	0	80	0	2 000
average	300	512	82	220	672.5
ecart type	165	609	62	231	943

Table 11. Stakeholders and workforce on farm

Farms	Stakeholders	Employees	AWU/ha
B	41	29	0.01
E	-	49	0.01
H	62	70	0.03
K	60	11	0.01

4.3.2 Crop damage

4.3.2.1 Harvest period and consequences on damage

We distinguished, in the interviews with farm managers, the plots that have been flooded and the real crop damage suffered. Table 12 summarizes all crop types that have been cited during the interviews, if the plot where this crop was localized has been flooded in 2002, if the crop has been impacted by the flood which depends on the harvest time.

In fact, some plots have been flooded without suffering any damage if the crop were already harvested when the flood occurred (12th August). This is the case for

- winter barley,
- winter rape,
- winter rye.

Table 12. Crop damage

Crops	Plot flooded	Yet harvested in August 2002	Remarks
grain maize	no	no	
grassland	yes	one cut done on some farms	
hops	yes	no	erosion problem
lupins	no	no	heavy rain
peas	yes	partly harvested	
silage maize	yes	no	
sugar beets	yes	no	
summer wheat	no	no	heavy rain
triticale	yes	no / partly harvested	
winter barley	yes	fully harvested	
winter rape	yes	fully harvested	
winter rye	yes	fully harvested	
winter wheat	yes	no / partly harvested	

Some crops were about or were in the process to be harvested. This means that a huge variability in crop loss can exist depending on local conditions of the plot. This was the case for:

- peas,
- triticale,
- winter wheat.

Some crops have been fully destroyed if exposed to flood. This is the case for:

- silage maize,
- sugar beets.

4.3.2.2 Flood and heavy rain damage

The interviews we carried out were focused on flood damage. However, the flood which happened in August 2002 at the Mulde River was associated to heavy rains which happened in July and August 2002. For some interviews, it was not easy to really differentiate crop damage related to flood or heavy rain. The main difference between flood and heavy rain comes from soil damage. Heavy rains do not induce deposits but can erode soils. This is, in particular, the case for plots planted with hops.

In 2002, heavy rainfalls had also consequences on the wheat harvest. In fact, many fields where not yet harvested due to these rainfalls as it would usually be the case by the 13th of August.

4.3.3 Damage to buildings and contents

The total area of the farm buildings has been collected for two farms. These were about 20 ha and the buildings are usually located on different sites on the farm. Among the four farms interviewed, only one had its buildings severely impacted by the 2002 flood due to a breach in a dyke nearby (Table 13).

Few damage to building contents (machinery and inputs) have been noted during the interviews.

Table 13. Flood damage on farms' buildings

Farm	Building area	Building flooded in 2002
B	-	none
E	22	5 warehouses for machinery, 4 for fodder and wheat and the office seat
H	20	none
K	-	1 shed

4.3.4 *Animal fatalities and evacuation*

None of the farms interviewed endured animal fatalities in 2002 but some animals had to be evacuated (Table 14).

Table 14. Animals evacuated due to 2002 ood

Farm	Evacuation
B	30 cows
E	200 calfs
H	-
K	120 milk cows, 80 calfs and 2000 pigs

4.3.5 *Soil damage*

Five types of damage to soil resulted from the interviews:

1. deposit of sands, gravels and woods,
2. deposit of litter,
3. erosion,
4. compaction,
5. contamination.

The problem of soil contamination due to flooding has been raised in some interviews. One farm manager said that the levels of heavy metals on grassland (arsenic) and arable land (cadmium) have increased after 2002 flood. Generally, when an important concentration of cadmium in wheat is detected, it cannot be sold for human consumption. However, this phenomenon cannot be clearly linked with the flood since wheat is quite frequently declared unfit for human consumption due to this reason (every 3 years in average).

Two types of actions were carried out to recover after flooding: the tasks properly related to soil recovery and the tasks necessary to clean plots from destroyed but remaining crops.

• The first category mainly aims at removing deposits from the river flow. Removing sands, gravels and woods have been identified, in the interviews, as the most time demanding tasks that have to be carried out after flooding. Usually, deposit removal has begun just after the flooding (August 2002). The priority has been given to plots that had to be seeded with wheat for the next campaign. However, in some instance, those soil recovery tasks have lasted until September 2003.

Table 15. Recovery tasks for soil damage

Soil recovery task	Specific machinery needed
filling holes and levelling soils after erosion	-
removal damaging compaction by subsoiling	subsoiler
removing of discharge i.e. sands, gravels, woods	caterpillar, telescopic loader
removing of litter, plastics	tractor
Cultivation tasks	**Specific machinery needed**
cutting damaged wheat	-
drilling cereals	-
drilling peas	-
drilling sugar beets	-
incorporation cereals (wheat/barley)	-
incorporation peas	-
incorporation sugar beets	-
mulching	-
ploughing	-
reseeding grassland partly	-

- The second category of recovery tasks has to be done mainly because crops could not be harvested and plots must be cleaned to prepare the next crop. They are closed to some production tasks achieved on the farm and usually do not require specific machinery.

4.3.6 Achievement of farm recovery and solidarity processes

Most of the farms recovered by using their own internal resources, except if some specific machinery was necessary (Table 16). Only the farm that has been the most severely exposed to the 2002 flood needed to hire service providers for recovery tasks. The recovery has lasted until more than one year for some farms. Two farms benefited from low cost (ABM) or voluntary workforce. Farm managers did not mention having received help from other farms of the region except for forage for cattle which was organized by the regional farmers' association.

Table 16. Solidarity processes at farm level

Farm	Help received	Help offered
B	Recovery mainly carried out with own resources Hired service providers for specific tasks Workforce from unemployment agency (ABM)	Mainly focussed on their own recovery Solidarity has been mainly supported by farmers' association
E	Recovery only carried out with their own resources Took up to a year	Evacuation of the citizens with their tractors
H	Recovery mainly carried out with their own resources Voluntary workforce organized by the town	Help offered to farms where buildings had been impacted
K	Recovery partly carried out with their own resources Mainly carried out by hired service providers	-

4.3.7 Consequences on crop management sequences for the next years

In the case of sugar beets, direct damage on plot exposed was a loss of 100 %. Then, sugar beets needed to be drilled and incorporated in the soil. One farm manager explained that they tried to seed wheat on these plots (around November) but the wheat yield, the next year (2003) was less than 50 % of the average yield.

Some plots were planned to be seeded with rape for the next year. This was not possible for all the plots that have been flooded since rape seeding has to take place between the 15th and the end of August. At this time, plots were not yet removed from discharge and litter.

4.3.8 Compensations after 2002 flood

Most of the farm's managers have established a paper file to describe precisely damage endured due to flooding and tasks that have been carried out. The compensations have been provided by the Free State of Saxony and it was an ad hoc system. Two farms out of four have benefited from these compensations.

We tried to collect this information with institutions. However, representatives of administration we interviewed did not participate in compensation process or could not give us information about a potential data base.

4.3.9 Insurance

We collected few information about insurance. Note that only one farm has contracted an insurance for the loss of yield after 2002. None of the other farms have this kind of insurance. One of the reasons which could explain this is the financial criteria. All farms are insured for the buildings except one.

5 Conclusion and further research

Two research questions were to be addressed in the MuldEVA project:

1. Knowing that the EVA model is highly data demanding, which are the conditions and difficulties to transfer EVA model to a case study in Saxony?
2. Can different patterns of vulnerability to flooding be identified between the farms on the Rhône River downstream and on the Mulde River?

In the next two sections, we proposed some conclusions about these research questions and perspectives for continuing this research.

5.1 Conditions and difficulties to transfer EVA model to a case study in Saxony

Concerning data collection, one of the results of the collaboration is already the production of a framework which precisely describes every data needed and the way it can be collected on a case study.

Two different methods were used in the Rhône River downstream and in the Mulde River area to collect data at farm level. On the Rhône River downstream, EVA model has been applied on typical farms whereas on the Mulde River, it has been applied on real farms. From a research point of view, it was interesting to test that data collection was possible on field with real farms. The next step of the collaboration could be to define typical farms in the Mulde River and vice-versa to apply EVA method on real farms in the Rhone River downstream.

5.2 Comparison of farm vulnerability patterns of the Rhône and Mulde case studies

The Table 17 proposes a comparison of the flood risk and farm vulnerability patterns on the two case studies.

As said earlier, with the definition of risk we adopted, three components have to be analysed: hazard, exposure and vulnerability.

As a reminder, hazard refers to the flood probability and characteristics and exposure refers to the value of assets in the hazard-prone area. Vulnerability can be distinguished into susceptibility (or sensitivity) and coping capacity as suggested by Gallopin (2006a). Susceptibility / sensitivity refers to the potential of elements at risk to suffer harm or loss while coping capacity describes their potential to cope with these losses and to recover afterwards. All these risk components can be altered by mitigation/adaptation measures (i.e. explicit risk management measures).

Concerning the analysis of the risk, it is clear that two different patterns exist on the two case studies. This is mainly due to a different distribution of flood period of occurrence and a different pattern of farm exposure which lead to a different damage distribution. This point could be deepen by simulating damage on typical farms for given flood scenarios and compare them on the Mulde and Rhône cases studies.

Concerning farm vulnerability patterns, given the fact that we did not find specific data on farm component (crop, buildings, machinery...) sensitivity, we assumed the same sensitivity for the two case studies. This assumption may need to be confirmed but is acceptable since we did not identified, during the interviews, specificities on the Mulde CS which would let us think that damage functions need to be adapted. However, the interviews revealed different patterns for coping capacities: different institutions in charge of solidarity organization, different needs of external resources, different compensation systems, different impacts on farm cash flow. These aspects require further field research to be analysed.

Table 17. Comparison of risk and vulnerability patterns on the two case studies (CS)

Risk component	Rhône downstream	Mulde	Comparison
Hazard			
Flood type	Plain flood	Plain flood	No major difference
Period of occurrence	Autumn, Winter	Summer, Winter / spring floods (less extreme)	Different distribution
Dike ruptures	Yes in 2002 and 2003	Yes in 2002	No major difference
Flood management orientations	Flood plain restoration but severe difficulties for acceptability	Flood plain restoration but severe difficulties for acceptability	No major difference
Last extreme flood	December 2003	August 2002	Both relatively old
Farm exposure			

Plot localization	50% of area exposed (simulation)	Less than 30% of arable land exposed and grassland priorly flooded (interviews)	higher exposure of arable land in the Rhône CS
Building localization	70% of the farm exposed have their buildings in the floodplain (literature)	1 building impacted by 2002 flood due to a dyke failure (interviews)	Higher exposure in the Rhône CS
Crop distribution in the floodplain	Crops with relatively high value (literature)	Crops with relatively low value (interviews)	Higher exposure in the Rhône CS, due to higher crop values
Susceptibility / Sensitivity			
Crop sensitivity	Damage functions	No specific data	Considered similar
Building sensitivity	Damage functions	No specific data	Considered similar
Machinery sensitivity	Damage functions	No specific data	Considered similar
Measures to decrease sensitivity	Elevation of buildings and pieces of machinery	None	More frequent in the Rhône River case study
Coping capacity			
Internal resources			
Workforce (AWU/ha)	0,01 to 0,25 AWU / ha	0,01 to 0,03 AWU / ha	similar in AWU per ha
Workforce (AWU/farm)	1 to 2 employees per farm	30 to 70 employees per farm	More reactivity of farms in the Mulde CS if plot exposure is low
Cash flow	Cash flow difficulties (high % of exposure, huge loss of added value)	No critical cash flow difficulties (revenue from cops not impacted)	Higher impacts on cash flow in the Rhône CS
External resources			
Type of external workforce	Mainly solidarity and civil force	Solidarity and workforce from unemployment agencies	Different types
Need of external workforce	Frequent	Not frequent	Higher need in the Rhône CS

Measures to enhance coping capacity	Workforce from solidarity organised by the Chambers of Agriculture	Workforce from solidarity organized by town	Different institutions in charge of workforce organization
		Low cost workforce from unemployment agencies	Higher workforce capacity in Mulde CS
		Free garbage containers organized by town	Higher capacity in Mulde CS
Damage compensation procedure	National funding procedure (FNGCA)	Ad hoc system of compensation at federal scale	No durability of the ad hoc system in Mulde CS
Level of compensation	30% of yield loss and soil damage	Compensations quite high in 2002 for some farms	Higher compensations in Mulde CS / Less sustainability of the system
Crop insurance	Few insurance for loss of yield	Few insurance for loss of yield	Similar
Building insurance	Buildings always insured	Buildings not always insured for flood risk	Higher insurance coverage in the Rhône CS
Flood damage			
Main damage categories for last extreme floods	1. Damage to buildings and contents 2. Damage to soil 3. Damage to vegetal material	1. Damage to crop 2. Damage to soil	Different damage distribution

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