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M.SC. THESIS

RISK ANALYSIS AND RISK FINANCING OPPORTUNITIES FOR LARGE GLASSHOUSES IN THE NETHERLANDS

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Summary

The research was triggered by changes in the greenhouse sector regarding the average size of the greenhouses. This paper is summary of the impact of the changes on the risk profile and related risk financing methods provided by the insurance companies.

The main research objective was to perform risk analysis to investigate risk financing opportunities for large greenhouses in the Netherlands.

First, the study focused on the analysis of the greenhouse sector. The sector is created by approximately 8,600 greenhouses which own 10,500 hectares under glass. Although the number of hectares is increasing slowly (due to lack of land), the number of greenhouses is decreasing rapidly. It is expected that it will reach 4200 greenhouses in 2015. The related average size will get doubled (from current 1.25 to 2.5 hectares). Additionally, some of the greenhouses will rise to very large size (above 20 hectares). Furthermore, greenhouses are expected to remain concentrated in one place (Westland).

To investigate current insurance practices the study analyzed few cases of insurance contracts. Cases were compared in order to give insight into replacement values of greenhouses as well as related premiums. The main conclusion from the analysis is the complexity of the insurance contracts with many perils, categories of coverage and different types of greenhouses and equipments. In general premiums for the greenhouse range from 1 up to 2.5‰ and for crop even up to 4‰. The value of property is calculated based on replacement value and for crop based on the average yearly turnover.

The main part of the research was performed from risk perspective. The main perils were chosen for analysis (wind, hail, biohazard and flooding). A Monte Carlo simulation model was built for each peril and the loss functions were estimated. The functions were combined to provide a general picture of the risk exposures for greenhouses. Additionally future scenarios were developed to investigate the influence of increasing size of the greenhouses on risk profile. It was concluded that in current market conditions the expected annual losses are almost 7.3 million EUR. Windstorm losses are responsible for vast majority of that amount (above 6 million EUR). Other perils despite large individual damage have small scale of occurrence which makes them much less significant. Flooding, despite the large possible value of losses, has very small probability of occurrence what keeps the expected annual losses low. Additionally, future scenarios showed that the expected changes in the greenhouse sector will have a significant impact on the risk exposure. The results of the aggregated model showed that the increase of the annual losses up to 10 million EUR can be expected. Moreover, the magnitude of damage per extreme events (1/10, 20, 100 years) is expected to increase.

The results from insurance contracts and risk analysis were combined in risk financing part. The main conclusion derived from the investigating risk financing method is that the individual risk of greenhouses is to large for small insurers to handle. The value at risk might reach 100 million of EUR which is very large value in comparison with the values paid by greenhouses in premiums. Insurance company needs many insurance policies to be able to effectively pool the risk.

Such high individual risk is an opportunity for introduction of alternative insurance product like coinsurance. However the research indicated that complexity of the greenhouse insurance contracts is an obstacle for introduction of such product.

Contents

1. **Research description**

1.1 Introduction

The Dutch glasshouses sector is subject to long term systematic changes. Whereas in general the farm area in the Netherlands is shrinking (due to changes in land destination, mainly for housing) the area of greenhouses shows rather an increasing trend. Its total area size reached almost 10500 hectares in 2005 - an increase of 20% in the last 20 years (CBS, 2006).

In contrast to the area size, the number of greenhouses is permanently decreasing. This applies to the whole horticultural sector – vegetable, flower and pot plant farms. Farmers deciding to stop their businesses, most often sell their greenhouses or land to others, who want to expand their farms. In this way the average greenhouse size is increasing sharply in all sectors. It reached 1.2 hectares in 2005 and is expected to grow to 2.5 hectares within 10 years (Berkhout and Bruchem 2006).

The advantage of such an increase is achieving lower costs per unit, mostly labor costs (Berkhout and Bruchem 2006). Greenhouses are forced to seek for ways to decrease costs because of intensification in international competition (mostly from Mediterranean countries with their warmer and brighter climate) (Lansink and Bezlepkin, 2005) and a sharp growth of production factors' prices (like gas and energy).

Moreover, small farm size has been a main barrier for improving technology adoption, productivity and efficiency. It has also been a major cause of inefficiency in the marketing chain since it requires many layers of intermediaries between producer and retailer (Dimyati, 2005).

As a consequence, the number of large greenhouses is growing when compared to the number of small ones. Some of them are achieving sizes exceeding the normal glasshouse size to a great extent. The so-called "mega farm" term is used for glasshouses bigger then 3.5 hectares (Berkhout and Bruchem 2006). However, there is an increasing number of glasshouses achieving a size over 20 hectares (ING, 2007).

The fact of these new types of very large horticulture holdings is both a problem and an opportunity for associated companies, such as insurance firms. The values of property, investment expenditures or energy costs can be enormous. That is why large glasshouses require new types of risk management solutions. However, with respect to the insurance products, the current portfolio does not seem to follow the changes in the market and often it does not seem to be suitable for the large glasshouses. From the point of view of an insurance company, due to the large value of the assets and potential risk, the expected losses can easily exceed the value of premiums. Thus, it is important to analyze the risks of large glasshouses to be able to adjust the current insurance offer.

1.2 Research objective

The main problem that triggered the research was the increasing size of the greenhouses and the related changes in risk profile. That is why it is interesting to investigate how these changes will influence the level of exposure and what answer can be proposed by insurers.

The main research objective is then *to* *<u>investigate the opportunities for improvement of an insurance offer for large glasshouses</u>*. This main objective was divided into two consistent sub-objectives:

- To analyze risks involved in the greenhouse agriculture by investigating the characteristics of the glasshouses and perils.
- To analyze opportunities for risk financing including coinsurance product by comparing discovered risks and current insurance offer.

Although most parts of the study relate to the Netherlands as a whole, some parts are made with an assistance of the ING Risk & Consultancy employees and correspond to the situation of the company in the greenhouse sector.

1.3 Research questions

Research objectives were divided into more specific questions:

(1) Market analysis of the greenhouse sector
What are the characteristics of horticulture glasshouses farms and the glasshouse industry?
- What is the overview of the market in terms of size, number and location of farms?
- What are the characteristics of ING Bank clients (potential insurance receivers) comparing to the whole market (ING portfolio analysis)?

(2) Current insurance offer
What are the common practices for insuring greenhouses?
- What is the current offer of ING?

(3) Risk analysis and risk modeling
What are the risks for the glasshouses?
- What are the potential threats provided by literature and empirical research?
- What is the frequency of losses for each threat?
- What is the severity of losses for each threat?

(4) Risk Financing
How the risk can be financed?
- What are major conclusions from the risk analysis?
- Is there an opportunity for coinsurance?

1.4 Materials and methods

Research assumed using different sources of materials for all four chapters of the project.

(1) Market analysis of the greenhouse sector
The information about glasshouses is widely accessible. A description is made based on the data from CBS, LEI databases and academic journals. Furthermore the ING market share is described.

(2) Current insurance offer

To discover common practices for greenhouses' insurance specific cases of insurance contracts are analysed. The main output of this part includes way of valuing property, range of insurance premiums and deductibles standards.

(2) Risk analysis and risk modelling

The research strategy assumed identifying the main risk perils and analyzing the probability and severity of losses per each peril separately. Four main perils are analyzed – that are windstorm, hail, flooding and biohazard risk. Due to lack of historical damage the input data to the risk model is based on scientific literature and insurance companies' reports. The model makes use of the catastrophic models methodology. It estimates separately frequency of occurrence of certain type of damage and the values of damage per each occurrence. Because of different input data provided by literature the specification of the model differs between perils. The general description of the way of estimation is presented at the beginning of chapter 4 and details are described by each peril separately. After partial estimations the conclusions will be summed into a consistent picture of the relevant risks.

(4) Risk Financing

Conclusions are made base on results of the previous analysis. The comparison between the current practices applied in insurance contracts and the results of the risk analysis is used to formulate general conclusions about risk financing opportunities for large greenhouses.

2. Overview of the Dutch horticulture sector

2.1 A global overview of protected horticulture

Horticulture is a form of an agriculture production characterized by intensive usage of labor and capital in relation to used land. This is especially visible in the case of the protected cultivation of vegetables and ornamentals (cut flowers and pot plants). Its recent development is the result of both technological improvement and the growth in the demand for more expensive, exotic products in every season, which is a consequence of the increasing prosperity of a growing number of people. Cultivation in greenhouses (protected cultivation) may be considered the most advanced form of crop production. In fact, it is often described as the “greenhouse industry” which emphasizes the role of technology and different the character of the production then in other agriculture sectors.

Greenhouse horticulture offers the possibility of year round production, higher yields by better control of pathologies and climate and higher water use efficiency then in any other agriculture form of production. However, in spite of the high resource use efficiency, production in greenhouses is very intensive, with a significant environmental impact.

Protected cultivation ranges from row covers (small tunnels) to unheated and heated greenhouses and is mainly concentrated in the temperate latitudes. In 1999 the world’s total protected cultivation area (small and large plastic tunnels and glasshouses) was estimated to be 16 million ha with about 700 000 ha occupied by greenhouses and large plastic tunnels and 900 000 ha occupied by low tunnels (Buurma, 2001).

The geographic distribution of protected cultivation shows different patterns for cultivation under plastic or under glass. Asia has the largest concentration of plastic greenhouses in the world. The second largest concentration of plastic greenhouses is located in the Mediterranean Basin, which includes several South European countries (e.g. Spain, France, Italy, Portugal, and Greece) and countries from North Africa (e.g. Morocco, Egypt) and the Middle East (Israel, Turkey). On the American continent, plastic greenhouses are mainly found in Latin American countries and in Southern parts of USA.

World wide, the total area of glasshouses has been estimated at 40 000 ha. The largest area is located in Europe, in particular in the Netherlands (10 500 ha) but also other countries like Italy, Spain or France posses considerable areas. On the American continent, glasshouses are limited mainly to USA and Canada. The area of glasshouses in Asia is small, but countries like Japan and South Korea possess a considerable area and in countries like China the glasshouses area is increasing (Buurma, 2001)

Traditionally the Netherlands has had a dominant position in the international trade of cut flowers. More then 50% of world export is traded in the Netherlands. However its rank is being currently challenged by a growing number of producers in several countries in Africa and South America. Europe is the main destination of products from Kenya, Zimbabwe, Costa Rica, Spain and Israel which results in increase competition for Dutch producers (Wijnands and Hack 2000).

Moreover, the Netherlands together with Spain have a leading position in the export of vegetables to the European market. Both countries used to have a different growing season and were supplementing each other in providing fresh products all year. However, recent knowledge and technology diffusion as well as opening of the European market give new opportunities for large producers like Turkey, Morocco and Egypt and change the role of Spain (Wijnands, 2001). Competition from these countries results in deterioration of the strong competitive position of the Netherlands and can have serious impact on the future of Dutch vegetable industry. Nevertheless, not only negative – Dutch suppliers are strongly involved in the development of the greenhouse sector in Spain which provides benefits for both sides (Velden et al. 2004).

2.2 General overview of the Dutch agricultural sector

Over 60% of the total Dutch area is defined as "rural", i.e. area with fewer then 100 addresses per km^2 and with less then 10% built-up areas. Approximately only 13% of the population lives in these areas. Additionally Dutch agriculture area is shrinking as a result of development and urbanization. This is taking place at an expense of grassland which has decreased 100,000 hectares over the last 10 years. The other forms of agricultural activities like arable farming and horticulture are increasing their land usage (table 2.1). Additionally Dutch parliament passed in early 2006 new Spatial Policy Document which expands the possibilities for residential and small scale industrial functions in the rural areas. Due to new regulations and a large number of farms ceasing their operations more non-agriculture activities will continue to appear. Forecasts indicate that it can result in significant changes in Dutch landscape (Berkhout and Bruchem 2006).

Table 2.1 Land use in the Netherlands

	1995/97	2003/04	2003/04	1996-2004
Type of land use	**(1,000 hectares)**		**(in %)**	**Change (%)**
Grassland	1,336	1,226	36.3	-8.2
Arable farming and horticulture	934	959	28.4	2.7
Greenhouse horticulture	13	15	0.5	19.0
Woodland	306	316	9.4	3.0
Other areas of nature	160	182	5.4	13.5
Built-up areas	528	575	17.0	9.0
Roads and railways	100	102	3.0	1.7
Total land area	**3,378**	**3,376**	**100.0**	**-0.1**
Based on satellite data.				

Source: Berkhout and Bruchem (2006)

In 2005 the number of farms in the Netherlands decreased by 2.5%. The average decrease in the last 10 years was 3% yearly. The decline is particularly visible in intensive livestock production (over 5%), greenhouse horticulture (almost 5%) and dairy farms (4%). In general since 1990 the number of holdings decreased by over 30%. The small farms are ceasing their operations the most. The number of large farms is more or less stable (table 2.2). However a small proportion of the businesses continues to grow to a size that clearly exceeds the normal family farm. The number of these so-called "mega farms" tripled between 1994 and 2004 but still amounts to just 1.5% of the total. A lower limit of 500 DSU (Dutch economic size) is used as the reference point, equating to approximately 320 dairy cows, 12,500 pigs, 160,000 laying hens, 340 hectares of arable land or 3.5 hectares of horticultural greenhouses. The share of the mega farms in the total production capacity amounted to almost 17% in 2004 (5%

in 1994), but their share in the total area remained limited to 3.5%. This difference is brought about by the fact that most mega farms can be found in greenhouse horticulture. The mega farms are typically more than ten times bigger than the average Dutch agricultural or horticultural holding. The most important advantage of increases in scale lies in the lower labor costs per product unit (Berkhout and Bruchem 2006).

Table 2.2 Economic size of holdings

Agricultural and horticultural holdings Economic size in Dutch size units (DSU)					
	Number of holdings, total	**3 to 20 dsus**	**20 to 70 dsus**	**70 to 150 dsus**	**150 dsus and more**
Period	*absolute*				
1980	144 994	46 487	71 668	23 277	3 562
1985	135 900	41 300	62 483	27 612	4 505
1990	124 903	40 022	56 525	23 439	4 917
1995	113 202	32 592	36 873	33 320	10 417
2000	97 483	27 706	29 405	28 644	11 728
2001	92 783	26 770	27 030	27 184	11 799
2002	89 580	25 696	25 910	26 222	11 752
2003	85 501	25 026	25 052	24 445	10 978
2004	83 885	24 705	24 133	24 017	11 030
2005	81 830	24 358	24 076	22 836	10 560
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The total agriculture complex can be divided into two main parts. The first one includes processing, delivery and distribution of domestic agriculture raw materials, whereas second contains delivery and distribution of imported agriculture raw materials (e.g. tobacco). In 2004, the total economic activities relating to the agriculture were responsible for 9.3% of total national added value and for 10% of national employment. Both values are gradually declining. The production and processing of domestic raw materials were responsible for more then half of it - 5% of value added and 6% of employment. The detailed division of this percentage by production type is presented in table 2.3

Table 2.3 Dutch agro-complex by production type (%)

	Gross value added		**Employment**	
	2001	**2004**	**2001**	**2004**
Arable farming	22.0	19.5	20.5	18.1
Greenhouse horticulture	20.1	22.0	16.0	17.5
Open field horticulture	7.8	8.4	8.7	9.9
Grassland based livestock production	27.6	28.3	31.3	32.9
Intensive livestock production	22.5	21.9	23.5	21.6
Total	**100.0**	**100.0**	**100.0**	**100.0**

Note: Agro-complex based on domestic raw materials
Source: Berkhout and Bruchem (2006)

Arable farming and intensive cattle breeding show a declining trend of theirs shares in Dutch agro-complex. On the contrary, the greenhouse horticulture's relative share is increasing. Its percentage in national value added increased over the last years to 22% of the total value of agro-complex and is larger then arable farming.

The Dutch agriculture complex strongly depends on export. Between 1995 and 2003, export was responsible for three quarters of both the value added and employment in the part based on domestic raw materials (Anonymous, 2004). In terms of export surplus, Netherlands comes second on the list of the international traders only behind US. The surplus in 2003 reached €20 billion. The greatest contribution to that value is made by ornamental crop products (cut flowers and pot-plants) which accounted for €5.9 billion, followed by meat (€2.5 billion) and dairy products (€1.9 billion). The Netherlands is also the major importer of meat and dairy products.

The destination of Dutch agriculture export is mainly EU. In 2003 almost 75% of export was sold on that market. The main receiver's place is traditionally occupied by Germany (€6.5 billion) although its role is decreasing. Its position is followed by UK, France, Belgium and Luxemburg. Additionally Germany, Belgium, Luxemburg and France are the main exporters of agriculture products to the Netherlands.

Worth mentioning is the recent trend of the growing number of farmers who decide to emigrate to or establish a holding abroad. Most of them are dairy farmers (Leeuwen and Tabeau, 2005).

2.3 Dutch horticulture sector

The production value of glasshouse horticulture complex (production, processing and distribution) increased by 6% in 2005 compared to 2004 and accounted for almost €5 billion. Together with mushroom farming greenhouse horticulture had 22% share of added value and a share of 17.5% in employment of all agricultural sector based on domestic raw materials (table 2.3).

There are three main groups of horticulture products – vegetables, cut flowers and pot plants. In 2005 cut flowers accounted for 2,220 million EUR of production value, pot plants 1,530 million EUR and vegetables 1,200 million EUR. All values increased comparing to year before (table 2.4).

Table 2.4 Production value (million EUR) in Dutch greenhouse horticulture 1990 – 2005

	1990	1995	2000	2004	2005	Change (%)
Greenhouse vegetables	1 173	1 067	1 259	1 100	1 200	9
Cut flowers	1 480	1 614	2 086	2 137	2 220	4
Pot plants	769	865	1 149	1 421	1 530	8
Total greenhouse horticulture	**3 422**	**3 546**	**4 494**	**4 658**	**4 950**	**6**
Mushrooms	182	245	316	265	235	-11

Source: Berkhout and Bruchem (2006)

Tomato, pepper and cucumber are the most important vegetables grown in the Netherlands. The country is the third net exporter of these vegetables in the world, after Mexico and Spain, more of the 70% of the production is sold abroad. Main receiver of vegetables is Germany. With regard to ornamentals products Netherlands is the largest auction of them and plays an important role in world trade. The auction is also the means for selling the majority of domestic production. Approximately 90% of domestic ornamentals find clients in this way. From that only 10% goes to internal trade and the rest is exported (Berkhout and Bruchem, 2006).

Total value of export of greenhouse products reached €17 billion in 2005. That means an increase of 5% comparing to 2004 (Anonymous, 2006).

The area of glasshouses has grown from 7,370 ha in 1971 to 10,540 ha in 2005. It is expected that it will continue to grow to 11,500ha in 2015 (Berkhout and Bruchem 2006). The growth is mainly a result of an expansion of ornamental plant cultivation. In fact, the area of vegetables shrank from 5,275ha to 4 430ha. Within the vegetable sector, the largest groups are tomatoes with 1,380ha (compared to 3,000ha in 1971), peppers with 1,240 (less then 50 ha in 1971) and cucumber with 630ha (865ha in 1971). The area of cut flowers has multiplied in the given period from 715 to 3,430 hectares. Rose is still the most important flower with a share of 25% of cut-flower area. However rose sector is under strong competition from countries from Africa and has been recently decreasing. Similar situation can be observed in case of chrysanthemum, the second cut-flower. Last year its area decreased by 12%. The area of pot plants increased from 215 ha in 1971 to 1,925 ha in 2005. The remaining area of greenhouses is occupied mainly by fruits and flower balls – together they are grown on 755 ha (Berkhout and Bruchem, 2006).

Table 2.5 provides the summary of the information on area of glasshouses from CBS (Statistics Netherlands).

Table 2.5 Area of horticulture holdings under glass 1980 -2005

	Area of greenhouses, total (excl. fruits)	Vegetables	Ornamentals	Fruits
Period	*hectares*			
1980	8 760	.	4 041	56
1985	8 973	.	4 370	39
1990	9 769	4 453	5 283	32
1995	10 154	4 405	5 715	34
2000	10 491	4 200	6 291	30
2001	10 492	4 271	6 221	32
2002	10 500	4 287	6 213	38
2003	10 468	4 320	6 148	71
2004	10 446	4 359	6 087	40
2005	10 494	4 445	6 049	46
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The number of farms continues to decrease from 18,980 in1971 to 8,600 in 2005. According to LEI, the largest decrease was seen in vegetables companies - from 5,500 to 1,960 in the given period. There were 2,765 cut flowers and 1,360 pot plants farms. Number of pot plants companies was stable during last 35 years. In general the number of greenhouses is expected to fall approximately 3.7% yearly and reach 4 200 farms in 2015 (Berkhout and Bruchem, 2006).

The result of the decline in the number of farms is the strong increase in the companies' size. The average size in seventies was less then 0.5 hectare for ornamentals and almost 1 hectare for vegetables. In 2005 these values were 1.3 for cut flowers, 1.4 for pot plants and 2.3 for vegetables. It is expected that this trend will remain in the following years and greenhouses average size will reach 2.5 hectares in 2015 (Berkhout and Bruchem, 2006).

The summary of the changes in number and area of glasshouses is presented in figure 2.2.

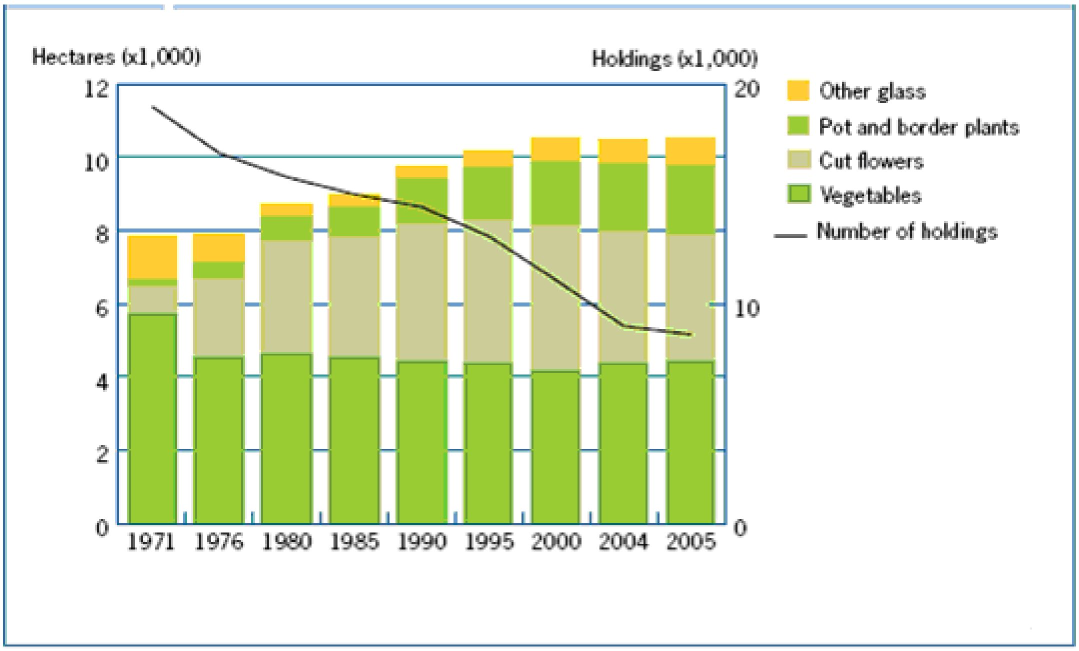

Figure 2.2.Area and number of horticulture holdings under glass 1971-2005
Source: Berkhout and Bruchem (2006)

Table 2.6 shows the changes in number of holdings segregated by the size of the greenhouse. The number of small holdings (smaller then 1 hectare) is decreasing constantly during given period in contradiction to the large ones. The number of holdings above 2.5 hectares grows rapidly and has been doubled in the last 10 years. The number of greenhouses larger then 5 hectares reached 289 in 2005.

Table 2.6 Number of horticulture holdings by size

	Horticulture holdings under glass, total						
	total	0,01 to 0,25 ha	0,25 to 0,50 ha	0,5 to 1,0 ha	1 to 2,5 ha	2,5 to 5 ha	5 ha and more
Period	*absolute*						
1980	15 772	5 833	2 837	4 571	2 295	218	18
1985	14 986	5 473	2 392	4 299	2 552	231	39
1990	14 413	4 945	2 111	4 005	2 951	341	60
1995	13 044	4 109	1 862	3 383	3 183	422	85
2000	11 070	3 188	1 537	2 595	2 905	695	150
2001	10 345	2 955	1 361	2 332	2 784	735	178
2002	9 876	2 854	1 211	2 158	2 674	766	213
2003	9 456	2 699	1 166	2 010	2 565	772	244
2004	8 989	2 557	1 122	1 853	2 402	797	258
2005	8 600	2 442	1 033	1 754	2 261	821	289
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Table 2.7 provides information about number of large holdings divided by type of production. The majority of the greenhouses bigger then 5 hectares are vegetable holdings. It can be result of both - more capital needed to expand ornamental business and more labor intensive production of vegetables. Since main advantage of large size is lower cost per labor unit, vegetable holdings have more incentives to expand and more benefits of economy of scale.

Table 2.7 Horticulture holdings with more then 2.5 hectares

Period: 2005			
		> 5ha	2.5 - 5ha
Greenhouse vegetables. Total	*absolute*	**166**	**352**
tomatoes		77	103
cucumbers		19	61
peppers		42	128
other		22	59
Cut flowers, total		**46**	**259**
roses		12	74
chrysanthemum		17	72
freesias		-	11
orchidaceous		-	12
lilies		4	17
gerberas		3	21
other		7	37
Pot plants, total		**40**	**101**
pot plants for flowering		20	56
booklet plants		16	44
other ornamentals		27	72
Greenhouses, total		**289**	**821**
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Main concentration of glasshouses in the Netherlands is in South Holland province, especially in Westland (table 2.8). Almost half of the farmers locate their business there. The next popular provinces are North Holland and North-Brabant (around 10% of holdings for each province). It is worth mentioning that the relative concentration of large glasshouses is similar to the whole industry. One exception is the fact that it is even more concentrated in Westland.

Table 2.8 Number of greenhouse holdings by size and location

		Horticulture holdings under glass						
		Total	0,01 to 0,25 ha	0,25 to 0,50 ha	0,5 to 1 ha	1 to 2,5 ha	2,5 to 5 ha	5 ha en more
Region	Period	*absolute*						
Nederland	2005	8 600	2 442	1 033	1 754	2 261	821	289
Groningen (Prv)		80	28	13	18	16	4	1
Friesland (Prv)		72	31	12	11	6	7	5
Drenthe (Prv)		147	50	17	12	34	25	9
Overijssel (Prv)		149	70	30	19	15	11	4
Flevoland (Prv)		106	14	4	20	44	16	8
Gelderland (Prv)		902	311	155	217	156	49	14
Utrecht (Prv)		145	61	20	27	22	11	4
Noord-Holland (Prv)		1 130	449	175	189	226	70	21
Zuid-Holland (Prv)		3 931	852	363	835	1 270	452	159
Zeeland (Prv)		123	48	22	20	23	6	4
Noord-Brabant (Prv)		1 160	374	150	225	277	92	42
Limburg (Prv)		655	154	72	161	172	78	18
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According to the Ministry of Agriculture, due to the fact that greenhouse horticulture has good prospects for future, government intends to give to the sector a necessary space for growth. One of the strengths of the sector is its close collaboration between farmers and partners in the chain. Collaboration has a spatial aspect – the greenhouses are concentrated in few main “greenports”. The current governmental policy is to sustain the concentration of greenhouses since it can help facilitate new partnerships and innovation. The Spatial Policy Document designates ten agriculture development areas for greenhouse horticulture. The sector will get an opportunity to develop in these areas (Anonymous, 2006)

Despite these plans and many opportunities for farmers to relocate their operations Westland will remain the largest concentration for glasshouses. For cut flowers and particularly pot plants growers the close proximity of the auctions and trade is an important motive for staying there. However they may start additional branches outside Westland. In general the vegetable glasshouses are the most likely to move outside (Reijnders at all. 2005).

Dutch horticulture is one of the most intensive farming systems in the world achieving high level of output, using the newest technologies (Goncharova et al. 2001). In fact, one of the reasons of success of that industry was a sharp increase in production per m^2, resulting in decreasing costs per output unit, despite rising prices of labor and land. However recent market conditions puts producers in a new situation, where declining selling prices exceeds the decline in cost, leading to a decrease in profit for many farms (Trip et al. 1996). Worth mentioning is the fact that in contrast to the other sectors, the incomes from outside the farm in greenhouse horticulture play a less important role even in small holdings.

In general, the sharp increase in energy prices in 2005 was a reason for a decline of the profit. It affected all three horticulture sectors, despite the increase in yield. The decrease was the strongest in vegetable farms. On average its profitability fell from 91% to 88%. For cut flowers and pot plants the profitability was at the same level as in 2004 – 91% and 95% respectively. Taking into account the increase in the prices of oil, the market conditions will be even worse in the following years (Bont and Knijff, 2005).

On average, 30% of families working in greenhouses had a negative income in 2005. On the other hand, around 10% of them had income above €100.000 (Berkhout and Bruchem 2006). If the profitable companies invest the income in further improvements the gap between small and large greenhouses will get bigger. The small glasshouses, which do not bring profit, have to decide about their future – either investments which could result in crossing the break-even point or ceasing the operations.

In last years, horticulture holdings have invested mostly in lighting equipment, mobile cultivation systems and robots.

Parallel to the increase in the average company size the changes also occur in greenhouses ownership. There is a strong increase in companies with legal personality. This form of activity has certain tax advantages and helps gaining funds for necessary investments. In 2005 on average almost 20% of firms had legal personality (cut flowers 18%, pot plants 26% and vegetable 15%). What is more, there is a relation between farm size and an ownership. Among greenhouses larger then 5ha, more then half have legal personality. In the group between 3 to 5ha it is 37%, between 1 and 3ha - 21% and at smaller then 1ha it is only 10% (Berkhout and Bruchem 2006).

Because of increasing competition and rising production factors' prices the greenhouse holdings are under strong pressure to expand their businesses and achieve high level of efficiency. However, in this industry the investments needed for growth can be enormous. It is one of the reasons for ceasing the operations of small farms. Table 2.9 shows the replacement cost for different type of glasshouses

Table 2.9 Replacement cost (EUR) for 6 types of glasshouses (2 hectares)

1	Groente, buisverwarming, steenwol, recirculatie	1 437 800
2	Groente, heteluchtverwarming	1 036 300
3	Bloemen, buisverwarming, steenwol, recirculatie, incl. belichting	1 783 600
4	Bloemen, buisverwarming, steenwol, recirculatie, geen belichting	1 306 000
5	Potplants, roltafels, eb/vloed, recirculatie	2 073 600
6	Potplants, betonvloer, eb/vloed, recirculatie	1 738 800

Source: Woerden 2003

2.4 Future of the horticulture sector

The future of the horticulture industry depends on the interaction of many factors, such as the dynamics of demography, economic growth, advances in science and technology (Dimyati, 2005). Thus it is not easy to define the future of the whole complex, dynamic system.

Before dealing with a particular segment it is important to know what can be expected from the sector as a whole in the following ten to fifteen years. Over that period the total agriculture complex is projected to grow approximately by 14% (comparing to the 58% of the Dutch economy). The employment level will decrease by over 12% mostly due to increase in labor productivity (table 2.10). The number of holdings is estimated to fall on average 3% each year which means a fall of 30% till 2015 (Anonymous, 2005)

Table 2.10 Added value and employment in agriculture complex in 2003 and 2015

	Gross value added		Employment	
	2001	2015	2001	2015
	(1000 million €)	(2003=100)	(1000)	(2003=100)
Agriculture complex total	23.7	114	369.9	87
Arable farming	4.7	109	75.7	85
Greenhouse horticulture	2.3	121	41.8	97
Open field horticulture	4.8	122	66.8	95
Grassland based livestock production	6.7	106	133.3	84
Intensive livestock production	5.2	114	79.3	87

Source: Ministry of Agriculture, 2005

Projections assume that all segments will have share in the growth of agriculture complex. In most of them this growth will come mostly from processing industries. The exception is horticulture where development will be thanks to primary sector.

Exports will stay crucial – in 2015 almost 75% of Dutch agriculture production will go abroad. Moreover internationalization will remain an important trend and many entrepreneurs are expected to invest abroad (Anonymous, 2005).

Prospects regarding fruits and vegetables are promising. The sector produces high quality products with advanced techniques and a small amount of crop protection products. Together with sophisticated logistics and close markets it gives the sector a competitive edge in international environment. The position can be improved through more distinctive products, economy of scale and better organization of marketing.

The biggest change in the sector is the increasing role of the large retailers. The three main chains in the Netherland have already a 70% market share. It is expected that the consolidation trend will lead to ten supermarkets chains dominating the whole European market for vegetables and fruits in 2010. These supermarkets have certain requirements towards their suppliers which include a complete range of products, certified quality and advanced logistics. The Dutch horticulture has a remarkable competitive advantage in that field.

A further increase in scale is expected. The area of vegetable glasshouses will not change much, but the number of farms is expected to fall by half over the next ten years. Some of the projections assume that in future there will be only 10 – 15 large vegetable providers that thanks to collaboration and purchasing products from abroad will be able to provide all range of fresh fruits and vegetables all year (Anonymous, 2005).

Worth mentioning is also the large number of technological innovations being developed. Innovations regarding cultivation, products, greenhouse construction, climate control and energy efficiency ensure the leading position of Dutch horticulture.

Prospects regarding ornamental cultivation are similar. The most important trends in near future are innovation in labor saving methods, greater cost control and increase in scale. The suitable spatial planning policy is required for the future expansion of the sector. The Netherlands is the centre of the world trade in cut flowers and is therefore the leader in this sector. It is expected that the organization of the market will follow a similar path as vegetables towards large ‘flowers providers’ which will do business all over the world and provides all range of cut flowers. In this case the auctions become less important. However it is likely that providers will be mostly from Dutch origin which can strengthen the country’s international competitiveness despite the decreasing meaning of auctions. The enlargement trend can also affect the pot plants sector due to the fact that providers would have to be able to supply total package consisting of pot plants and cut flowers together (Anonymous, 2005)

Interview with Cees and Leo van der Lans, large tomatoes growers

Cees and Leo van der Lans grow and package tomatoes. Their company has about 43 hectares under glass at three locations in Maasland, Gravenzande and Rilland. According to their opinion in ten or fifteen years there will be just twenty tomato growers dominating the market. They are certain about the future of the vegetable industry – growth is essential. Producers have to achieve certain scale to be a valuable partner for the customers. They expect scaling up to continue. Already the major twenty tomato producers have a total of 1000 hectares and another 80 the remaining 200 hectares.

The company established also production in Spain, to be able to achieve the customer’s requirements (they are a supplier of Tesco) and produce tomatoes all year also in winter. However, nowadays thanks to artificial lighting it is possible to produce year-round in the Netherlands too. In general, according to Cees van der Lans the technological solutions provides the Dutch horticulture a position not threatened by any other country. His company is not using chemicals, the food safety standards are on the highest possible levels and they are close to the markets. What is more, their new closed-cycle greenhouse consumes 30% less energy and represents a step forward in the greenhouse technology.

Source: Ministry of Agriculture, Nature and Food Quality 2005

2.5 The ING market share

When analyzing the market share of ING in the field of horticulture it is important to make a distinction between the clients of the ING bank and clients of the ING Insurance and Risk Consultancy. The first group consists of the farmers who are looking for the opportunity to finance their investments and establish contacts with the bank to get funds. The farmers who own an insurance provided by ING are in the second group. To provide a full picture of the market share and its perspectives in the insurance market it is crucial to describe both sets of clients. The ING Insurance and Risk Consultancy does not organize any other form of marketing or distribution of their products then through clients of the bank. Thus the market share in loans is both the potential market and the limitation for their insurance offer.

Although the ING bank has a strong position in the Netherlands, it is generally not considered as a major player in agriculture. In fact, the agriculture sector is traditionally dominated by Rabobank. The market share of ING in agriculture is estimated to be 5.9% in 2005. That means 8,300 clients in primary and secondary sector. The main competitors are Rabobank with 79% and ABN-Amro with 15% of market share. The current ING plans assume to achieve 7% by the end of 2007.

In the horticultural sector the market share of ING is approximately 6-7% based on the total value of loans and around 4% based on the number of farms. The difference is a result of the scope on the large agriculture clients. The main competitors are Rabobank 80%, ABN Amro 12% and Fortis 3% - based on value of loans. In total ING has around 350 horticulture clients. The majority grows vegetables (185) which are tomatoes (50), peppers (50), cucumber (35) and other (50). The others grow ornamentals (165), which are roses (15), Chrysanthemum (25), pot plants (30) and other (95).

Most of the ING clients are larger then 1.5 hectares. Around 10 – 15 farms are bigger then 10 hectares.

The ING insurance had 296 clients in the end of 2005 in the whole agro sector who purchased 1622 insurance policies. The total number of bank relations for the same period account for 5330 which gives only 5.55% of the exploiting of the possibility of cross selling.

3. Analysis of the current insurance offer

The goal of this chapter is to introduce common practices used in insurance contracts in the greenhouse sector. Classification of perils and exposures were analyzed in order to provide a framework for further risk analysis. Additionally, cases of insurance contracts are presented give insight to the insured values and premiums.

On Dutch market there are three main insurers which provide policies for greenhouses. That are Interpolis, Avero achmea and Delta Lloyd. First two are part of one financial group connected with Rabobank. According to their agreement Interpolis is providing policies to clients of Rabobank only (80% of the horticulture market), whereas Avero achmea deals with the rest of the greenhouses. That is why widely accessible for all glasshouses (especially for clients of ING) are only policies of two insurers.

Thus, 4 cases of Delta Lloyd contracts were chosen for analysis.

Delta Lloyd divides its contracts into two main groups. First one is ‘greenhouse’ which provides coverage for greenhouse and property in the greenhouse. The values of the property are calculated based on replacement value. The second group is ‘crop’ which covers losses of turnover due to random events. The insured values are based on the maximum business interruption and the average company’s turnover from last three years.

Greenhouse

Standard contracts of Delta Lloyd describe greenhouse perils by alphabetical letters:

CAR – construction all risk
A – Fire, thunder, explosion, implosion, and damage from plain accidents
B – A and storm, hail and snow pressure damage
C – B and escape of steam, liquids, precipitation damage
D – “Droogstoken of ketelinstallatie” only with combination with C
E – Other damage from external perils and failure of equipment
F – Vandalism, damaged and stolen property
G – Induction damage as a result of thunder
F – Damage from hail to garden centre from 1 April to 31 October

Class C is most common and is considered as standard coverage.

4 greenhouses were analyzed. The summary of the companies is presented in table 3.1

Table 3.1 Summary of the four horticulture holdings

	Case 1		Case 2	Case 3	Case 4			
Location	Waddinxveen		Bergschenhoek	Waddinxveen	Hensbroek			
Type	Venlo	Venlo	breedkap	Venlo	breedkap	breedkap	breedkap	bree. mit canteen
Size: (m2)	4,019	5,760	37,581	17,224	16,000			
Crop	Gerbera		Orchid	Roses	Flowers and Tulips			

All of the available examples are unfortunately cut flowers what narrows down the scope of the presented values. Summing up the first company has about 1 hectare of Gerberas, second almost 4 hectares of Orchid, third 1.7 hectares of roses and the next 1.6 hectares of different flowers and tulips (in four greenhouses).

These four companies purchased insurance policies from Delta Lloyd. The policies value all the property of the greenhouse and calculate premiums based on premiums ratios. Premium ratios differ due to differences in greenhouses construction specifications, covered perils, location and size. In general Delta Lloyd specifies separate calculations for greenhouse itself, building and all installation inside greenhouse. The overview of insured values of greenhouses and buildings and premiums is presented in table 3.2

Table 3.2 Greenhouses and buildings insurance for 4 cases

		Case 1		Case 2	Case 3	Case 4				
Glass house	Type	Venlo	Venlo	breedkap	Venlo	breedkap	breedkap	breedkap	bree. mit canteen	Sum
	Size: (m2)	4,019	5,760	37,581	17,224	16,000				16,000
	Construction:	NEN 3859	aluminum	NEN 3859	NEN 3859	NEN 3859				
	Value: (EUR)	190,500	234,800	4,298,300	895,200	194,200	176,900	204,600	883,800	1,459,500
	Value per ha (EUR)*	473,999	407,639	1,143,743	519,740	-	-	-	-	912,188
	C: (‰)	1.17	2.7	-	1.4	-	-	-	-	
	E: (‰)	0.13	0.23	-	-	-	-	-	-	
	F: (‰)	0.09	0.09	-	-	-	-	-	-	
	G: (‰)	0.04	0.04	-	-	-	-	-	-	
	Premium ratio paid(‰):	(C+E) 1.3	2.93	(C+G) 1.52	(C) 1.4	(C,E,G) 1.89	(C,E,G) 1.44	(C,E,G) 1.44	(C,E,G) 1.44	1.50
	Basis premium paid(EUR)	247.65	687.96	6,533.42	1.253	367.03	254.73	294.62	1,272.67	2,189.05
Building	Value: (EUR)	144,900		1,115,000	258,000	15,300	86,300	29,800	138,000	269,400
	C: (‰)	1.13		1.06	1.25					
	F: (‰)	0.13		0.09						
	G: (‰)	0.13		0.14						
	Premium ratio paid(‰):	(C+F) 1.26		1.06	1.25	(C+G) 1.26	(C+G) 1.26	(C+G) 1.26	(C+G) 1.26	1.26
	Basis premium paid(EUR)	182.57		1181.9	322.75	19.27	108.73	37.54	173.88	339.42

Values from insurance contracts
* - own calculations

The first conclusion from the table is that the insured value of a greenhouses ranges from approximately 400 thousands to 1.15 million EUR per hectare. The source of difference is complexity of the building. This one is a consequence of the year of construction. The younger the glasshouse, more complex it is and higher replacement value it has. The cheapest one is not only the oldest but also its construction is based on cheaper aluminum (and more fragile).

Premiums can not be compared straight forward due to differenced in desired coverage. Only contract for the first company was available with additional information about premiums per different coverage. The rest provides only the final premium paid. Although the premiums differ between companies, it can be seen that their range is between 1.17 to 1.50 ‰ for the basic coverage (C). The one exception for the second greenhouse in case 1 is due to more fragile construction of this warehouse. The basic premium rate is 2.7 ‰ in that case.

The insured buildings are much different in terms of size or usage for each company, that is why cannot be compared straight forward. Instead general summary can be done about premium ratios. In case of buildings they are slightly lower then in case of greenhouses. It supports the conclusion that greenhouses are more exposed to external damage then buildings. Premiums ratios range from 1 to 1.25 ‰.

The analysis of the installations and equipment are separated from the previous property. Companies differ greatly in terms of installations they have. All of them have heating and watering systems but complexity of these systems vary. Additionally only in case 2 companies has cooling system, heating centre and complex internal transport system. That is why only general overview of the values is presented (table 3.3). More detailed comparison of the installations and related premiums is in appendix.

Table 3.3 Installation and equipment insurance summary

		case 1	case 2	case 3	case 4
Istallation & equipment	Value: (EUR)	743,500	9,916,400	1,424,600	949,300
	Value per ha (EUR)*	760,303	2,638,674	827,102	593,313
	Premium ratio paid(‰):	2.39	1.71	1.78	2.49
	Basis premium paid(EUR)	1,780	16,954	2,532	2,359

Values from insurance contracts
* - own calculations

The differences between premiums ratios are higher then in previous cases. However it is due to variations in chosen coverage between companies. Company 4 chose for many perils insured whereas company 2 stayed only with basic one (C).

In general it can be concluded that company 2 is significantly different. Its insured value is few times higher then other ones.

All of the above insurance contracts included basic own risk. Basic own risk includes deductibles of 1% of damage with minimum 675 EUR and maximum 1,000 EUR in case of hail wind or snow damage. For damage from perils A there are no deductibles. For all other perils deductibles are 225 EUR

Crop

The second group of policies is insurance contracts for crop. Delta Lloyd has a clear policy for valuing crop in the glasshouses. The common practice is to draw average turnover from last 3 years. This value is adjusted by maximum business interruption period to calculate the value at risk. Maximum business interruption is the time needed to restore production after total loss to greenhouse (that means building a new greenhouse).

Perils are described by alphabetical letters:

A – Fire, thunder, explosion, implosion, and damage from plain accidents
B – A and storm, hail and snow pressure damage
C – Water pollution
D – Brake down of heating
E – Yield insurance
F – Damage from wrong substrate (bottom)
H – Transport damage
I – Wrong plant materials
J – Wrong production factors delivered

For the analyzed cases the crop insurance summary is presented in table 3.4.

Table 3.4 Crop insurance summary

		case 1		case 2	case 3	case 4	
Crops	Type	Gerberas	Gerberas	Orchid	Roses	flowers	Tulips
	area (m2 except Tulips)	4,100	5,700	37,000	17,224	16,000	6,000,000 (flowers)
	max Business Interruption (years)	1.5	1.5	1.5	1.0	1.0	1.0
	value (EUR)	247,500	345,000	15,000,000	1,400,000	500,000	780,000 (0.13 per stuck)
	value per hectare*	603,659	605,263	4,054,054	812,819	312,500	-
	value per hectare per year*	402,439	403,509	2,702,703	812,819	312,500	-
	Premium ratio paid(‰):	(B+C+D) 2.57	(B+C+D) 3.31	(B) 1.17	(B+C+D) 3.80	(B+C+D) 3.29	(B+C+D) 3.29
	Basis premium paid(EUR)	636.07	1,141.95	17,550.00	5,320.00	1,645.00	2,566.20

Values from insurance contracts
* - own calculations

Value of the cut flowers ranges from 300,000 to 2,700,000 EUR per year, per hectare. This value depends on the type of the flower but also on the type of production. Since it is based on turnover more effective ways of productions (with higher yields) will result in higher insurance value of the crop. This can be seen in case 2 where modern greenhouse has significantly higher value of flowers. The case 4 contains different way of calculating the proper value. It is based on number of produced flowers and their average price.

Business interruption ranges from 1 to 1.5 years. This factor is used in calculating the insurance value.

Premium ratios range from 1.17 ‰ for perils B to 3.80 for perils B, C and D. These premiums are positively correlated with the premiums for the glasshouse. It is expected that crop will suffer more damage in more fragile greenhouse.

All of the above crop insurance contracts included basic deductibles. Basic deductibles cover 5% of damage with minimum 675 EUR and maximum 2,250 EUR

4. Risk analysis of glasshouses

4.1. Introduction - Definition of concepts

European Spatial Planning Observation Network in their study on hazards in Europe used the definition of risk which will be used in this paper:
"Risk is a combination of the probability (or frequency) of occurrence of a natural hazard and the extent of the consequences of the impacts.
*Risk = Hazard potential * Vulnerability*" (Schmidt-Thomé, 2006)
In this meaning risk is understood as expected losses from random events.

All forms of economic activities are subject to two main types of risk:

- Pure risk, which involve a potential loss only and are generally viewed as incidental (like fire loss)
- Speculative risk, which involve both a potential loss and gain, arising from uncertainty about future consequences of company decisions (like price risk or investment risk) (Gahin, 1967).

The framework of risk types is presented in figure 4.1

The subject of this paper is limited to the management of pure risk.

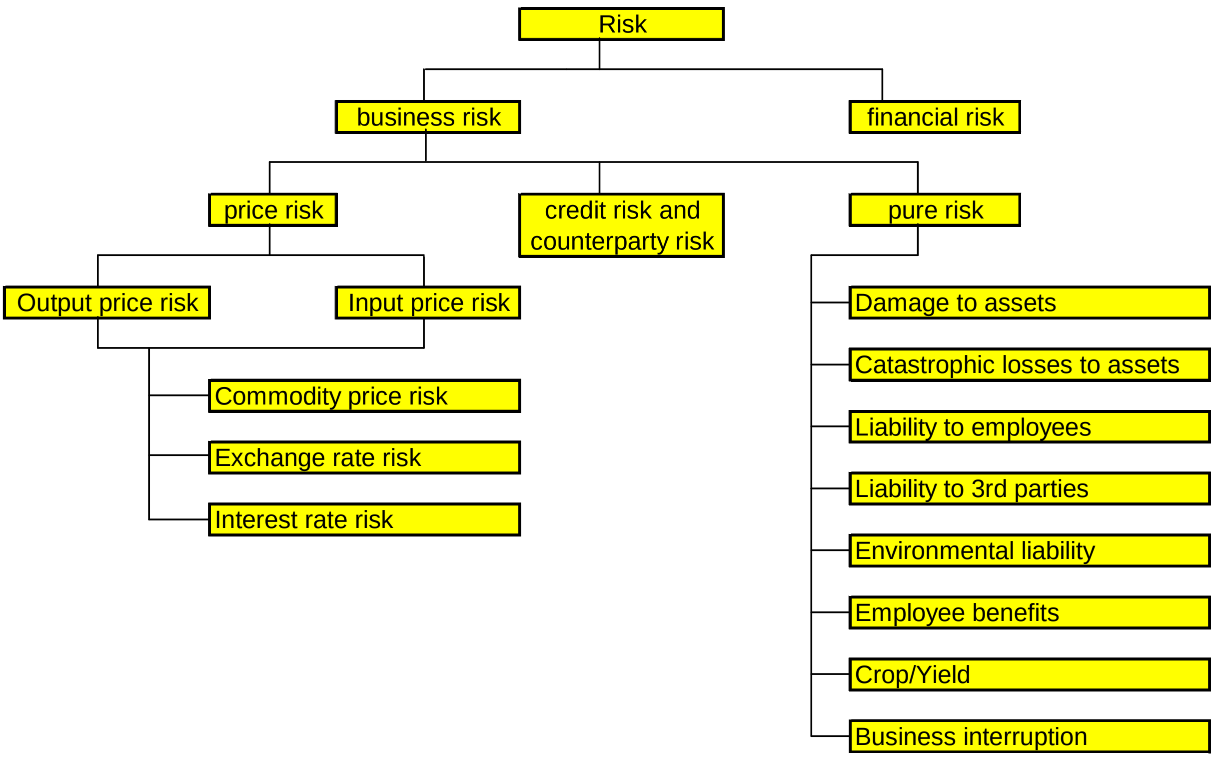


Figure 4.1 Framework of risk types
Source: Harrington and Niehaus, 1999

Management of the pure risk is a major concern to the modern companies due to number of reasons. First of all some of the risk involve catastrophic losses to assets which are the threat to the continuity of the firm. Moreover protecting the firm's property and personnel requires expenditures of considerable funds increased economically by their opportunity cost. That is why there is a need in any form of economic activity to asses the threat of the incidental losses in order to design a proper planning and an optimal protection.

Taking into consideration the desired outcome of the research the main groups of exposures were selected. Figure 4.2 presents the general classification of pure risk for glasshouses

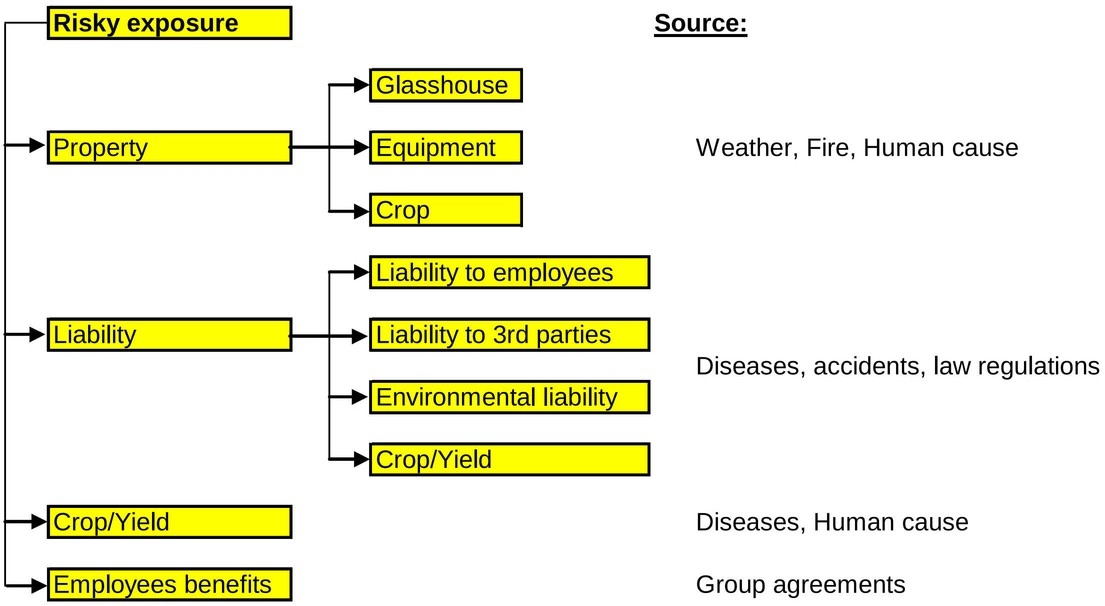


Figure 4.2.Pure risk exposures for glasshouses
Source: Own classification based on interview with ING employees

Pure risk can be divided into few main groups. First one is property damage. It is usually the most frequent insured exposure. It is further divided into categories

- glasshouse which means damage to the building itself (ranging from damage to single glass to total glasshouse loss)
- equipment which is quite broad; it covers damage to everything (except crop) inside the glasshouse (that is water installations, heating installation, robots, computers etc.)
- crop which means damage to the crop only; it covers physical damage as well as any damage which make it impossible to sell products on the market (any visual defects)

Next category is created by liabilities. Liabilities are understood as claims that company is exposed to from other parties. It covers claims from employees (for example in case of accidents), from business partners for not fulfilling the agreements and claims for harming the environment. This point also includes liabilities that are results of bad quality or safety of products as well as not sufficient production to fulfill business agreements (crop/yield).

The next category crop/yield can be also understood as losses in production due to business interruption. It covers losses in sales due to production lower then expected.

Employees' benefits are separate category. It is not a type of exposure. However it is often combined with other insurance products, that is why it is in this classification. Employees' benefits cover all insurance policies that can be offered to employees from the glasshouse.

Because of large amounts of policies company can provide them cheaper then the employees separately

This paper focuses on property damage (and eventually business interruption) as these ones are considered as primary exposure for glasshouses. That is why the perils which can result in property damage are analyzed. These perils include:

- Windstorm risk
- Hailstorm risk
- Flooding risk
- Disease risk

The probability of damage occurrence and its consequences due to above perils is analyzed in following parts.

4.2. Materials and Methods

Most popular method of modeling expected losses is analyzing historical data on indemnities. Based on past data the statistical methods are applied to discover the probability distribution of losses and thus annual expected losses. This information is then used to design the insurance offer and calculate premiums.

Due to lack of historical loss information which makes it impossible to use standard actuarial techniques, this paper applies methods known from catastrophe models and combine it with modeled indemnities from previous studies. Because of rarity of catastrophes, modelers were forced to develop alternative methodologies of risk analysis. These methods combine meteorology, engineering, biology and statistics and other disciplines in order to provide the most accurate estimations of likelihood of losses from extreme events.

Catastrophe models are made of three main components:

- Hazard component – which deals with the probability, location, magnitude and intensity of events
- Engineering component – which determines the vulnerability of the structure to damage at a given level of intensity of the extreme event.
- Financial component – which takes as an input risk financing solutions to determine net losses for given level of damage (Born, 2006).

The first, hazard component assesses likelihood of an event occurring, where it may occur and how large it might be. For this part (re)insurers employ people with knowledge in appropriate science of a hazard (e.g. meteorologists or biologists) who can interpret historical data on past events (Born, 2006).

Monte Carlo technique is usually used to simulate future scenarios (Born, 2006). It involves a simulation of a set of random variables (e.g. wind speed or barometric pressure) based on their theoretical probability distributions. Distributions are developed form historical data. By repeating the simulation process a sample of many thousands of years can be generated.

Engineering component assesses the particular client’s (or group of clients) exposure to damage from defined events. It consists of developing a damage function which expresses the relationship between the magnitude of the event and damage to the client’s property. It requires information about characteristics of the assets like building characteristics, used materials, content. That is why it usually requires experienced engineers who develop damage functions for different construction types. The final output of this part is a complete probability distribution of damage.

The last component of the model consists of calculation of insured losses by applying specific insurance policy for given level of damage. Policy conditions may include aspects like deductibles, coverage limits and coinsurance or reinsurance terms. Output of the model is then an optimal insurance policy for particular peril, location and client or type of property.

In general, risk analysis requires a large amount of information. Considerably amount of multi-disciplinary and technical data have to be collected, processed and analyzed. That is why these types of models are created rather by large financial institutions for commercial purposes. The examples of such models are MRQuake, MRStorm, MRFlood (MunichRe) RiskLink (RSM), EQEHAZARD (EQECAT), CATMAP or CLASIC (AIR). These models as well as data are not freely available (Westen, 2005).

The other group of models consists of estimations for which data is freely available, but due to complexity and large input data it is rather difficult to apply them in other parts of the world then they were initially designed for (e.g. HAZUS for United States) (Westen, 2005).

Taking into account the lack of appropriate historical data and access to the above models, this paper attempts to analyze the three components of risk analysis by review of the results from scientific literature and applying basic techniques of statistical analysis. This chapter covers the first two components (hazard and engineering), whereas the financial aspect is a subject to the next chapters.

Because the type and amount of information in literature is different for each peril it is difficult to build general model. That is why the estimations are made separately for each peril. The detailed description of the models in presented in appropriate subchapter and the summary is made at the end of chapter 4.

4.3. Windstorm risk

Storminess over the Netherlands and Europe and its impact on the insurance industry were subject to many studies and are a major concern to several institutions. It is hardly surprising that especially the reinsurance companies such as Munich Re or Swiss Re are very active in developing models and finding future trends in this type of risk. For them the recent increasing losses are a great threat for their profit and existence. Their publications provide draft approximations of future frequency of storms and loss potentials.

Trends in storminess and possible climate change were analyzed by number of studies conducted at Royal Netherlands Meteorological Institute. Unfortunately different models provide opposite results what make it often difficult for interpretation. The major findings of these researches are summarized in this report.

Additionally due to lack of the historical data on indemnities this paper base some of the findings on previous study (Asseldonk et al 2001) which presents the description of the historical indemnities of the insurance company Hagelunie in years 1980 – 1998. The results of the article are analyzed and discussed.

Types of hazard

In the world there are few main types of physical activities that can result in wind damage. The strongest of them are ‘tropical storms’ which can hit large areas with wind speed up to 250km/h, in some cases even 300 km/h (they are called hurricanes, typhoons or tropical cyclones then). Fortunately this type of storms is not present in Europe. Instead Europe is exposed to extra-tropical storms called also ‘winter storms’. The main difference is due to the physical process by witch they are generated. Extra-tropical storms are created in the transition region between subtropical and polar climatic zones i.e. in the latitudes between about 35˚ and 70˚. In these regions cold polar air masses collide with tropical air masses forming extensive low –pressure eddies. Naturally the intensity of the storm is proportional to the difference in temperature between the two air masses. Therefore it is at its greatest in late autumn and winter when the oceans are still warm but the polar atmosphere is already extremely cold (this is the reason why they are referred to as winter storms). The maximum wind speed of extra-tropical storms is approximately 140 – 200 km/h but in under extreme conditions may even reach 250 km/h. The storm area may be up to 2000 km wide (Berz et al., 2001).

The other type of windstorm hazard are ‘regional storms’. Their occurrence is highly dependant on topography. Example of regional storm is downwind that can be observed in every mountain region in the world. In general the topography dependency makes these kind of event to occur always in the same places (for example valleys) and with the same wind direction. Netherlands is free from damage caused by this kind of threat.

Damage can be caused also by local wind which is generated by the local difference in the temperature (and pressure) of moving air masses. The strength of the wind is rather small comparing to the hazards mentioned earlier. Nevertheless it may cause accidental and individual damage (i.e. falling down an old tree etc). Moreover these local storms can be accompanied by thunderstorms which can inflict serious damage depending on the vulnerability of the structures.

Other form of dangerous atmospheric activity is hailstorm. Although the Netherlands is not exposed to this type of risk as much as other parts of Europe (e.g. South Germany or Switzerland) still it can cause an enormous damage especially in horticulture sector. The advantage of hail over the wind for the insurance industry is that hailstorm affects relatively smaller area then the windstorm. Thanks to that the damage risk is more amenable to pooling. The hail risk is analyzed at the end of this chapter.

History

Windstorm disasters (including storm surges) account for about one-third of all natural disasters throughout the world (by number, fatalities and economic losses) but for more then two-thirds of the corresponding insured losses. It means that there are responsible for a much grater number of damaging events then any other types of natural disasters. In last 10 years damage of US$ 150 billion were caused all over the world (Berz, 2005). Regarding the insured losses, wind in various forms dominates the statistics. Among top ten insurance payouts, nine are from windstorm category (figure 4.3) (Munich Re, 2006)

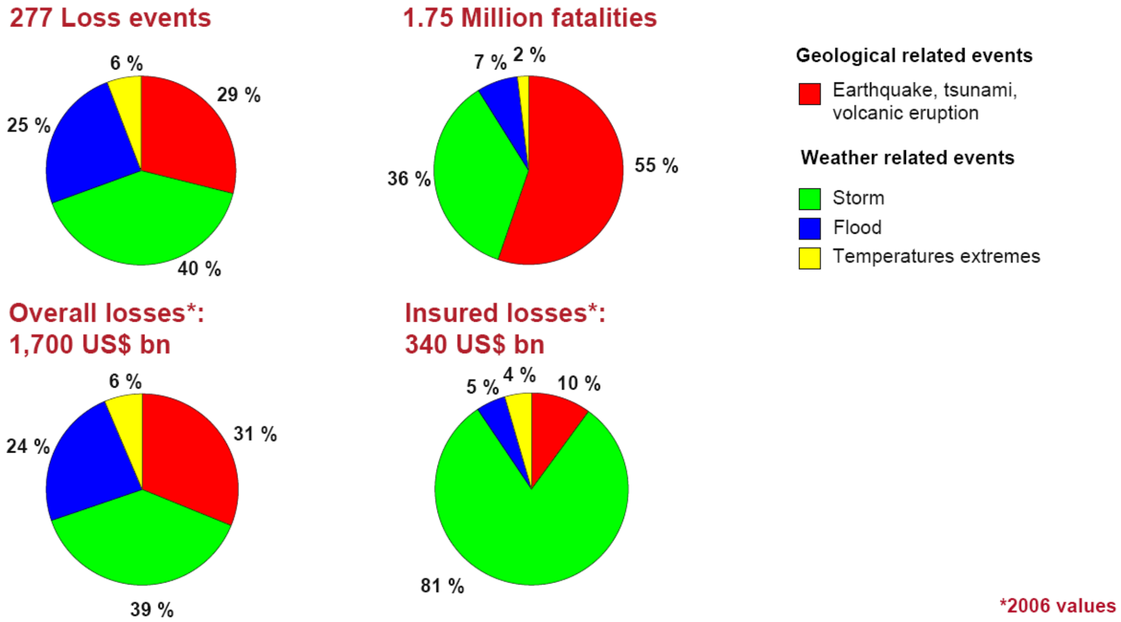


Figure 4.3 Great natural disasters 1950 –2006
Source: Munich Re 2006

Among the other regions of the world, Europe is one of most exposed area to wind damage especially to extra-tropical storm. Figure 4.4 shows the geographical paths of the main historical events in last century.

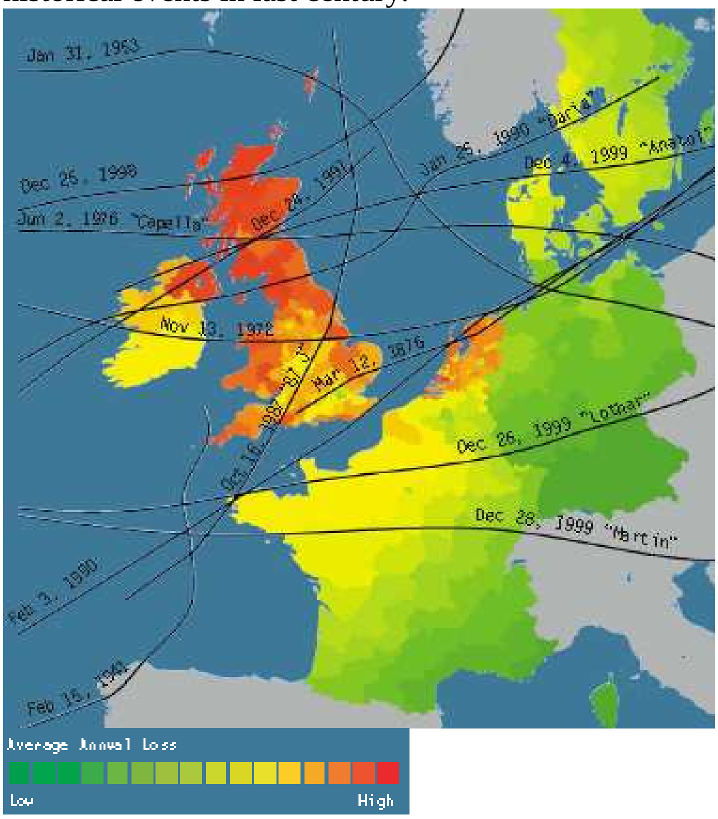


Figure 4.4 Geographical pattern of risk in Europe, with the path of low pressure centers for key historical events
Source: Risk Management Solutions (RMS) 2005

Based on the past events, ESPON created a map showing the potential exposure of the Europe to the extra-tropical storms (figure 4.5). Map shows that the areas more exposed to north Atlantic experience higher threat of winter storms. The majority of the damage occurs in overseas territories. The winter storm hazard lessens towards southeast as the climate change from Atlantic influenced towards more continental. Netherlands belongs to the highly exposed group (Schmidt-Thomé, 2001).

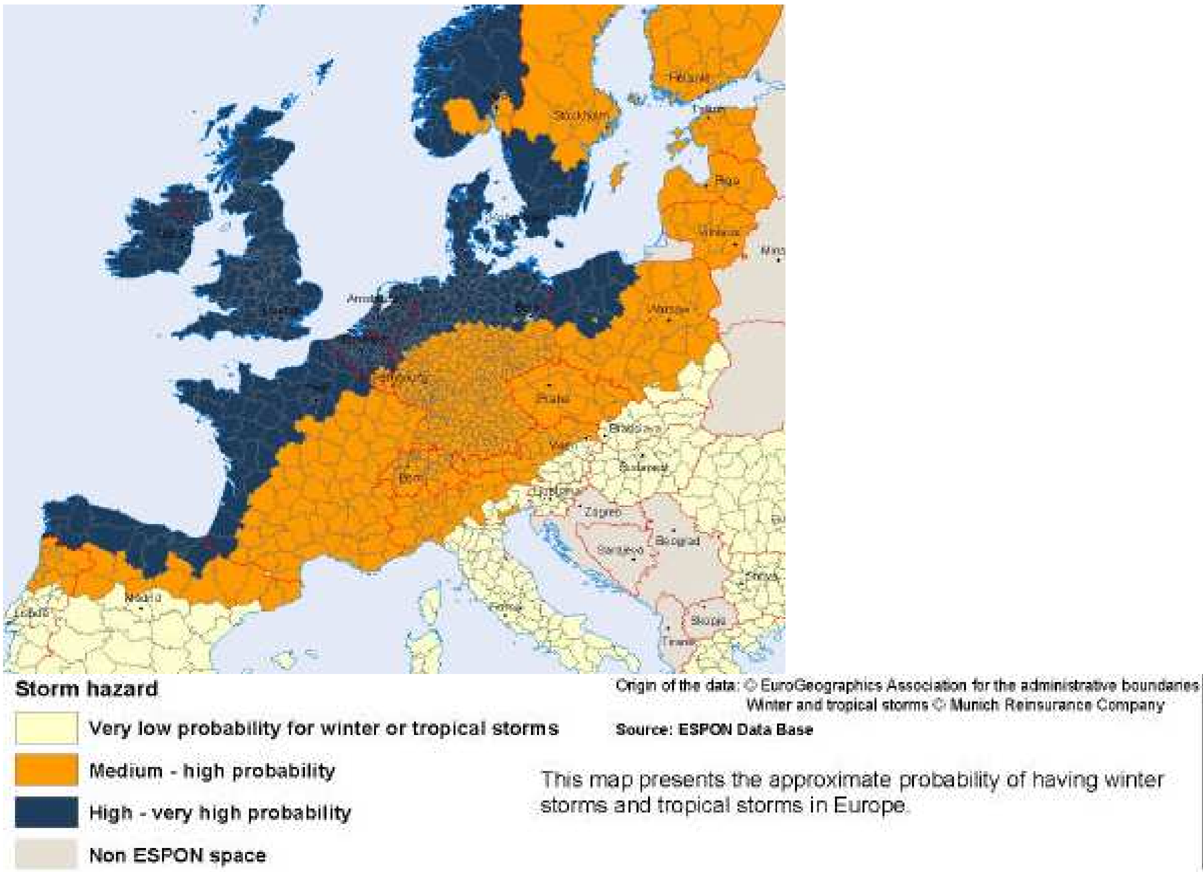


Figure 4.5 Winter storm hazard in Europe.
Source: Schmidt-Thome, 2001

For many years winter storms with economic losses over few billions U.S$ were considered unlikely. That is why insurance industry was not prepared for the series of windstorms that hit Western Europe in late 1980 and early 1990. The estimated economic losses were between U.S$ 4 and 15 billion (valued at 1992 prices). The winter storm Daria in January 1990 alone caused economic losses around U.S$ 6.8 billion, of which U.S$ 5.2 were insured. In the Netherlands these values were round 1.3 and 0.75 billions respectively (Dorland et al 1999).

In December 1999 Europe was stroked again by two sever winter storms Lothar and Martin. Lothar crossed northern France, southern Germany and Switzerland. The next day Martin passed further to the south also causing heavy losses in central and southern France, northern Spain, Corsica and northern Italy. The losses were paralleled to the storms of 1990. 60 percent of the roofs in Paris were damaged, 80% of buildings in surrounding towns and countless greenhouses were destroyed. Together Lothar and Martin caused US$ 18 billion of economic losses. From that 8.2 billions were insured.

According to Swiss Re these events have shown that insured storm losses of UD$ 7 billion can be expected to occur in Europe every ten years (Bresch, 2000).

Probability of occurrence

The main purpose of analyzing the recent storms is to estimate the most likely number of events which will trigger the indemnities payments. The windstorm hazard may be described by the probability of certain wind speed at a specific location or the average frequency in years needed to trigger defined indemnities. Using meteorological data from the past, statistical methods are usually applied to estimate the return period of wind speeds at individual weather stations. The additional significant information includes the chosen extrapolation method and the consideration of possible changes in wind climate.

Lothar and Martin confirmed that insured storm losses in the billions are not infrequent. Although Lothar in France and in Switzerland multiplied the losses caused by 1990 storm series, in Europe perspective the loss extent was not a surprise. Swiss Re predictions show that losses over USD 1 billion are to be expected in a return period of 2 – 3 years. The magnitude comparable to Lothar is expected to occur every 8 – 10 years. Moreover storm losses in the order of USD 30 billions may occur on average once every 100 years (Bresch, 2000).

In order to predict the frequency of windstorm over Netherlands the historical records were analyzed. Table 4.1 includes historical data about storms in Netherlands.

Table 4.1 Heavy winter storms over land in the Netherlands since 1910

Nr.	Year	Day/month	Intensity			Nr.	Year	Day/month	Intensity		
			$\bar{v}_{max}$ [a]		$\hat{v}_{max}$ [b]				$\bar{v}_{max}$ [a]		$\hat{v}_{max}$ [b]
			Bf	m/s	m/s				Bf	m/s	m/s
1	1911	30/9–1/10	11	30	38	15	1949	1/3–2/3	11	29	39
2	1912	27/8	10	27	41	16	1953	31/1–1/2	10	27	40
3	1914	28/12–29/12	11	32	42	17	1960	20/1	10	26	41
4	1916	13/1	10	27	42	18	1967	17/10	10	27	40
5	1921	6/11	11	32	45	19	1972	13/11	11	29	42
6	1925	9/2–10/2	10	27	39	20	1973	2/4	11	30	43
7	1926	9/10–10/10	10	26	35	21	1976	2/1–3/1	11	30	41
8	1928	16/11–17/11	11	29	38	22	1983	1/2	10	27	38
9	1928	23/11	10	25	38	23	1983	27/11	10	27	40
10	1928	25/11	10	28	37	24	1984	14/1	10	27	37
11	1938	4/10	10	26	38	25	1987	16/10	10	27	41
12	1940	13/11–14/11	10	26	38	26	1990	25/1–26/1	11	29	44
13	1943	7/4–8/4	11	31	35	27	1990	3/2–4/2	10	24[c]	34[c]
14	1944	7/9	12	34	–	28	1990	25/2–27/2	10	26	41
						29	1990	28/2–1/3	10	24	35[c]

[a] $\bar{v}_{max}$ – highest measured hourly mean wind speed.
[b] $\hat{v}_{max}$ – highest measured gust speed.
[c] Estimated values from Swiss Re (1993).

Source: Dorland, 1999

Based on the historical records the frequency of wind storm was divided into three categories:

- Storm in 10th Buford scale with wind speed means above 25 m/s and gust wind speed up to 40 m/s. It occurs on average 18 times in 80 years.

- Heavy storm in 11th Buford scale with wind speed means above 28 m/s and gust wind speed up to 45 m/s. It occurs on average 10 times in 80 years
- Very heavy storms in 12th Buford scale with wind speed means above 32 m/s and gust wind speed above 45 m/s. It occurs on average once in 80 years.

It is assumed that each of these events will trigger damage to the glasshouses. The level of damage is different depending on the type of event.

Climate change

Despite the economic importance of the storminess for safety and economy, little is known of climate changes that can affect storminess. There is a continuous discussion between scientists whether a number and magnitude of storms is changing and how can it be influenced by greenhouse gases.

Global warming is a fact. Direct measurements indicate that temperature is increasing on average about 2.0 degrees Celsius per century. Discussion is now focusing on the consequences of the global warming. However it is not clear if it will lead to more storms over Europe (Bersch, 2000). Number of studies was conducted to discover the systematic changes in storminess in recent decades. Schiesser et al. (1997) reported a significant declining trend in the number of storms in Switzerland. Sweeney (2000) did not find any significant trend in Dublin. The main critic of these analysis stresses that the trends might be not reliable because of inhomogeneities in data series and that the recent increase in activity might be the result of natural long term variations (Pinto et al. 2007).

In years 1994-1996 European Union's Environment lunched Waves and Storms in the North Atlantic (WASA) project to verify or falsify hypothesis of worsening storm and wave climate in the Northeast Atlantic. In their major findings they concluded that North Sea has undergone significant variations on time scale of ten years. They noticed an intensification of storms in last decades. However these events are comparable with the intensity at the beginning of the 20th century. They concluded that there is no evidence of systematic changes in storminess along Northwest coast and recent intensification can be explained rather by weather variability. Part of the variability is found to be related to North Atlantic Oscillation (NAO) (WASA, 2003).

Interesting study was conducted by Smits et al. (2005) who investigated storm trend in the Netherlands in 1962 – 2002. He analyzed the historical data from 13 weather stations and separated weak (30 times per year), moderate (10 times per year) and strong events (2 times per year). The results indicated the overall decrease in storms in last 50 years but also big differences between particular stations (figure 4.6)

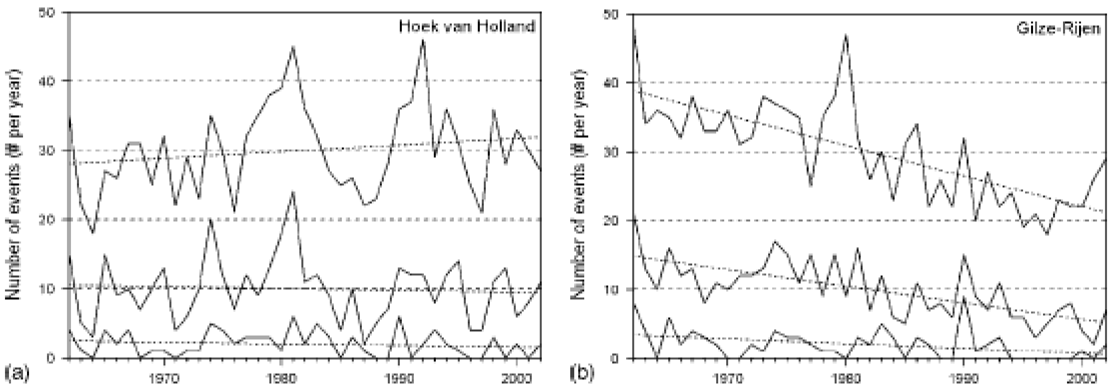


Figure 4.6 Annual number of wind events for three defined levels of severity (weak, moderate, strong) for stations Hoek van Holland and Gilze-Rijen
Source: Smits, 2005

In general, the study shows an overall negative trend for the Netherlands with larger decrease for inland stations (except the Beek station far to the south) then the coastal one. Figure 4.7 shows the graphical trends for the Netherlands using statistical interpolation of the station values. According to the map, storms' number in Westland is expected to decrease slightly.

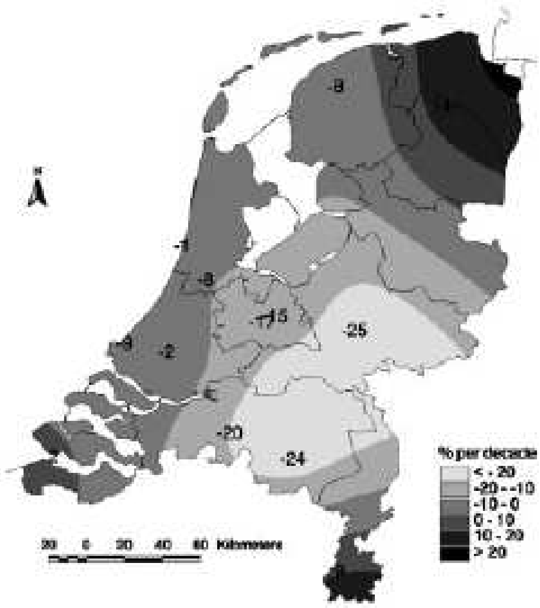


Figure 4.7 Trends of annual number of strong winds (2 times per year)
Source: Smits, 2005

The authors of the article could not model the events more rare then 2 times per year because of not enough number of observations. It decreases the value of the findings from point of view of insurance company (the really dangerous extreme events happen less then ones per year). Nevertheless all groups of events (weak, moderate, strong) shows similar pattern of change which can indicate the general rule for storminess.

There are few major hypotheses which aim to explain the results of different studies on trends of storminess and try to create the possible scenarios of future events.

First of the hypothesis suggests that variability on the decadal scale is a normal feature of the storminess (witch can be partially explained by impact of NAO index). Moreover, there is no trend throughout whole period of last 100 years and recent increasing trend which started in

1970 can be explained rather as function of decadal scale variability rather then a product of global warming (Dorland et al., 1999) Similar intensity was reported at the beginning of the 20^{th} century which can be considered as a proof of that hypothesis (WASA, 2003).

One of them takes into account the warming up of water in the oceans. Extra tropical storms emerge when humid subtropical air masses mix with cooler Arctic ones, thus the conclusion have been made that warmer water will result in mixing of the air further to the north. In fact the trend has been discovered that the paths of the storms tend to be moved slightly to the north (Bresch, 2000). It can be an explanation for the decrease in the inland storminess discovered by Schiesser et al. (1997) and Smits et al. (2005) and not significant change or increase over the North Sea and Atlantic (Sweeney, 2000 and WASA, 1998). Most recent study of Pinto at el. (2007) partly confirms this theory of changing the geographical distribution of the extreme events. It concludes that Western Europe is expected to be more exposed to the influence of extreme wind storms under present climate conditions, whereas the decrease can be expected in lower latitudes and far to the North. Additionally the study discovered significant increase in the standard deviation of wind speed which can increase the increase the intensity of single events.

Among other studies it was proved that part of the weather variability is highly correlated with the North Atlantic Oscillation (NAO). NAO refers to periodic shifts in the relative strength of the cell of the high atmospheric pressure over the Azores and low pressure over the Iceland. These shifts are most pronounced during winter. A standardized index quantifies shifts as the difference between the cells through February to December. If the Iceland low is well developed, corresponding to, positive NAO index, westerly air flowing from the Atlantic will be carried a long way into Europe. It crosses the relatively warm waters and brings to northwest Europe abnormally warm, wet, windy conditions, and dry, calm conditions to southern Europe. Opposite, if the index is negative, westerly winds are blocked and cold sub-arctic dominates the weather bringing conditions significantly colder but less windy (Malmquist, 1999). Behavior of the index helps to explain the high variability of the storminess on small scale basis which was responsible for the difficulties in trend researches.

The hypothesis exists that global warming could increase the NAO index by enhancing the subtropical stream – that would lead to the increase of number of storms. However computer models do not yet clearly indicate such behavior (Malmquist, 1999).

What is worth mentioning, NAO index is linked to the activity of North Atlantic tropical cyclones, but their relation is reversed then in Europe. It creates anti-correlation conditions between hurricane frequency and the European windstorm during following winter provides a potential opportunity for diversification of a portfolio.

The same discussion about future impact of global warming on storminess is also lead by two major European reinsurance companies Swiss Re and Munich Re. Swiss Re predicts small annual risk increase witch will lead to 60% change over 100 years. These expectations have been already integrated in the companies underwriting system. On the other hand, Munich Re in official declarations agrees that winter storms will become more intense over time, however, they do not support the hypothesis of increasing number of storms, especially in the nearest decade (Miller, 2007)

Summing up scientists come up with different often contradictory results about trends in storminess. The most interesting results presented above were created by Smits et al. They showed an overall negative trend in storminess for Netherlands. However their analysis was based on the weather stations data from last 50 years similar to the one used for calculating hazard component. That is why it is assumed that the presented trends are already incorporated in the probabilities presented earlier. Thus the results were not adjusted by any expected changes in storminess frequency.

Vulnerability

Although the total damage arising from the last storms seems high, they were only a small proportion of the exposed property.

Expected damage from windstorm is a function of not only wind magnitude but also the vulnerability of a given structure. In common techniques of property loss estimation vulnerability is incorporated into the model by few main characteristics which describe the features of the structures. Namely commercial and residential structures are divided into building classes (From A+ for fully strengthened to D for not damage resistant). Each of the building class has different damage function. The most common features, which can be used to indicate the proper class, are building age, building height, building occupancy and other special considerations such as roof and windows protection (Chandler et al., 2001) and early warning and precautions (Munich Re, 2002).

Because of predominantly massive construction of buildings in Europe, structural damage is usually an exception even when speeds are high. Two main types of loss involve damage to the outside shell of the building like roofs and windows. Also the recent trend of building attachments like pergolas antennas makes them potentially more exposed to damage at high wind speed then the building themselves (Munich Re 2002).

In general vulnerability of certain area to the damage is a sum of two factors. First describes the number of policies affected in case of windstorm (scale). Second one described the average damage per affected policy (scope).

In order to asses the number of affected policies by event, study of Munich Re (2002) was used. They analyzed the storms in 1990 and based on that presented general figures describing vulnerability of the structures. Figure 4.8 shows the curve of affected policies in relation to wind speed (loss frequency)

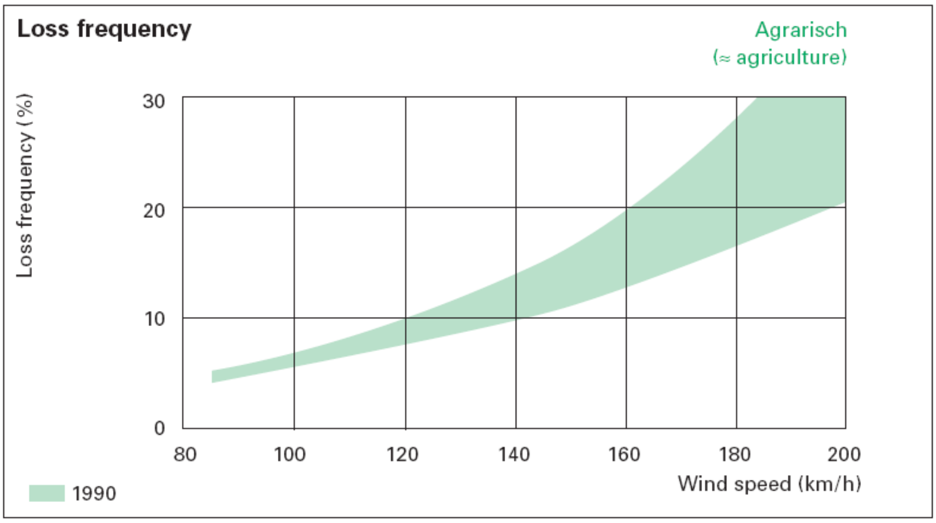


Figure 4.8 Loss frequency from storms in 1990 in the Netherlands
Source: Munich Re, 2002

The above figure was used to read the loss frequency in relation to wind speed (table 4.2). It is expected that greenhouse highly exposed to wind damage the highest values were chosen.

Table 4.2 Loss frequency (%) for the given wind speed for the case of storm in 1990 in the Netherlands.

Policies afected	wind speed:	min	most likely	max
storm	126 - 144 km/h	10	12	14
heavy storm	144 - 162 km/h	14	17	19
very heavy storm	162 - 180 km/h	19	24	28

Source: Based on figure 4.9

The above range was used in estimation of expected losses.

The second variable required for loss estimations is average damage per policy. Due to the fact that this information was absent in literature, the assumption was made about its average value and range (table 4.3).

Table 4.3 Damage per affected policy (‰)

Damage per policy	wind speed:	min	most likely	max
storm	126 - 144 km/h	1	2.5	5
heavy storm	144 - 162 km/h	10	20	30
very heavy storm	162 - 180 km/h	20	30	100

Deductibles can results in significant decrease of loss burden for the insurers. The average loss after windstorm Lothar was just 1,500 USD the amount which is not rather likely to ruin most of the policyholders. The deductibles help to exclude minor damage and also prevent from moral hazard. However nowadays the deductibles are very low and do not bring any significant change to the loss burden. Their average is about 100 dollars for many European markets. Swiss Re proposes to establish deductibles of about 1% of the insured value. It ensures the real participation in the loss and would cut the claims by 50%. Additional savings would be from the lower administration costs. However in case of glasshouses which value often exceed 100 millions EUR the proposed deductibles over 1 million are not likely to be accepted.

To be able to apply the loss ratios values it is required to estimate the property value which is exposed to the wind losses. Property value is a sum of value glasshouses and value of crops. Value of glasshouse is based on the table 2.10. Value of the crop is based on the study of Waarts and Vrouwenvelder (2004). They estimated that average production value per hectare range from 185,000 EUR/ha for vegetables to 275,000 EUR/ha for pot- and bed-plants. The average value was then based on weighted average. The weight was created using the share of the given type of crop in the total number of hectares of glasshouses in the Netherlands. The table 4.4 shows the average value of the glasshouse per hectare.

Table 4.4 Average value (EUR) of one hectare of glasshouse with the crop value in Netherlands.

	Average Replacement Value* (ha)	Turnover** (ha)	Sum (ha)	Overal Share***	Value of one hectare
Vegetables	618,525	185,000	803,525	0.42	339,953
Cut flowers	772,400	225,000	997,400	0.38	383,615
Pot plants	953,100	275,000	1,228,100	0.19	236,173
				1.00	**959,741.35**

*Replacement value based on table 2.10
**Turnover from Waarts and Vrouwenvelder (2004)
***Overall share based on the appropriate share for the Netherlands

The average value of insured hectare of glasshouse is estimated to be approximately 0.96 m. EUR. Taking into account the amount of greenhouse hectares in Netherlands which is equal to 10,500, the total property value is 10,071,807,179 EUR.

The last component required to estimate the windstorm damage is average size of the affected greenhouse. According to CBS the average size of greenhouse in Netherlands is approximately 1.23 hectares. To take into account fact that average size of affected greenhouses is a random sample and can differ from the whole population, the range was applied. Table 4.5 shows the values used for estimations

Table 4.5 Average size of greenhouses affected by windstorm

	min	most likely	max
Average size of affected greenhouses	0.25	1.22	2.00

Source: "most likely" from CBS; min, max – own assumption

Parameterization of risk model and results

The information from different sources was combined to estimate wind losses to glasshouses. Table 4.6 shows the parameters input for basic scenario.

Table 4.6 Model input for windstorm losses estimations (basic scenario)

	variable	unit	risk function	source	description	parametrisation
	Occurance of wind speed in a given interval				wind speed:	
1	Storm	Number	Poisson	Dorland et all 1999	35 - 40 m/s	18 / 80
2	Heavy storm				40 - 45 m/s	10 / 80
3	Very heavy storm				above 45 m/s	1 / 80
	Policies afected				wind speed:	
4	storm	percentage	triangular	average from Munich Re (2002), assumption about the range	35 - 40 m/s	10; 12; 14
5	heavy storm				40 - 45 m/s	14; 17; 19
6	very heavy storm				above 45 m/s	19; 24; 28
	Damage per policy				wind speed:	
7	storm	promile	triangular	assmuption	35 - 40 m/s	1; 2.5; 5
8	heavy storm				40 - 45 m/s	10; 20; 30
9	very heavy storm				above 45 m/s	20; 30; 100
10	**Average size of affected glasshouses**	hectar	triangular	average from CBS assumption about the range		0.25; 1.22; 2

Because the risk analysis is performed with a Monte Carlo simulation model a number of iteration was executed in order to provide a reliable output results. The results presented here are based on 10000 iterations. Because the simulated distributions of results changed only a little as more iterations were performed, it can be concluded that the amount of iterations was sufficient. Characteristics of windstorm loss function for the basic scenario is presented in table 4.7.

Table 4.7 Characteristics of distribution of windstorm losses for basic scenario

Statistics	Loss function
Minimum	0.00
Mean	6,168,493.00
Maximum	336,527,900.00
Std Dev	19,372,370.00
Skewness	6.50
Kurtosis	65.39

*Values in EUR

Overall simulated mean is approximately 6.17 million EUR and standard deviation 19.37 million EUR. Almost 70% of iteration gave 0 as an output indicating that windstorm is expected on average 3/10 years. It underlines the catastrophic characteristics of the used model. The positive skew indicates the long right 'tale' which is typical for catastrophic events.

Because the parameters used in the model were partially based on assumptions the additional alternative scenarios were built. The more optimistic scenario was created by dividing by two parameter "damage per policy" and pessimistic one was creating by doubling it. Third scenario was created by adjusting the values per hectare. Values per hectare are based on data from 2003-2004 and might be lower then current replacement value. Additionally according to employees of Delta Lloyd currently built modern greenhouses are valued approximately 2 million EUR per hectare. That is why the value per hectare was increased by approximately 30% (table 4.8).

Table 4.8 Characteristics of distribution of windstorm losses for alternative scenarios

	basic scenario	low damage scenario	high damage scenario	high replacement value
Minimum	0.00	0.00	0.00	0.00
Mean*	6,168,493.00	3,076,894.00	12,329,190.00	8,019,040.00
Maximum	336,527,900.00	156,654,900.00	555,069,600.00	437,486,300.00
Std Dev	19,372,370.00	9,728,587.00	38,140,500.00	25,184,080.00
Skewness	6.50	6.61	6.10	6.50
Kurtosis	65.39	67.59	55.54	65.39
75%**	2,442,139.00	1,210,093.00	5,064,251.00	3,174,781.00
90%	23,788,210.00	11,491,880.00	47,328,090.00	30,924,680.00
95%	38,298,150.00	19,399,990.00	76,614,940.00	49,787,590.00
99%	83,765,500.00	42,559,140.00	170,966,300.00	108,895,100.00

*values in EUR
** Cumulative values of probability distribution

There are large differences between the scenarios. However, low damage scenario does not seem to present realistic results. The true values are rather expected in the range from basic to high damage scenario results.

Future scenario

The windstorm losses were modeled also with taking into account the changes in the greenhouse sector. The most important change is the growing average size of the greenhouses. According to Berkhout and Bruchem (2006) it can be expected that till 2015 the number of farms will decrease to approximately 4.300, whereas average size will reach 2.5 hectares. These new values were applied to the model for future scenario. To eliminate influence of other factors the assumption was made that the total area of greenhouses will remain constant. It is expected that the average number of affected policies in case of windstorm will slightly increase. However the variance is expected to rise significantly. Table 4.9 shows the parameters used for model.

Table 4.9 Input parameters for future scenario

	variable	unit	risk function	source	description	parametrisation
	Occurance of wind speed in a given interval				wind speed:	
1	Storm	Number	Poisson	Dorland et all 1999	35 - 40 m/s	18 / 80
2	Heavy storm				40 - 45 m/s	10 / 80
3	Very heavy storm				above 45 m/s	1 / 80
	Policies afected				wind speed:	
4	storm	percentage	triangular	average from Munich Re (2002), assumption about the range	35 - 40 m/s	5; 12; 28
5	heavy storm				40 - 45 m/s	7; 17; 38
6	very heavy storm				above 45 m/s	10;24;56
	Damage per policy				wind speed:	
7	storm	promile	triangular	assmuption	35 - 40 m/s	1;2.5;5
8	heavy storm				40 - 45 m/s	10;20;30
9	very heavy storm				above 45 m/s	20;30;100
10	**Average size of affected glasshouses**	hectar	triangular	Berkhout and Bruchem (2006) assumption about the range		1.5; 2.5; 3.25

Table 4.10 Windstorm losses for future and basic scenario

	basic scenario	futre scenario
Minimum	0.00	0.00
Mean*	6,168,493.00	7,983,129.00
Maximum	336,527,900.00	483,727,600.00
Std Dev	19,372,370.00	24,960,600.00
Skewness	6.50	6.60
Kurtosis	65.39	70.97
75%**	2,442,139.00	3,153,680.00
90%	23,788,210.00	29,966,960.00
95%	38,298,150.00	49,763,840.00
99%	83,765,500.00	112,512,400.00

*values in EUR
** Cumulative values of probability distribution

Future scenario differs significantly from the basic scenario. The average rise of expected losses accounts for more then 25% and is equal to almost 8 million EUR. It can be concluded that the in the given simulation the changes in the greenhouse sector will have significant impact on windstorm losses distribution.

4.4. Hail risk

Hailstorms cause extensive damage to agriculture and also to buildings and vehicles. If an event occurs over large conurbation, the economic losses can run into billions.

In 1984 very intensive hailstorm came through southern Germany affecting Munich. During 20 minutes some 300 people were injured and 230,000 cars and 70,000 buildings were damaged. The economic damage was estimated to be around 1.5 billion euros from which half was insured. The motor damage was responsible for the main part of claims – 450 m. 200 m was paid for buildings and household contents. The rest was paid for aircraft hull and agriculture insurance (Zimmerli, 2005).

Hail events with similar intensity occur over central Europe every couple of years (Zimmerli, 2005). Once in 12 years en event triggering insured losses of some 1 bn euros is likely to happen somewhere in Europe. Once in 35 years an event of 1.5 bn euros can be expected. Once in 250 years a loose event of 3 bn euros is expected (Zimmerli, 2005).

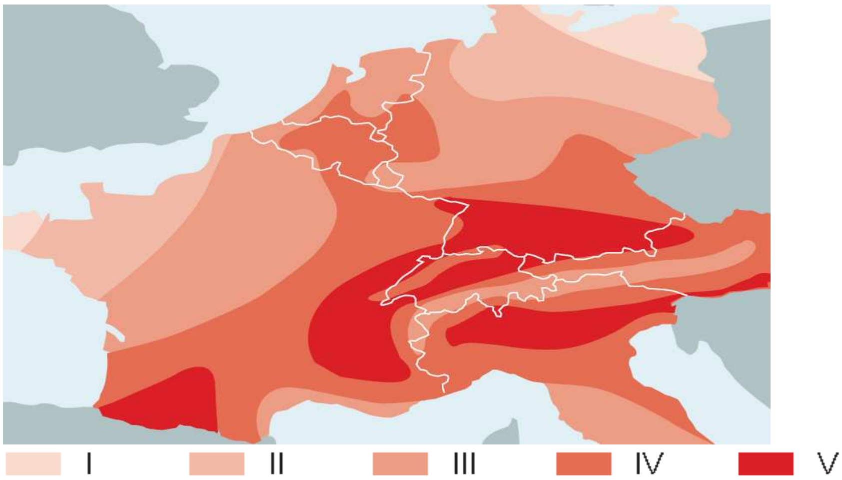


Figure 4.9 Hail exposure in Europe
Source: Zimmerli, 2005

The comparison has been made by Swiss Re between the risk from hail and windstorm. For the Southern Germany the damage from these two perils can be comparable. On the other hand for Northern Germany, which exposure pattern is more similar to the Dutch one, the hail damage accounts for less then 1/10 of the windstorm damage (figure 4.9 and 4.10). Northern Europe is more exposed to wind damage and less to hail which results in such a difference.

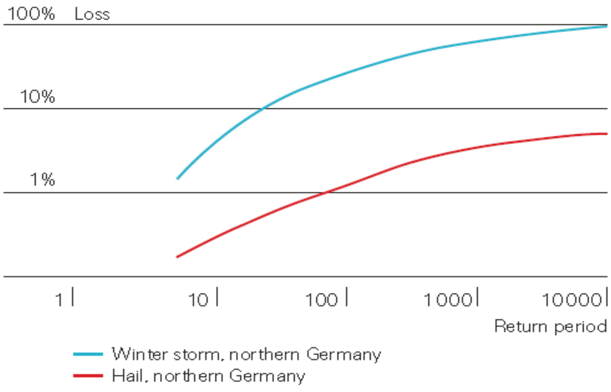


Figure 4.10 Comparison of wind and hail exposure in North Germany
Source: Zimmerli, 2005

Additionally coastal regions are on average less prone to hail damage then the interior ones (Assledonk et al. 2001). This feature of hail can have significant impact on damage for horticulture sector since majority of the greenhouses are located near the coast.

It is not clear how global warming will influence future hail events In recent years there have been number of strong hail events (Germany 2001, Austria 2000 and 2003, Switzerland 2002 and 2004). However, whether a casual relation exists can not be proved (Zimmerli, 2005).

Some of the Swiss Re estimations predict increase of frequency of severe hail events by 5 to 10 % till 2020 (Ortlof, 1998).

Parameterization of risk model and results

Because of lack of any historical figures on hailstorm losses which would enable building model, the results of Asseldonk et al (2001) were used. Asseldonk et al. conducted a simulation of the hail damage to glasshouses in the Netherlands. Their results were based on historical indemnities from Hageluine (insurance company with approximately 80% market share). Summary of the indemnities for 1980 – 1998 is presented in table 4.11.

Table 4.11 Summary of the historical indemnities (EUR) for Dutch greenhouse sector for years 1980 - 1998

	Insurance contract	Number of claims	Number of cases	Average number of claims per case	Average indemnity per claim
Hailstrom	Greenhouse	519	119	4.36	6,858
	Crop	190	63	3.02	11,633
	Building	133	64	2.08	1,899

Source: Asseldonk et al. 2001

Based on the above results the model was built to estimate damage from hail.

Table 4.12 Input variables for hail damage estimations

variable	unit	risk function	source	description	parametrisation
Occurance of hail yearly	number	Poisson	Asseldonk et al. 2001		119/18 = 6.611
Policies afected* per event	number	triangular	average from Asseldonk et al. 2001	Greenhouse Crop	min; most likely; max 1; 5.45; 10 0; 1.89; 3.5
Average damage per policy**	promile	triangular	average from Asseldonk et al. 2001	Greenhouse Crop	min; most likely; max 1; 7.6; 15 20; 44; 70
Size of affected greenhouse	hectare	triangular	average from CBS assumption about the range		min; most likely; max 0.25; 1.22; 2

* average extrapolated from the table 4.11
** average calculated in relation to average greenhouse values (table 4.4)

Table 4.13 Estimated hail losses

	hail damage
Minimum*	0.00
Mean	380,993.20
Maximum	2,448,810.00
Std Dev	258,670.10
Skewness	1.67
Kurtosis	7.64
50%**	322,118.50
75%	493,126.20
90%	797,440.60
95%	885,987.90
99%	1,289,352.00

*values in EUR
** Cumulative values of probability distribution

Overall hail losses are more frequent then windstorm losses but their magnitude for single event is much smaller. The average expected annual losses are equal to approximately 381,000 EUR which account for 6% of the expected windstorm damage.

Future scenario

The future scenario was created to take into account the changes in the sector. The most likely and the bottom values were lowered for 'policies affected' and 'average damage per policy' parameters, to take into account changes in risk profile. The upper values were not changed in order to include the magnitude of extreme events. The average size of the farm was doubled.

Table 4.14 Input variables for hail damage future scenario

variable	unit	risk function	source	description	parametrisation
Occurance of hail yearly	number	Poisson	Asseldonk et al. (2001)		119/18 = 6.611
Policies afected per event*	number	triangular		Greenhouse Crop	1; 2.725; 10 0; 1; 3.5
Average damage per policy**	promile	triangular		Greenhouse Crop	0.5; 3.8; 15 10; 22; 70
Size of affected greenhouse	hectare	triangular	Berkhout and Bruchem (2006)		1.5; 2.5; 3.25

*most likely values were lowered, range remain the same as in basic scenario
** most likely values were lowered, the range was increased comparing to basic scenario

Table 4.15 Estimated hail losses for basic and future scenario

	basic scenario	future scenario
Minimum*	0.00	0.00
Mean	380,993.20	527,966.90
Maximum	2,448,810.00	3,501,289.00
Std Dev	258,670.10	365,126.50
Skewness	1.67	1.76
Kurtosis	7.64	8.46
50%**	322,118.50	440,646.10
75%	493,126.20	691,053.30
90%	797,440.60	1,002,176.00
95%	885,987.90	1,213,410.00
99%	1,289,352.00	1,761,016.00

*values in EUR
** Cumulative values of probability distribution

According to the simulation of the future scenario the average annual losses increased up to 528,000 EUR. Results indicate that the increasing size of the greenhouses will have significant impact on the losses distribution.

4.5. Flooding risk

Large parts of the Netherlands are placed below the water level of the rivers and sea. The location in the delta of the Rhine, Meuse and Sheldt was from one side the source of development of the trading based wealth of the Netherlands and from the other the threat of floods. That is why Netherlands have a long tradition of protecting land against rivers and sea and is known for its advancement in building dykes and hydraulic structures.

Flooding in the Netherlands can lead to huge financial damage. In order to prevent insurance companies from getting bankrupted in case of huge flood, the Dutch government has accepted a law which forbids insurance companies from insuring any damage caused by flooding or dike failure. Instead the government agreed to pay for the occurred damage. In practice these payments are either not sufficient or much delayed (Baars, 2004).

Types of hazard

More then 50% of the land is below the level of sea and rivers. To prevent these areas from flooding dikes are build along the rivers and seas, with total length of 3,200 km. These dikes are called primary dikes.

The precipitation of the low areas drains into the ditches crossing the land. From the ditches the water is pumped up into canals with water sometimes few meters higher then the land. Then the water is pumped into the rivers. The water in the canals is surrounded by dikes which are called secondary dikes. There is about 14,000 km of secondary dikes in the Netherlands.

The water level in the primary dikes are driven by nature like melting glaciers of the Alps, whereas in secondary dikes are controlled by man. Secondary dikes are protecting much smaller areas then the primary one. The damage from primary dike failure would be significantly higher then the secondary one.

The last cause of flooding is local flooding due to lack of discharge capacity – directly because of extreme rainfall. It has the smallest scale of damage, but can occur more frequently then previous two hazards.

History

In 1953, a storm tide hit the South Western Delta area. Almost 2000 people died and economic consequences were enormous. Afterwards The Delta committee was established to improve the protection against flooding. One of the achievements of the committee was to introduce new approach to determine the required level of protection against flooding based on the return period for the design water level. Taking into account the variances in the level of water and the potential damage, height of the dike rings was defined (figure 4.11) (Most, 2005).

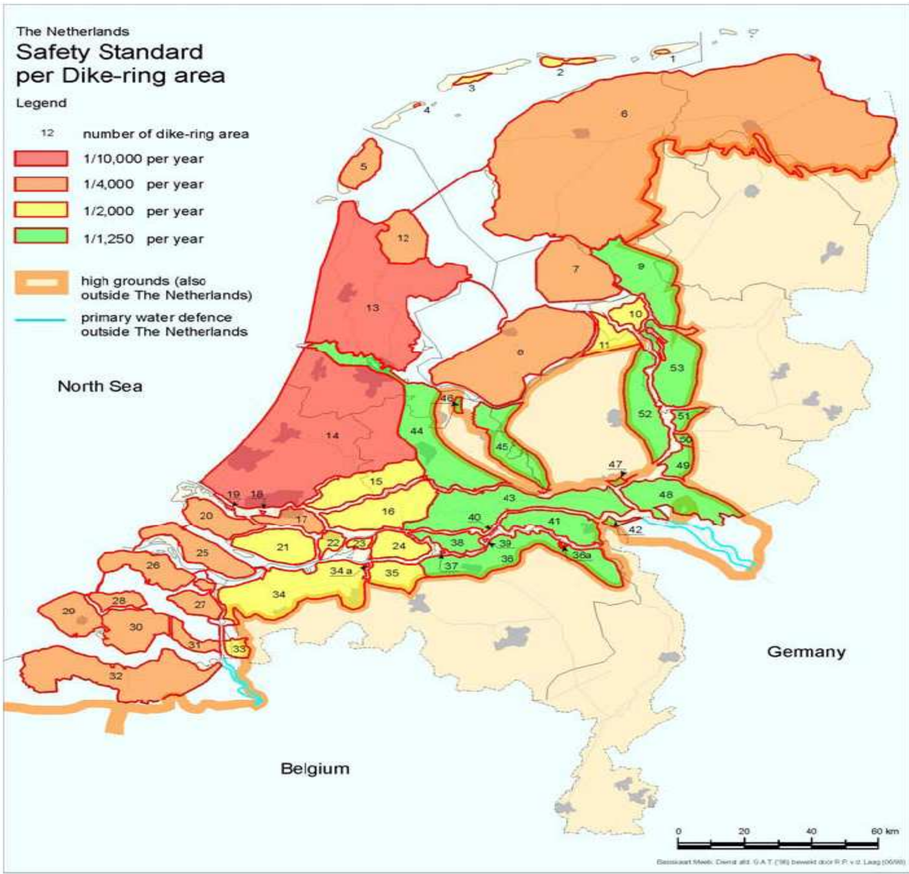


Figure 4.11 Safety standards per dike ring area
Source: Most, 2005

For the central western part of the Netherlands where the major cities are located the propose level of protection is the highest 10,000 years and for the branches of the river Rhine was set on 1250 years not to change drastically the landscape cultural and historical sites.

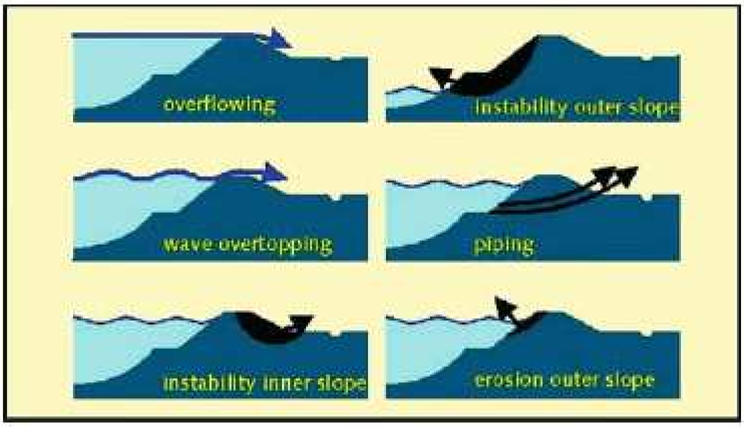
Despite the well designed structures the recent events show that the risk is still present. In 1993 and 1995 serious flooding occurred in the basin of river Meuse which accounted for 200 million of economic losses. Additionally early in 1995 the serious threat of dike collapse resulted in evacuation of 250,000 inhabitants from the area of Rhine. The dike did not collapse but the evacuation costs were enormous, also disrupting the local daily economic life.

Probability of occurrence

Primary dike failure

The method proposed by Delta committee took into account the probability of overflow or overtopping. It means that the probabilities shown in the figure 4.11 show the probability that the level of water exceeds the level of dikes. However recent studies are focusing also on other possible causes of floods.

A dike ring normally consists of large segments of dikes or dunes interrupted by a few hydraulic structures such as locks, pumping stations, tunnels and others. These structures might be the weak point of the dikes resulting in flooding even when the level of water is not high. Failures of hydraulic structures include non-closure on time or fully or the structural collapse. Dikes can be also undermined through water creating the channels under it. Slope protection of dikes may be washed away which can result in instability of the slope.



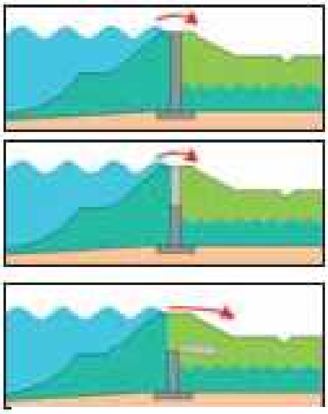


Figure 4.12: Failure modes of the dikes
Source: Westen, 2005

Fall of hydraulic structure

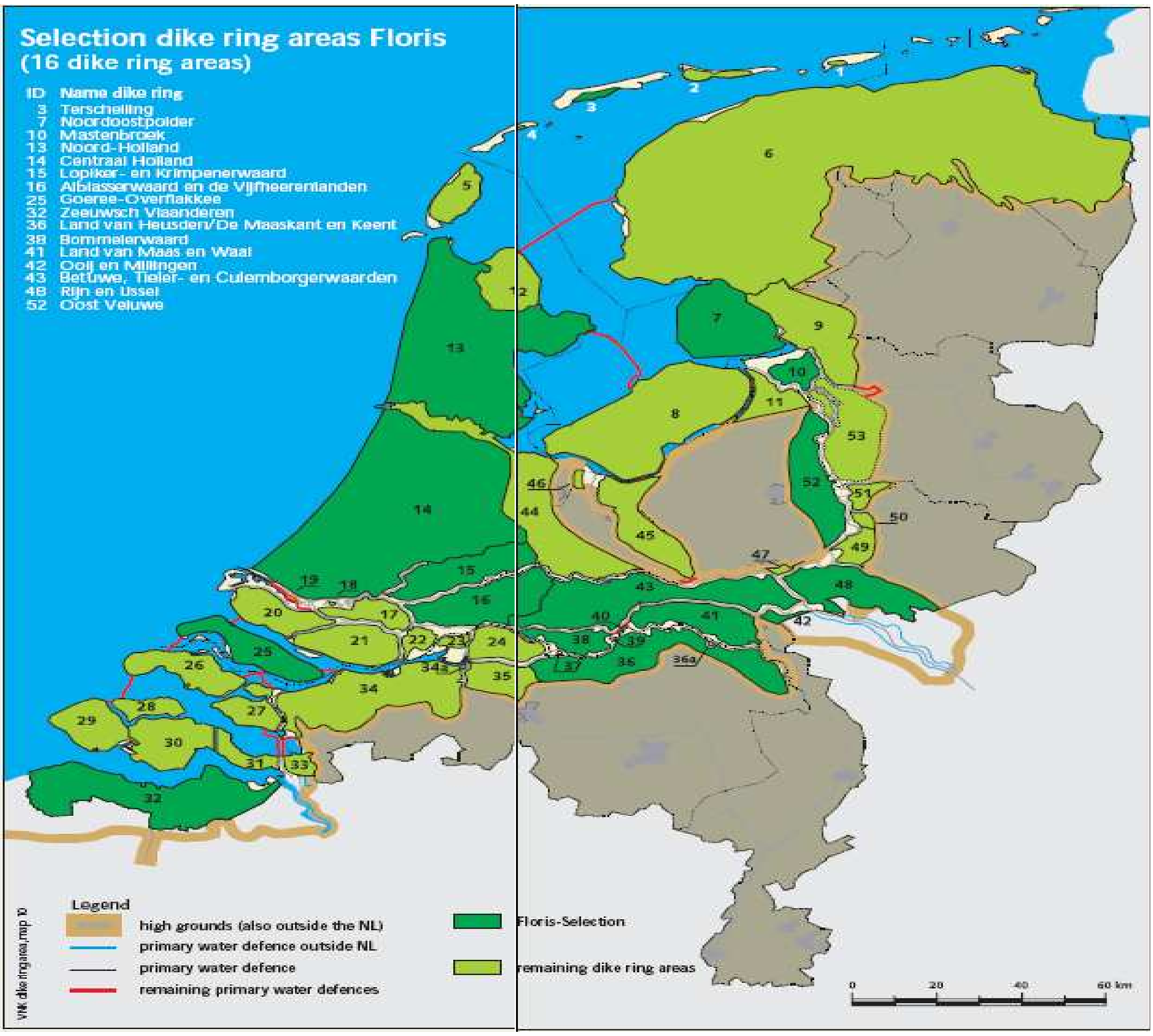
Probability of the failure of a particular dike section is a combination of the probabilities of each failure modes.

Because of the many other causes of flooding then overflowing the safety standards, the current level of protection is a matter of intensive researches. In order to take into account the various causes of flooding in 2001 the Floris project was established. Its main aim was to calculate the current level of protection against the large scale flooding of different primary dike rings. The research is not yet completed. However few of its findings were recently published.

The project developed new method of risk calculation and applied it to 16 of the 53 dike rings. However according to the authors only to 3 of them the detailed method was used which gives robust results eliminating the uncertainty (Westen, 2005).

Floris study showed that the water defenses are generally so high that the probability of the flooding due to extremely high water levels is very small. The main threat of potential flood is currently assigned to 'piping' and the failure of hydraulic structures.

In the study the number of dikes was selected and the probability and consequences of flooding were calculated. The figure 4.13 presents the selection of the dike rings.



Source: Westen, 2005

Figure 4.13: Selection of the dikes for the Floris calculations

Calculated probabilities of selected dike ring failures with the description are included in the appendix

In this study the probability of primary dike failure is based on results of Floris project and on safety standards for dike rings not included in the project. To take into account other forms of dike failure then overflowing the safety standard probability is doubled. Because the results of Floris study are known by dike managers an appropriate upgrade of the dikes is expected. That is why the most optimistic probabilities where chosen. The aggregation from dike ring level to province level is done by calculating the probability that any of the dike rings will fail (P(A or B or ..)). The exception is made for the large rings (6 and 13 and 14) which cover almost whole province. In this case the aggregation is made based only on the probability of flooding for these rings.(table 4.16)

Table 4.16 Probabilities of primary dike failure aggregated to province level

province	dike ring*	probability of failure**	Aggregation for province***
Groningen	6	0.05%	0.05%
	0	-	-
	1	0.05%	
Friesland	2	0.05%	
	3	0.067%	0.05%
	4	0.05%	
	6	0.05%	
Flevoland	7	0.032%	0.082%
	8	0.05%	
Drenthe	0	-	-
	0	-	-
	9	0.16%	
Overijssel	10	0.25%	0.668%
	11	0.1%	
	53	0.16%	
	5	0.05%	
North Holland	12	0.05%	0.2%
	13	0.2%	
	14	0.014%	
	15	0.111%	
	16	0.25%	
	17	0.05%	
South Holland	18	0.02%	0.014%
	19	0.02%	
	20	0.05%	
	21	0.05%	
	22	0.05%	
	25	0.083%	
	0	-	-
Utrecht	44	0.16%	0.32%
	46	0.16%	

province	dike ring	probability of failure	Aggregation for province
	26	0.05%	
	27	0.05%	
	28	0.05%	
Zeeland	29	0.05%	1.297%
	30	0.05%	
	31	0.05%	
	32	1%	
	0	-	-
	23	0.1%	
	24	0.1%	
	33	0.1%	
North Brabant	34	0.1%	1.268%
	35	0.1%	
	36	0.455%	
	37	0.16%	
	39	0.16%	
	0	-	-
	38	0.385%	
	40	0.16%	
	41	1%	
	42	0.071%	
Gelderland	43	1%	
	47	0.16%	4.084%
	48	0.500%	
	49	0.16%	
	50	0.16%	
	51	0.16%	
	52	0.4%	
Limburg	0	-	-

*Dike ring 0 is used when territory is over the sea level. The division of rings per province is based on Figure 4.14

** Probability of failure: the grey cells are from Floris project, the rest are doubled safety standards

*** Aggregation is made based on formula: P(AuB) = 1- [(1-P(A)) x (1- P(B))], that is: the probability that any of the dike rings in the province will fall. Exception is made for large rings which covers majority of the province: Groningen - dike ring 6, Friesland - dike ring 6, North Holland - dike ring 13, South Holland - dike ring 14 (majority of glasshouses is in this ring)

Secondary dike failure

In 1993 the report was published about the condition of the secondary dikes. From 1730 km of surveyed dikes 156 km were considered unsafe. However the secondary dikes are ruled by the local authorities and it is in their responsibility to improve them. In general the secondary dikes are in a worse condition then the primary one (Baars, 2004).

There are no researches about current level of protection from the secondary dikes failure or extreme rainfalls. In publications estimation can be found that the real risk is even 10 times higher for secondary dike failure then in the standards. Extreme rainfall standards are considered as more accurate (Veen et al. 2005).

Safety standards for regional flood defenses are not stated in the Dutch law, but the InterProvinciaalOverleg (IPO) commission has defined guidelines. Table shows an overview of the IPO safety standards. The categorization of the flood defenses into different classes is described by the water boards and has to be confirmed by provinces (Veen et al. 2005).

Table 4.17 Safety standards for secondary dike failure

class	Flood damage (Meuro)	Safety Standard (1/yr)
I	0-8	10
II	8-25	30
III	25-80	100
IV	80-250	300
V	>250	1000

Source: Veen et al., 2005

Hazard component is based on IPO standards and the study of (Baars, 2004). To take into account many weaknesses in secondary dikes the authors assumed 10 times higher probability of failure then the one in standard. For the urbanized area then the probability of failure was set as 1/100 years for each province.

Extreme rainfall

The demand of explicitly stating norms for flooding from extreme rainfalls has emerged after events in 1998. It has been chosen that the standards are set for different types of land use. The extreme water levels are calculated with a rainfall-discharge model. The standards and bottom level criterion for each land type are given in table… Bottom level criterion describes the part of the land which is not taken into account when applying the standard. The reason for that is that at some lowest parts the probability of the flooding is much higher and these lands are excluded from the analysis (Veen et al. 2005).

Table 4.18 Safety standards for extreme rainfall flooding

Landuse	Bottom level criterion	Standard (1/yr)
Grass	5%	1/10
Agriculture	1%	1/25
High value agriculture	1%	1/50
Greenhouses	1%	1/50
Urban area	0%	1/100

Source: Veen et al., 2005

In this paper the assumption is made based on the safety standards that greenhouses in Netherlands will be affected by extreme rainfall ones per 50 years.

Vulnerability

Area affected by flooding

Primary dike failure

Number of affected hectares differs greatly, for different dike rings and additionally depends on the place where the breach would occur. That is why recent studies focus rather on analyzing consequences for single events. Veen at al. (2005) analyzed the flooding for Brielse dike ring (20 on figure 4.11) for breach near Spijkenisse. In their study 15% of the dike ring would be flooded. The flood would stop on canals and secondary defenses. On the other hand Mannen and Brinkhuis (2005) analyzed the flooding consequences for Betuwe/Tieler- en Culemborgerwaarden (dike ring 43). Their results show that ring would be totally flooded 72 hours after breach (48 h needed to flood 90%) if the breach would result in extreme dike failure on a wide length. However the scenario does not include any preventive actions which could stop the flooding. For example flood would stop for 12 hours on the secondary dike along Amsterdam Rijn Canal before overtopping it. That would give the possibility to defend the rest of the ring (approximately a half). Additionally other forms of dike protection failure (like piping) are expected to cause less damage then the one used in the study. Based on that cases it is assumed that 40% of the dike ring are expected to be affected by the flooding.

The assumption is made that the crop damage is 100% after 72 hours continuous inundation and 50 % for shorter flooding time (Waarts and Vrouwenvelder, 2004).

That is why two the two levels of damage are created - half is affected heavily(100% loss of turnover) and half in medium degree (50%). These factors are then divided by number of dike rings in the province to calculate the aggregated values for a whole province. The output is then the expected percentage of affected hectares of glasshouses per province.

Table 4.19 Area affected by primary dike failure and number of greenhouse hectares below water level per province

Province	hectares*	heavy damage	medium damage
Groningen	68.0285	0.2	0.2
Friesland	111	0.2	0.2
Drenthe	238.5884	0	0
Overijssel	70	0.05	0.05
Flevoland	192.8329	0.1	0.1
Gelderland	648.0833	0.01818	0.01818
Utrecht	130.7521	0.1	0.1
Limburg	852.9563	0	0
South Holland	5609.1163	0.2	0.2
Zeeland	158.6573	0.02857	0.02857
North Brabant	358.8001	0.025	0.025
North Holland	983.588	0.2	0.2
Overall	9422.4032	0.2	0.2

* hectares below water level based on municipalities data

Secondary dike failure

The area affected was assumed to be 1/10 of the area affected by primary dike failure. This value is based on case study of Veen at al. (2005).

Damage per hectare

Damage per hectare is equal to value of the damaged crop. Value of the crop is based on the study of Waarts and Vrouwenvelder (2004) like in case of windstorm losses (table 4.20)

Table 4.20 Production value per hectare

	area		average inundation	produce	damage
crop	(ha)	(%)	(m)	(€/ha)	(M€)
grassland	36 094	71.4	1.75	900	32
glasshouse horticulture	3 494	6.9	2.35	225 000	786
cereals	2 394	4.7	3.32	900	21
potato (edible)	2 006	4.0	3.41	4 500	9
maize	1 413	2.8	2.14	900	1
sugar beets	1 144	2.3	3.30	2 800	3
orchard	100	0.2	2.92	11 500	1
total					835

Source: Waarts and Vrouwenvelder, 2004

The calculated damages given in Table 4.20 cannot be verified due to a lack of data. Waarts and Vrouwenvelder (2004), flood damage to crops was assessed by multiplying flooded areas with average crop yields. The product varied from 900 EUR/ha (cereals) to 30,000 EUR/ha (flower bulbs). In glasshouse horticulture, flooding damage reaches a maximum at 0.5 m flood depth. For flooding events less than 72 hours, the damage is assessed to be 50%; for longer periods 100%. Yield losses range from 185,000 EUR/ha for vegetables to 275,000 EUR/ha for pot- and bed-plants. Similarly to windstorm losses the average value was based on the weighted average and was equal to 217,700 EUR.

Secondary dike failure

For secondary dike failure the damage per hectare would be significantly lower then in case of primary dike failure because the level of water in secondary canals is managed by people. That means in case of failure water can be stopped and the flooding is expected not to last longer then 24 hours. That is why damage is assumed to be medium for all area affected.

Extreme rainfall

To calculate the damage in case of extreme rainfall the specific case of 1998 was used. Table 4.21 shows the damage to glasshouses in that year.

Table 4.21 Governmental payments for flooding damage in 1998

	N-Br	Ov	Dr	Gr	Ze	N-H	Z-H	Fl	Other	TOTAL
WTS1										
Flowers, plants	174,535				107,987		4,019,474		7,617	4,309,613
Veg.	77,673						3,768,503			3,846,176
WTS2										
Flowers, plants		1,917	63,331	32,322		540,020		423,494		1,061,085
Veg.		2,090	17,427			29,163		1,945		50,625
total:	252,208	4,007	80,759	32,322	107,987	569,183	7,787,977	425,439	7,617	**9,267,498**

Source: Ministry of Agriculture, Nature and Food Quality, personal communication

Based on that data the assumption is made that the most likely rainfall will trigger the damage of 9,267,500 EUR.

Parameterization of risk model and results

The given above information was used to create a model to estimate the expected flooding losses. The model combines losses from primary and secondary dike failure as well as rainfall.

Table 4.22 Input variables for flooding damage estimations

variable	unit	risk function	source	parameterization	
probability of primary dike failure per year	number	Poisson	Floris project safety standars	per province table 4.16	
probability of secondary dike failure per year	number	Poisson	safety standards Veen at al. (2005)	0.01 per province	
probability of occurance of rainfall damage per year	number	Poisson	safety standards	1/50	
area affected from primary dike failure heavily medium	number	deterministic	assumption based on Veen at al. (2005) & Mannen and Brinkhuis (2005)	per province table 4.19	
area affected from secondary dike fialure medium	number	deterministic	assumption based on Veen at al. (2005) Mannen and Brinkhuis (2005)	1/10 of area affected from primary dike failure	
number of hectares below water level	hectares	deterministic	CBS	per province table 4.19	
damage from rainfall per event	EUR	triangular	governmental payments in 1998	min* m. likely max	4,633,750.00 9,267,500.00 13,901,250.00

* min, max assumed to be +/- 50%

Table 4.23 Estimated distribution of flooding losses

	Primary dike failure	secondary dike failure	rainfall	Sum of flooding damage
Minimum	-	-	-	-
Mean*	447,751.90	305,389.30	188,084.40	910,002.80
Maximum	366,318,400.00	24,904,510.00	26,665,760.00	366,417,100.00
Std Dev	5,991,450.00	2,452,248.00	1,358,704.00	5,559,117.00
Skewness	48.02	9.48	7.62	32.57
Kurtosis	2,809.25	93.04	66.21	1,910.57
50%**	-	-		-
75%	-	-		-
90%	-	-		1,480,220.00
95%	2,929,051.00	284,637.30		3,923,904.00
99%	3,847,711.00	4,765,668.00	9,263,265.00	24,421,230.00

*values in EUR
** Cumulative values of probability distribution

Annual expected flooding losses are equal to 910,000 EUR. That is much less then windstorm losses. The reason behind it is very low probability of occurrence.

Flooding can not be insured and the change in the flooding exposure is not required to meet the research objectives. That is why future scenarios were not built for flooding damage.

4.6. Biohazards

Pest control is vital for producers of greenhouse crops that are subject to aesthetic damage by arthropods (insects and mites).

Achieving disease free products in glasshouse industry requires lots of attention form the growers. Integrated pest management (IPM) is a cornerstone of the industry. The strategies include sanitation, clean stock, host resistance and control through biological, cultural, environmental chemical and regulatory means. Breeding selection and biotechnology can provide crops resistant to the pathogens. On the other hand introduction of new species and new production techniques creates opportunity for pathogens as well.

Plant health management is major concern for both ornamentals and vegetable sectors. Vegetables are matter of strict food safety regulations. In case of ornamentals the sale ability is directly related to the visual attractiveness of flowers stems and leaves.

Types of hazard

There are two main sources of biological threat to glasshouse production. First one is the result of the progressing globalization and intensive trade. The seeds or plants can be produced thousands of kilometers from the place they are finished and sold. This foreign trade can bring new types of pathogens which are not controlled on regular basis. Although the probability of establishing new colony in new environment is relatively small the potential costs can be very high.

Second source of threat is not proper treatment and protection by grower or supplier. Despite intensive control on all stages production chain (especially the supplier stage) there is a risk of contamination. For example soil particles in the greenhouse moved by grower activity may be a source of Pythum or Rhizoctonia and dead leaves are the base for Botrytis cinerea.

The reason for that is dynamic environment of production conditions resulting introduction of new technologies and production processes.

There are few main threats for the glasshouse plants. Their brief description is included in appendix

Probability of occurrence

The calculations of probability of outbreak are based on historical data. The number of outbreak in years (1992 – 1999) is presented in table 4.24.

Table 4.24 Number of outbreaks of harmful organisms in greenhouse crops in Netherlands

organism	crop	1992	1993	1994	1995	1996	1997	1998	1999
Japanese rust	chrysanthemum								
Radopholus similis	plant materials								
Opogona sacchari	plant materials							7	1
Liriomyza soorten	plant materials								1
Bemisia tabaci	plant materials								2
Thrips palmi	Fichus	3		8	22	3		1	7
Ralstonia solanacearum ras 1	Curcuma		2		5	7	3		6
Ralstonia solanacearum ras 3	Tomatoes					1			1
Helicoverpa armigera	Dianthus Lisianthus						1	2	
Tabakskringvlekkenvirus	Lobelia						5		
Xanthomonas dieffenbachiae	Anthurium					1	6	7	2
Xanthomonas fragariae	strawberry					4	1		1
Clavibacter michiganensis	Tomatoes		2	1	1	12	4	3	
Spodoptera litura	plant materials	4	5		1	12	4	3	1
Rhizoecus hibisci	Bonsai								7
Xiphinema americanum	Buxus								4
Oligonychus perditus	Juniperus bonsai	1						3	1
Anoptophora chinensis	Acer bonsai							1	1
total		8	9	9	29	40	24	27	35

Source: Mutual Insurance Organization for Horticulture Sector (FYTO)

Based on the result from the table the assumption can be made on general frequency of crop damage due to biological exposures. The average number of greenhouses affected yearly is approximately 22.6. Approximately 8 were affected seriously (Opogona sacchari – banana moth).

Vulnerability

The difficulties with assessing the losses due to biological threats are result of variety of perils. Not only they attack different plants but also are cause to much different level of damage. In some cases the total production is removed including plant material (banana moth). In other contamination leads only to lower yields (dagger nematode).

That is why the assumption has been made that the overall damage from biohazard. The peril was divided into two categories – general and serious outbreaks. First one is less harmful and results in lower yields and additional pesticides costs. These costs were based on study of MacLeod et al. (2004) and were assumed to be 5 to 15 % loss of turnover. Second group represents serious threat which results in loss of the total turnover for the infected greenhouse.

Parameterization of risk model and results

Information was combined to estimate the biohazard losses. Table 4.25 presents the input parameters of the model and table 4.26 shows the results.

Table 4.25 Input variables for biohazard losses estimations

variable	unit	risk function	source	description	parameterization
number of farms with medium damage due to biohazard yearly	number	triangular	FYTO		8; 22.6; 33
occurrence of serious disease outbreak	number	poisson	FYTO		1/7
decrease of yield due to biohazard	percentage	Uniform	MacLeod et al. 2004		5; 10; 15
number of affected greenhouse due to serious outbreak	number	triangular	FYTE		1; 7; 15
Average size of greenhouse	hectare	triangular	CBS	current future	0.25; 1.22; 2 1.5; 2.5; 3.25

Table 4.26 Estimated biohazard losses

	biohazard medium damage	serious outbreak	Sum of biohazard damage	future scenario
Minimum*	48,585.04	-	48,585.04	180,220.10
Mean	400,433.10	272,996.60	673,429.70	1,414,216.00
Maximum	1,284,077.00	9,325,745.00	10,162,310.00	18,569,290.00
Std Dev	181,232.40	816,887.60	837,808.40	1,697,669.00
Skewness	0.75	3.73	3.51	3.27
Kurtosis	3.49	20.16	18.93	16.27
50%**	374,064.70	-	411,169.60	861,317.40
75%	509,273.60	-	605,613.40	1,172,211.00
90%	649,893.60	1,211,679.00	1,623,604.00	3,737,665.00
95%	741,509.20	2,173,219.00	2,589,327.00	5,478,399.00
99%	910,697.60	3,738,462.00	4,116,189.00	8,113,347.00

*values in EUR
** Cumulative values of probability distribution

The estimated annual biohazard losses are equal to 673,500 EUR, which is higher amount then in case of hail but much smaller then windstorm losses.

The future scenario was created by adjusting the average affected size of the greenhouse. The result is a strong increase of expected annual losses. They are doubled in future scenario. It is a direct consequence of much higher value at risk.

4.7. Estimation of aggregated losses to greenhouses

The analyzed perils were summed into one model. Table 4.27 shows the results of four estimations. First one is the basic scenario for current level of damage, second is the future estimations which take into account the increase in size of the greenhouses and the expected rise of variability of the damage. Last two cases include also flooding damage. Flooding is excluded from the insurance contracts, that is why it is analyzed separately.

Table 4.27 Aggregated losses to greenhouses from wind, hail, biohazard and flooding

	total damage	total damage future scenario	total damage plus flooding	total damage plus flooding future scenario
Minimum*	126,087.90	293,247.90	103,709.60	298,608.70
Mean	7,277,481.00	9,978,448.00	8,012,315.00	10,607,300.00
Maximum	323,500,100.00	397,671,400.00	370,978,000.00	371,918,600.00
Std Dev	18,988,300.00	24,789,890.00	18,861,780.00	23,989,150.00
Skewness	6.15	6.16	5.80	5.63
Kurtosis	60.94	59.61	59.58	51.12
50%**	1,058,228.00	1,768,917.00	865,900.90	2,143,974.00
75%	3,792,354.00	5,941,804.00	4,865,734.00	6,938,523.00
90%	25,180,300.00	32,382,070.00	26,855,240.00	32,736,790.00
95%	40,668,110.00	52,485,200.00	41,878,090.00	52,661,040.00
99%	85,741,980.00	113,748,100.00	87,007,470.00	109,519,000.00

*values in EUR
** Cumulative values of probability distribution

First and the most important conclusion from the analysis of the aggregated model is that the results are very similar to the windstorm damage results. Actually on average the windstorm damage accounts for more then 85% of expected total annual losses. Considering more rare events this impact is even higher.

Despite the fact that windstorm losses are in reality responsible for the biggest part of the total losses, the presented results are influenced by the way of estimation which makes this impact even larger. It is the result of using average values as input parameters. This method can exclude the extreme events (like for example serious outbreak in 100ha greenhouse). It affects the results of biohazard and hail estimations much more then windstorm. That is why it can be concluded that wind losses account for up to 85% of total losses from analyzed perils (without flooding).

The method of estimation makes the results of a total damage model a bit more flat than they are in reality. That means that the extreme events might have larger magnitude that it is presented. However the same is applied to the bottom values, what makes that the annual losses are considered accurate.

Not all the perils were analyzed. From missing perils the most important are fire and thunder damage. According to ING employees the fire risk profile might be similar to the biohazard profile. That is minor damage to several greenhouses are expected yearly and major damage ones in few years. Thunder losses are much smaller and are very small part of total losses.

The future scenario shows a significant increase in level of annual losses. It applies to scenarios with and without flooding, and for all values of probability distribution.

Overall the aggregated results show that expected annual losses to greenhouses are equal to 7,277,000 EUR and are expected to rise to 9,978,000 EUR in 2015 as a consequence of the increasing average size. Additionally increase of damage per extreme event can be expected (the events which occur less then ones per 10 years).

5. Risk financing

The last part of the research is focused on the analysis of the changes in risk profile from the insurer's point of view.

The results indicate that for analyzed types of risk (without flooding) the annual damage of 7,277,000 EUR can be currently expected. It can be assumed that together with fire and thunder losses the annual losses is expected not to exceed 8.000.000 EUR.

This assumed amount accounts for approximately 0.8 ‰ of the insured amount. The loss ratio in comparison with basic coverage premium (1.17‰) from chapter 3 is 0.68 which seems is a safe ratio for insurance companies. This value is additionally lowered by the deductibles which lower even more the payments in case of damage.

Future scenario assumed rise of the annual losses to 9,978,000 EUR. Taking account fire and thunder risks the annual loss is not likely to excide 11,000,000 EUR. In this case the expected indemnities will account for 1.09‰ which is significantly higher than in basic scenario. The annual expected loss ratio is 0.93.

It can be concluded that the changes in the greenhouse sector should result in increasing rate of insurance premiums. However the effect of the changes can be overwhelmed by technological improvements, increasing the resistance of the greenhouses to external and internal damage. These innovations are matter of technological study and were not a subject of this research.

Except the annual level of damage the important information include the distribution of extreme losses. The results of the model indicates that losses of approximately 25 million EUR can be expected every 10 years; 40 million EUR every 20 years and 86 million EUR ones on 100 years (for future scenarios these values are 32, 52.5, 114 millions respectively)

Presented figures concern the whole greenhouse sector. Analysis from the insurer's point of view requires adjusting the values by the company market share.

Company with 5 % of randomly distributed greenhouses has approximately 400 greenhouses with 500 million EUR of insured value. The average premiums paid (1.5‰) are equal to 800,000 EUR. In such case it is rather difficult to insure a new modern glasshouse of 50ha with value at risk equal to 100 million EUR.

However situation changes when the market share is rising. With 80% market share the average premiums paid yearly would be equal to 12,000,000 EUR. Taking into account that total loss has not been reported for years, taking risk of 100 million is becoming acceptable.

In general companies have two ways of dealing with high amount of risk. First one is reinsurance which is used for highly correlated perils that simultaneously affects many relations. Second is coinsurance which is used for individuals with very high insured values.

During the study the market conditions has changed what influenced the possibilities of introducing coinsurance product. These changes included:

- Merger of Avero achmea and Interpolis

- Merger of Delta Lloyed and other insurance company from Germany specialized in greenhouse insurance.

These new insurance companies changed their approach to greenhouses particularly to large glasshouses. Their larger size made it possible to accept larger amount of risk. That is why currently both Avero Achmea and Delta Lloyd are able to insure even the largest greenhouses (with surface over 20 hectares)

Results of the estimation confirmed that insuring very large greenhouse might have been considered too risky for the main insurers. The large amount of individuals businesses is required to be able to effectively pool the related risk (at least 80% of Dutch market share). However both insurers meet the currently have capacity to do that. Achmea with Interpolis probably have about 90% of Dutch market share and Delta Lloyd partner has large market share in Germany. That means that they have capacity to accept very high individual risk (such as hail or biohazard) related to large greenhouse.

However this conclusion does not apply to windstorm damage. Specification of this peril is much different (high correlation between greenhouses). Windstorm affects many individuals at the same time which can result in much larger losses then the value at risk for any individual company.

In case of greenhouses, windstorm is the most important peril which account for majority of the damage (even comparing with flooding). Nevertheless it is just small amount of total exposed value of property in the Netherlands. The greenhouses can not be analyzed separately from the other exposed property in case of windstorm. Table 5.1 shows the estimations of the windstorm losses in Europe.

Table 5.1 Probability of windstorm market losses in Europe

Windstorm market loss in €bn	Belgium*	Denmark*	France*	Germany*	Great Britain*	Netherlands*	Europe*
0.5	15–20	8–12	8–12	3–6	2–4	8–12	<1
1.0	40–60	20–40	12–15	8–12	8–12	15–20	1
2.5	>150	80–100	30–50	20–40	15–20	50–80	3–5
5.0			60–80	70–90	20–40	>100	8–12
10.0					70–90		20–30

*Return periods in years
Source: Munich Re, Geo Risks Research Department.

The windstorm losses to greenhouses account for only small part of total losses which is expected to exceed 1 billion EUR every 15-20 years. Both major insurers provide coverage to large part of the exposed property. That is why introducing coinsurance contract for greenhouses would not result in significant decrease of burden of indemnities payments for windstorm losses.

For this type of perils insurance companies buy coverage at major re-insurers. All losses exceeding certain level are being paid back by re-insurer. In this type of agreement there is no difference between greenhouses, homeowners or warehouses. Reinsurance agreements are widely used for coverage this type of correlated risk.

To sum up the major conclusion from the risk model and the analysis of the possible risk financing practices is that there are rather no opportunities for coinsurance contracts for large glasshouses. The current insurance offer even is not perfect (only 2-3 insurers) but provides sufficient coverage for large greenhouses.

ING business perspective

This part is focused on ING business perspective of the outcomes.

Complexity of the greenhouse insurance market is the first conclusion that can be derived from the analysis of the perils and exposures. There many different perils and exposures. The general groups can be identified like windstorm or hail losses but it is just a part of the whole spectrum of perils. This paper was aimed to identify and analyze the main threats but due to lack of damage records it appeared to be impossible for many perils. Complex knowledge about risks is kept within insurance companies and is almost impossible to derive precise figures that can be used for analysis, from general sources. That is why the perils like fire damage or breaking down of installations were not analyzed.

What is more, currently greenhouses differ strongly in terms of construction features as well as installations within the greenhouse. Precise valuating of this property as well as related risks involved requires high level of technical expertise. The average values can be derived from general sources but that underestimate the true differences between insured relations. In fact variance of the values of greenhouses is much higher then in any other group of primary agriculture producers.

The only way of dealing with the complexity of the exposures is to build own damage record. Damage record of the clients could be stored on regular basis. Knowledge of the losses in the past in ING is now kept only on the local level in the data of primary insurance consultants. The aggregation of this information to central level can bring certain advantages in the future. First of all we build own knowledge center that as addition to this report can be used in future to facilitate clients by choosing the best coverage based on risk/cost comparison. Additionally ING would get a tool which could be used in negotiations of the premiums with insurance companies. The information about non damage policies in the past of the greenhouse (or greenhouses located near by) can be used to negotiate lower premiums with underwriters. This rule can be applied also for coinsurance product.

The direct incentive for ING for introduction of coinsurance contract is not longer valid because of the changes in the insurance providers. There no financial incentives for introducing this type of product for insurance companies. That is why non-financial incentives are compared in order to provide possible usage of such product.

First general incentive is related to strategic approach of ING. Coinsurance contract in comparison to normal policies carry more cost for creating individual policy. This cost can be justified by strategic purposes. ING can build its own brand by offering policies with its own name. Even if it increases the overall costs in longer term it can bring other then financial, marketing benefits.

Standard coinsurance policy for all clients is a very promising argument for negotiations with insurance companies. Such a standard policy means that all clients of ING will be insured by risk takers which enter the coinsurance. If the amount of clients is big enough the perspective of giving many relations to one insurance company is good basis fro negotiations of premiums and conditions. Insurance companies might consider lower premiums because it will be compensated by large amount of relations. Such approach requires good relations with insurance providers and underwriters. The damage records can be additionally used as a proof of low risk exposure of the given group.

In general, there are two main ways of creating coinsurance contract. First includes using one of the main insurers as primary insurer who serves with its expertise on the potential exposures and values. He would accept a part of the risk whereas the rest would be taken by companies from coinsurance market. The second possibility is to create the coinsurance contract based on coinsurance market companies. Both ways carry certain problems. In first case primary insurers (Avero or Delta Lloyd) might not be interested anymore because they can accept 100% of risk by themselves. The only way incentive for them is the argument presented earlier – large amount of clients. In second case the obstacle is the complexity of the insurance. To asses the risk and exposures the expertise is required. The only ways to avoid this problem is to use the independent experts who would value the greenhouse and related risks on behalf of the ING. That means additional costs for ING because currently the expertise is paid by the insurers. Other way includes using the premiums set by primary insurer as guidelines for the brokers. They can use them on the coinsurance market to create a policy. Inevitably it would lead to deteriorating a relationship with insurers in long term. In long term they would realize that the amount of policies is surprisingly low comparing to time invested.

Instead of creating a new coinsurance contract maintaining a good relationship with insurers seems more justified. ING stays between customers and policies providers. This position gives them possibility and obliges them to express the wishes of customers. That is why these wishes should be monitored (similarly to damage records) and the appropriate changes to the policies should be negotiated with the insurers. These changes can include for example adjusting available forms of own risk. For large glasshouses it is useful to insure only large damage which threatens the existence of the company. This information could be used in creating new policy by insurers not necessarily in new coinsurance product.

In current market situation coinsurance contract might not provide additional value added to ING. That is why it seems reasonable to focus on other possibilities for ING to expand their offer. The main opportunity lays rather in enhancing cross selling rather then creating new product. In the beginning of 2007 only 5.55% of agriculture clients of ING bank had insurance provided by ING as well. This is where the changes could be applied.

The example can be taken from main competitors. Rabobank clients almost entirely are insured by Interpolis. The main reason for this successful cross selling is the integration of the banking and insurance unit within the small and medium enterprise (SME) department (which in Dutch is called MKB). MKB unit is focused on identification of the common events and creating consistent packages for each event. Such event includes:

- Building a new greenhouse
- Expand the business
- Building a new greenhouse abroad
- Purchasing and installation of new equipment

For each of these events Rabobank has prepared a package offer which includes banking and insurance products that are offered to clients.

6. Conclusion and discussion

6.1 Conclusion

With regard to the size of the greenhouses in the Netherlands, there are approximately 8,600 greenhouses which own 10,500 hectares under glass. However, although the number of hectares is increasing slowly (due to lack of land), the number of greenhouses is decreasing rapidly. It is expected that it will reach 4200 greenhouses in 2015. The related average size will get doubled (from current 1.25 to 2.5 hectares). Additionally some of the greenhouses will rise to very large size (above 20 hectares). What is more business is expected to remain concentrated in one place (Westland).

With regard to the existing insurance contracts for greenhouses, it can be concluded that insurance policies are very complex with many perils, categories of coverage and different types of greenhouses and equipments. In general premiums for the greenhouse range from 1 up to 2.5 ‰, and for crop even up to 4 ‰. The value of property is calculated based on replacement value and for crop based on the average yearly turnover. Flooding is not covered in current insurance schemes.

Results of the risk analysis for wind, hail biohazard shows that in current market conditions the expected annual losses are almost 7.3 million EUR. Windstorm losses are responsible for vast majority of that amount (above 6 million EUR). Other perils despite large individual damage have small scale of occurrence which makes them much less significant. Flooding on the other hand despite the large possible value of losses, has very small probability of occurrence what keeps the expected annual losses low. Results indicated that damage of approximately 86 million EUR can be expected every 100 years.

Future scenarios showed that the expected changes in the greenhouse sector will have a significant impact on the risk exposure. The results of the aggregated model showed that the increase of the annual losses up to 10 million EUR can be expected. This rise is a consequence of the double average size of the greenhouses and related to that much larger range of damage. Additionally the values of damage for extreme events (1/10, 20, 100 years) is expected to increase (from 86 up to 113 million EUR for the 1/100 years events)

With regard to the risk financing it was concluded that the individual risk of greenhouses is too large for small insurers to handle. The value at risk might reach 100 million EUR for the largest greenhouses whereas the average premiums (assumed from analysis of the insurance contracts) from greenhouse sector accounts for 15 million EUR (1.5‰ of the insured value). The company needs many insurance policies to be able to effectively pool the risk. That means that very large market share is required.

Such high individual risk is an opportunity for the introduction of alternative insurance product like coinsurance. However the obstacle for effective introduction of this product is complexity of the greenhouse insurance contracts. High level of expertise is required. Companies that have such expertise (Delta Lloyd and Achmea/Interpolis) will not be interested - they have enough capacity (market share) to provide the coverage by themselves.

6.2 Discussion

The research questions were answered using a quantitative Monte Carlo simulation model. Model is a simplification of reality and does not capture the whole complex nature of the analyzed events. However it does give insight into crucial parameters and ranges of outcomes.

The main drawback of the research was data availability. Risk analysis is usually based on damage records. However this information was only partially available. That is why part of the parameters is based on assumptions.

Values derived from risk analysis seem rather low especially if compared with losses to greenhouses in 1990. 80% of the greenhouses had damage of 74 million EUR (Asseldonk et al.2001). This value however is in the range of the results (83 million EUR ones on 100 years)

6.3 Further research

- Further development of the Monte Carlo simulation model. The area of interest could include introduction of correlation between hazards or probabilities distribution (instead of average values).

- Research reducing complexity of the greenhouse insurance contracts so that coinsurance might be introduced.

- Analysis of more empirical data for model verification

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Appendix

Part 1. Flooding

Table the results of the Floris project for selected dike rings (detailed and global method)

Table a1, Floris results

Dike ring	Economic risk: flooding probability times economic damage [million €/year]	Consequence: average economic damage* [million €]	Consequence: victims** [number]	Annual probability of flooding
Noordoostpolder	2.1	1,900	5 - 1400	1/900
Zuid-Holland	2.3	5,800	30 - 6100	1/2500
Land van Heusden / De Maaskant	37	3,700	5 - 800	>1/100

* The average damage in the different flood scenarios.
** The margin gives the number of victims for different flood scenarios and different evacuation scenarios.

Dike ring	Economic risk: flooding probability multiplied by the economic damage [million €/year]	Consequence: maximum economic damage* [miljoen €]	Annual probability of flooding
Noordoostpolder	10 **	9,000	1/900
Zuid-Holland	116**	290,000	1/2500
Land van Heusden / De Maaskant	180**	18,000	>1/100
Terschelling	0.1	160	1/1500
Mastenbroek	12	1,200	> 1/100
Noord-Holland	116	58,000	1/500
Lopiker- en Krimpenerwaard	100	10,000	>1/100
Alblasserwaard	48	19,000	1/400
Goeree-Overflakkee	3	3,700	1/1200
Zeeuws Vlaanderen	140	14,000	>1/100
Bommelerwaard	10	2,600	1/250
Land van Maas en Waal	64	6,400	>1/100
Ooij en Millingen	0.7	1,000	1/1.400
Betuwe, Tieler- en Culemborgerwaarden	180	18,000	>1/100
Rijn en IJssel	34	6,800	1/200
Oost-Veluwe	31	3,100	>1/100

* The damage is the maximum damage which would occur if the entire dike ring area were to be flooded. This is overestimated for major dike ring areas and dike ring areas with compartments. The number of victims cannot be determined with the global method.
** The damage calculated using the detailed method appears to be much less than the damage calculated with the global method.

Source : Floris project (2001)

Table a2.
List of muncipalities assumed to be exposed to risk of dike failures

Noord Brabant	**Gelderland**	**Utrecht**
's-Hertogenbosch	Arnhem/Nijmegen	Abcoude
Aalburg	Zuidwest	Breukelen
Bergen op Zoom	Ijseelstreek	De Ronde Venen
Cuijk		Houten
Drimmelen		IJsselstein
Geertruidenberg		Maarssen
Grave		Montfoort
Heusden		Nieuwegein
Lith		Oudewater
Maasdonk		Utrecht
Moerdijk		Vianen
Oss		Wijk bij Duurstede
Steenbergen		Woerden
Werkendam		
Woudrichem		
Overijssel	**Friesland**	
steenwijkerland	All provinces except:	
Staphorst	Heerenveen	
Zwartewaterland	Ooststellingwerf	
Kampen	Opsterland	
Zwolle	Weststellingwerf	
Olst-Wijhe		
Deventer		

Calculations of probabilities from Floris study

The flood probability in the **Terschelling** dike ring area (dike ring 3) was calculated to 1/1500 per year. It has been assumed in the calculated probability of flooding that the mud flats will help to prevent piping. The most important failure mechanism is non-closure of the two hydraulic structures. More insight into the reliability of the closing procedures could lead to a reduction in the flooding probability, possibly to 1/10,000 per year.

For the **Noordoostpolder** dike ring area (dike ring 7) flooding probability is 1/900 per year. Advanced testing of hydraulic structures are expected to reduce the flooding probability to 1/3100 per year.

Mastenbroek dike ring area (dike ring 10). The calculated flooding probability is greater than 1/100 per year. Further investigation of the structure of the subsoil may help to reduce the uncertainty surrounding piping, which could result in a lower calculation of flooding probability. Further to the safety assessment, physical measures may well also be taken to reduce the probability of piping. As a result the flooding probability could be reduced to 1/400 per year.

For **Noord-Holland** (dike ring 13) flooding probability is under 1/500 per year. The dike manager was aware that the dikes and dunes have a high probability of failure in some places. In several places repair work on the dike was already in progress. The probability of non-closure of the Sas lock at Enkhuizen also contributed to the high flooding probability.

For the **Zuid-Holland** dike ring area (dike ring 14) there is relatively small flooding probability of 1/2500 per year. The most important causes of flooding in this dike ring area are failure of the boulevard at Scheveningen, piping in one of the dike sections, and failure to close some hydraulic structures on time. The dike manager acknowledges this, with the exception of the dike section with a large probability of piping. By improving the relatively weak locations the flooding probability can be reduced to 1/7000 per year.

Lopiker- en Krimpenerwaard dike ring area (dike ring 15). The calculated flooding probability is more than 1/100 per year. The flooding probability is heavily influenced by the large probabilities for non-closure of a lock, loss of stability due to uplifting, as well as piping. The calculated probability of piping is mainly due to uncertainty in the data. Further investigation may well lead to a smaller probability. By strengthening the relatively weak spots, the flooding probability can be reduced to 1/900 per year.

Alblasserwaard en Vijfheerenlanden (dike ring 16). According to the calculations the flooding probability is 1/400 per year. The main cause of the large flooding probability is the large probabilities calculated for piping. In addition, uplifting and structural failure of the locks also play a role. The manager did not think the high probability of piping likely. However, seepage has been observed at high water levels. Further investigation can show whether the probability of piping has been overestimated. The dike manager did subscribe to the result that the dikes are subject to stability problems due to uplifting.

Goeree-Overflakkee (dike ring 25), calculated flooding probability is 1/1200 per year, The main causes of flooding according to the calculations were piping, damage to the asphalt dike revetment, the height of the Flaauwe Werk dike and, to a lesser extent, non-closure of several hydraulic structures. It is not clear whether these actually are relatively weak spots because the uncertainties in the data are great. In places where the dike manager did not expect there to be a large probability of piping, these probabilities were not included in the calculation of flooding probability. For two sections of dike the calculations indicated a large probability of instability. During the statutory safety assessment in 2001 these dike sections were not approved for these reasons and measures to improve them are now being implemented. In the calculation of the flooding probability it has been assumed that these measures have been completed.

Zeeuwsch-Vlaanderen (dike ring 32). The flooding probability is largely determined by stability problems near a pumping station and close to the dikes. For a second safety assessment of the water defences the Water Board collected more information, from which it appears that the pumping station could be approved in the second test. The data for the safety assessment of the dikes is not yet available. The calculated probability may therefore be an overestimate. It is clear that stability problems constitute a real risk here because the dikes are high and steep and stand on weak layers in the subsoil. The calculated flooding probability is greater than 1/100 per year.

For **Land van Heusden/de Maaskant** (dike ring 36) the calculation results in a flooding probability of more than 1/100 per year. The flooding probability is mainly due to the high probability of piping. The dike manager endorsed these results. When further research is done on this failure mechanism and strengthening measures are taken, if necessary, the flooding probability may be reduced to 1/220 per year.

Bommelerwaard (dike ring 38). The calculated flooding probability was 1/260 per year, the economic risk. The reasons for this relatively high flooding probability are a high probability of piping (particularly at two sites where there are sand strata under the water defence) and non-closure of hydraulic structures. The dike manager confirmed this picture and will further investigate whether the condition of the hydraulic structures needs improvement and what measures will be required for this.

Land van Maas en Waal dike ring area (dike ring 41). According to the calculations the flooding probability is greater than 1/100 per year. The reasons for the calculated high flooding probability are relatively large probabilities of piping and for the non-closure and structural failure of hydraulic structures. The dike manager confirmed this picture.

Ooij en Millingen (dike ring 42). Calculated flooding probability is 1/1,400 per year. In this dike ring overflow and overtopping is the indicative failure mechanism for a flood. The dike manager agreed with this picture.

Betuwe, Tieler- en Culemborgerwaarden dike ring area (dike ring 43). The calculated flooding probability is greater than 1/100 per year. Originally, relatively large flooding probabilities were calculated for the failure mechanism piping. The reason for this was major uncertainties in the data. The dike manager did not think that these problems applied at the sites in question. Therefore it was decided to exclude this probability of failure in the calculation of the flooding probability. Investigation of the soil structure could show whether there is a risk due to the failure mechanism of piping. Other reasons for the relatively large flooding probability are the large probability of structural failure and non-closure of some hydraulic structures. The dike manager acknowledged this and has started an investigation of the hydraulic structure with stability problems.

Rijn en IJssel (dike ring 48). Calculated flooding probability is 1/200 per year. The flooding probability is largely determined by the high probability of piping. In this case it would appear that this high probability cannot be put down to uncertainty about the soil data. Other causes for the relatively high flooding probability are the high probability of structural failure of three hydraulic structures and non-closure of two hydraulic structures.

In **Oost-Veluwe** (dike ring 52) the calculated flooding probability is more than 1/100 per year. The most significant contribution to the flooding probability comes from piping in a number of dike sections. Overflow and overtopping also play a role and, to lesser extent, non-closure of the Nieuwe Wetering discharge sluice. The dike manager confirmed some of this. If measures were to be taken in the dike section with the high probability of failure for overflow and overtopping, the flooding probability could be reduced to 1/250 per year.

Part 2. Detailed review of the insurance contracts

Table a3. Review of insurance contracts of Delta Lloyd

		Case 1		Case 2	Case 3	Case 4			
	Location	Waddinxveen		Bergschenhoek	Waddinxveen	Hensbroek			
	Type	Venlo	Venlo	breedkap	Venlo	breedkap	breedkap	breedkap	bree. met kantine
	Size: (m2)	4,019	5,760	37,581	17,224	16,000			
	Crop	Gerbera		Orchid	Rozen	Flowers and Tulips			
Glasshouse	Construction:	NEN 3859	aluminum	NEN 3859	NEN 3859	NEN 3859			
	Value: (EUR)	190,500	234,800	4,298,300	895,200	194,200	176,900	204,600	883,800
	C: (‰)	1.17	2.7	-	1.4	-	-	-	-
	E: (‰)	0.13	0.23	-	-	-	-	-	-
	F: (‰)	0.09	0.09	-	-	-	-	-	-
	G: (‰)	0.04	0.04	-	-	-	-	-	-
	Premium ratio paid(‰):	(C+E) 1.3	2.93	(C+G) 1.52	1.4	(C,E,G) 1.89	(C,E,G) 1.44	(C,E,G) 1.44	1.44
	Basis premium paid(EUR)	247.65	687.96	6,533.42	1.253	367.03	254.73	294.62	1,272.67
Building	Value: (EUR)	144,900		1,115,000	258,000	15,300	86,300	29,800	138,000
	C: (‰)	1.13		1.06	1.25				
	F: (‰)	0.13		0.09					
	G: (‰)	0.13		0.14					
	Premium ratio paid(‰):	(C+F) 1.26		1.06	1.25	(C+G) 1.26	(C+G) 1.26	(C+G) 1.26	(C+G) 1.26
	Basis premium paid(EUR)	182.57		1181.9	322.75	19.27	108.73	37.54	173.88
Heating installation	Value: (EUR)	199,500		751,700	348,200	275,000			
	C: (‰)	1.35		-	1.5				
	D: (‰)	0.9		-					
	E: (‰)	0.18		-					
	F: (‰)	0.18		-					
	Premium ratio paid(‰):	(C+D+E) 2.7		(C+G) 1.44	1.5	(C,D,F,G) 2.16			
	Basis premium paid(EUR)	538.65		1,082.45	522.3	594			
Water installation	Value: (EUR)	55,000		490,000	86,000	55,000			
	C: (‰)	1.58		-	1.75				
	E: (‰)	1.8		-					
	F: (‰)	0.18		-					
	G: (‰)	0.18		-					
	Premium ratio paid(‰):	1.58		(C+G) 1.82	1.75	(C,E,F,G) 3.74			
	Basis premium paid(EUR)	86.9		891.8	150.5	205.7			
Screens installation	Value: (EUR)	86,000		915,000	85,000	168,000			
	C: (‰)	1.71		-	1.9				
	E: (‰)	0.9		-					
	F: (‰)	0.18		-					
	G: (‰)	0.18		-					
	Premium ratio paid(‰):	1.71		(C+E+G) 2.63	1.9	(C,E,F,G) 2.97			
	Basis premium paid(EUR)	147.06		2,406.45	161.5	498.96			
Electric installation	Value: (EUR)	61,000		1,250,000	550,000	49,500			
	C: (‰)	1.35		-		1.94			
	E: (‰)	0.23		-					
	F: (‰)	0.45		-					
	G: (‰)	0.18		-					
	Premium ratio paid(‰):	1.35		(C,E,F,G) 2.07	(C+F) 2.00	(C,E,F,G) 1.94			
	Basis premium paid(EUR)	82.35		2,587.50	1,100	96.03			
Automatic equipment	Value: (EUR)	47,500		150,000	50,000	38,000			
	C: (‰)	1.71		-					
	E: (‰)	4.05		-					
	F: (‰)	0.72		-					
	G: (‰)	0.18		-					
	Premium ratio paid(‰):	(C,E,F,G) 6.66		(C,E,F,G) 6.08	(C+G) 2.10	(C,E,F,G) 6.66			
	Basis premium paid(EUR)	316.35		912	105	253.08			
Inventory and equipment	Value: (EUR)	79,500		75,000	50,000	115,000			
	C: (‰)	2			2.2				
	F: (‰)	0.72							
	G: (‰)	0.18							
	Premium ratio paid(‰):	2		(C+F) 2.52	2.2	(C,F,G) 2.88			
	Basis premium paid(EUR)	159		189	110	331.2			

…

…continuation review of Delta Lloyd contracts

Stocks	Value: (EUR)	15,000			
	C: (‰)	2			
	F: (‰)	0.72			
	G: (‰)	0.18			
	Premium ratio paid(‰):	2			
	Basis premium paid(EUR)	30			
Cleaning cost	Value: (EUR)	100,000	600,000	255,400	203,800
	Premium ratio paid(‰):	2.1	1.35	1.5	(C+G) 1.35
	Basis premium paid(EUR)	210	810	383.1	275.13
Extra cost	Value: (EUR)	100,000			
	Premium ratio paid(‰):	2.1			
	Basis premium paid(EUR)	210			
Cooling instalation	Value: (EUR)		1,249,700		
	C: (‰)		-		
	F: (‰)		-		
	G: (‰)		-		
	Premium ratio paid(‰):		(C+G) 1.44		
	Basis premium paid(EUR)		1,799.57		
cutting tables	Value: (EUR)		800,000		
	C: (‰)		0.51		
	E: (‰)		0.25		
	F: (‰)		0.04		
	G: (‰)		0.08		
	Premium ratio paid(‰):		0.51		
	Basis premium paid(EUR)		408		
Heating center	Value: (EUR)		835,000		
	A: (‰)		-		
	E: (‰)		-		
	F: (‰)		-		
	G: (‰)		-		
	Premium ratio paid(‰):		(A+G) 1.36		
	Basis premium paid(EUR)		1,135.60		
Internal transport	Value: (EUR)		1,500,000		
	C: (‰)		1.69		
	E: (‰)		1.27		
	F: (‰)		0.17		
	G: (‰)		0.17		
	Premium ratio paid(‰):		1.69		
	Basis premium paid(EUR)		2,535		
Packing line	Value: (EUR)		1,300,000		
	C: (‰)		1.69		
	E: (‰)		1.27		
	F: (‰)		0.17		
	G: (‰)		0.17		
	Premium ratio paid(‰):		1.69		
	Basis premium paid(EUR)		2,197		
Plant machine	Value: (EUR)				45,000
	C: (‰)				
	E: (‰)				
	F: (‰)				
	G: (‰)				
	Premium ratio paid(‰):				(C,F,G) 2.34
	Basis premium paid(EUR)				105.3

Source: ING Risk and Consultancy, 2006

Summary of insurance contracts of 4 companies with information about value of property and premiums paid.

Insured perils:

A – Fire, thunder, explosion, implosion, and damage from plain accidents

B – A and storm, hail and snow pressure damage

C – B and escape of steam, liquids, precipitation damage, (road and water damage)

D – “Droogstoken of ketelinstallatie” only with combination with C

E – Other damage from external perils and failure of equipment

F – Vandalism, damaged and stolen property

G – Induction damage as a result of thunder

F – Damage from hail to garden centre from 1 April to 31 October

Table a4. Review of insurance contracts of Achmea

		Case 1		Case 2			
Glasshouse		A	B				
	type	breedkap	breedkap + foliedek	breedkap			
	size						
	Broeiglas	82,966.90	130,582.15	835,704.00			
	opstallen	113,639.73	189,820.80	713,100.00			
	apparatuur	149,127.86	126,301.50	3,215,875.00			
		345,734.49	446,704.45	4,764,679.00			
	monthly	97.28	305.51	806.30			
	yearly	1,167.36	3,666.12	9,675.60			
	premium ratio	3.38	8.21	2.03			
	coverage	all external risks*	all external risk	all external risk			
	cleaning costs	+10%cleaning costs*	+10%cleaning costs	+10%cleaning costs			
Buildings							
	value	38,717.00	8,470.00	659,336.00	98,012.00	39,127.00	286,774.00
	monthly	5.58	1.62	90.68	13.42	5.67	39.13
	yearly	66.96	19.44	1,088.16	161.04	68.04	469.56
	premium ratio	1.73	2.30	1.65	1.64	1.74	1.64
	coverage	A*	A	A and B*	A and B	A and B	A and B
	cleaning costs	+10%cleaning costs	+10%cleaning costs	+10%cleaning costs	+10%cleaning costs	+10%cleaning costs	+10%cleaning costs
	value	17,316.00		83,336.00	2,928,873.00	307,305.00	82,797.00
	monthly	4.33		11.47	403.72	42.27	13.45
	yearly	51.96		137.64	4,844.64	507.24	161.40
	premium ratio	3.00		1.65	1.65	1.65	1.95
	coverage	A		A and B	A and B	A and B	A and B
	cleaning costs	+10%cleaning costs		+10%cleaning costs	+10%cleaning costs	+10%cleaning costs	+10%cleaning costs
	value			426,129.00	800,000.00	250,000.00	
	monthly			58.64	110.00	34.37	
	yearly			703.68	1,320.00	412.44	
	premium ratio			1.65	1.65	1.65	
	coverage			A and B	A and B	A and B	
	cleaning costs			+10%cleaning costs	+10%cleaning costs	+10%cleaning costs	
Crop	value	1,000,000.00	100,000.00	50,000.00			
	monthly	355.00	23.10	25.65			
	yearly	4,260.00	277.20	307.80			
	premium ratio	4.26	2.77	6.16			
	coverage	A and C	A and C	A and C			
Equipment							
Inventory	value	339,654.50	131,596.26	936,000.00			
Stock	monthly	101.82	30.92	121.65			
	yearly	1,221.84	371.04	1,459.80			
	premium ratio	3.60	2.82	1.56			
	coverage	-	-				
Electronics	value	10,663.84	4,764.69	8,600.00			
	monthly	6.13	5.67	4.77			
	yearly	73.56	68.04	57.20			
	premium ratio	6.90	14.28	6.65			
	coverage						
Turnover	value	600,000.00		500,000.00	400,000.00		
	monthly	137.50		81.45	65.00		
	yearly	1,650.00		977.40	780.00		
	premium ratio	2.75		1.95	1.95		
Extra costa							
	value	22,689.01					
	monthly	4.25					
	yearly	51.00					
	premium ratio	2.25					

Source: ING Risk and Consultancy, 2006

Summary of insurance contracts of 4 companies with information about value of property and premiums paid.

*Insured perils:

A – Fire, thunder, explosion, implosion, and damage from plain accidents
B – A and storm, hail and snow pressure damage….
C – B and escape of steam, liquids, precipitation damage, (road and water damage)
D – “Droogstoken of ketelinstallatie” only with combination with C
E – Other damage from external perils and failure of equipment
F – Vandalism, damaged and stolen property
G – Induction damage as a result of thunder

Part 3. Biohazard characteristics

Opogona sacchari (banana moth)
O. sacchari has a wide host range, and is found mainly in the tropics on bananas, pineapples, bamboo, maize and sugarcane, in the field and on various stored tubers. In glasshouses in European countries, it has been found infesting various tropical or subtropical ornamentals, including mainly Cactaceae, *Dracaena*, *Strelitzia* and *Yucca* In Netherlands it can be found only in glasshouses, brought by the international trade in the propagation material of the host plants. When an greenhouse is affected it is cleared and replanted and the soil should be steamed (or removed) to eliminate any residual pupae.

Liriomyza
The vegetable leafminer, *Liriomyza sativae* Blanchard, is found commonly in the southern United States from Florida to California and Hawaii, and in most of Central and South America. It cannot survive cold areas except in greenhouses.

Bemisia tabaci (Tobacco whitefly, sweet potato whitefly, cotton whitefly)
Until recently, *B. tabaci* was mainly known as a pest of field crops in tropical and sub-tropical countries: cassava, cotton, sweet potatoes, tobacco and tomatoes. Recently *B. tabaci* has become a pest of glasshouse crops in many parts of the world, especially *Capsicum*, courgettes, cucumbers, *Hibiscus*, *Gerbera*, *Gloxinia*, lettuces, poinsettia. *B. tabaci* moves readily from one host species to another and is estimated as having a host range of around 600 species In Netherlands is limited only to glasshouses, but taking into account the outbreaks in other Northern countries the similar one in Netherland is possible.

The feeding of adults and nymphs causes chlorite spots to appear on the surface of the leaves. Depending on the level of infestation, these spots may coalesce until the whole of the leaf is yellow, apart from the area immediately around the veins. With heavy infestations, plant height, number of internodes and quality and quantity of yield can be affected (e.g. in cotton).
B. tabaci is the vector of over 60 plant viruses The geminiviruses are by far the most important agriculturally, causing yield losses to crops of between 20 and 100% Tomato crops throughout the world are particularly susceptible to many different geminiviruses, and in most cases exhibit yellow leaf curl symptoms

Thrips palmi (melon thrips)
It has the potential to infest greenhouse crops widely, but under field conditions its distribution likely will be limited to tropical areas. Among vegetables injured are bean, cabbage, cantaloupe, chili, Chinese cabbage, cowpea, cucumber, bean, eggplant, lettuce, melon, okra, onion, pea, pepper, potato, pumpkin, squash, and watermelon. Tomato is reported to be a host in the Caribbean, but not in the United States or Japan. Tsai et al. (1995) reported that cucurbits were more suitable than eggplant, whereas pepper was less suitable than eggplant. Other crops infested include avocado, carnation, chrysanthemum, citrus, cotton, hibiscus, mango, peach, plum, soybean, tobacco, and others. Melon thrips cause severe injury to infested plants. Leaves become yellow, white or brown, and then crinkle and die. Heavily infested fields sometimes acquire a bronze colour. Damaged terminal growth may be discoloured, stunted, and deformed.

Ralstonia solanacearum
Race 1 occurs in tropical areas all over the world and attacks tobacco, many other solanaceous crops and many hosts in other plant families. It has a high temperature optimum (35 °C, as do

race 2, 4 and 5). Race 2 occurs mainly in tropical areas of South America and attacks bananas and *Heliconia* (causing socalled Moko disease), but also in the Philippines (causing so-called bugtok disease on plantains). Race 3, occurring at higher altitudes in the tropics and in subtropical and temperate areas attacks mainly potato and tomato. Race 4 is particularly aggressive on ginger, race 5 (biovar 5) is specialized on *Morus* .

Helicoverpa armigera (Old World (African) bollworm, corn earworm, cotton bollworm)
It is currently placed on Annex I A II of Council Directive 2000/29/EC, meaning that it is considered to be a phytosanitary risk to the whole of the EU and that phytosanitary measures are required when it is found on any plants or plant products. EU Member states, in particular The Netherlands and United Kingdom, frequently intercept *H. armigera* on imported produce (especially *Dianthus* and *Rosa* cut flowers, *Phaseolus, Pisum* and *Zea mays*) and on some ornamental cuttings. These imports often originate from Third Countries. However, *H. armigera* is already widely present in some EC members such as Greece, Portugal and Spain and present though less widespread in many more such as Austria, Czech Republic, France, Germany, Hungary, Italy and Lithuania. Furthermore,

H. armigera is a highly polyphagous species. The most important crop hosts of which *H. armigera* is a major pest are tomato, cotton, pigeon pea, chickpea, sorghum and cowpea; other hosts include groundnut, okra, peas, field beans, soybeans, lucerne, *Phaseolus* spp., other Leguminosae, tobacco, potatoes, maize, flax, a number of fruits (Prunus, Citrus), forest trees and a range of vegetable crops (CAB, 2006).

Tobacco Ringspot Virus (TRSV) (Tabakskringvlekkenvirus)
TRSV gives damage to different kind of plants: *Vaccinium spp*., grape, *Gladiolus, Iris, Lilium, Narcissus, Petunia, Pelargonium* and *tulips.* It results in growing disorders and grow reduction and it gives spots and rings on the leaves. If there is a infection, the Plant Service standard destroys the party/badge.

Xanthomonas axonopodis pv. *Dieffenbachiae* (Bacterial blight of aroids, anthurium blight)
Natural hosts are ornamental foliage plants On *Aglaeonema* and *Anthurium,* the disease has two stages (leaf infection and systemic infection),. Systemically infected leaves or flowers easily break off and may show dark-brown streaks at their base, which gradually enlarge. When petioles are cut, yellow-brown vascular bundles are visible. Eventually the entire plant is killed.

Xanthomonas fragariae (Angular leaf spot)
X. fragariae was first described in 1962 in North America. It probably spread from there, with planting material, to other continents but this is only a presumption. Locally present in many European countries

Clavibacter michiganensis subsp. *michiganensis (*Bacterial canker, bird's eye)
The main host of economic importance is tomatoes, but the pathogen has also been reported on other plants. Recently it has been also reporteded presence on wheat, barley, rye, oats, sunflowers, watermelons and cucumbers as hosts on artificial stem inoculation. In the EPPO region, the main host is tomato, while some susceptible solanaceous weeds could be potential reservoirs of the pathogen.

Spodoptera littoralis (Cotton worm, African cotton leafworm)

In Italy, mostly found in glasshouses where it causes damage to plant and flower production, recognizable by the large bites taken out of leaves. In Sicily, vegetables and fodder crops are affected, as well as maize. In North Africa, industrial production (tomato, capsicum, cotton, maize) and vegetables are affected. In Egypt, it is one of the most serious cotton pests.

Rhizoecus hibisci root mealybug
The literature mainly refers to pot plants (especially bonsais). Most such records are on the bonsai plant. Other hosts include ornamentals, foliage plants. In all, 20 plant families are represented. It has spread to a limited extent to North America and Europe. Damage by the root mealybug is nonspecific in that the most common symptoms are slow plant growth, lack of vigor and subsequent death. Root mealybug is not evident unless the root ball is examined by removing the plant's pot. White, waxy substance and adult females will be noticeable especially between the pot and root ball

Xiphinema americanum The Dagger nematode
Dagger nematodes cause root stunting and tip galling. In addition, as virus vectors they can be damaging at very low population levels. Enlarged root tips and feeder roots may occur which could result in a 'witches' broom' effect on the root. Yields may be reduced when nematode populations reach high levels. It has a wide host range including strawberries, soybeans, forest trees (spruce, pine, etc.), perennial orchards as well as grape. Chemical control is effective in protecting new roots from nematode feeding until they can become established.