Climatic Risk Analysis in Horticulture – a Methodological Approach in Hungary

Ladányi, M., Gaál, M., Hegedüs, A., Szenteleki, K.
Corvinus University of Budapest, Department of Mathematics and Informatics
Villányi út 29-43. H-1118 Budapest, Hungary, e-mail: marta.ladanyi@uni-corvinus.hu

ABSTRACT

Experts of risk analysis aim to help decisions with efficient information. The decision itself is not included in their duties; nevertheless, they are responsible for confronting the decision makers with the expected consequences of their decisions. To this high standard data gained by modelling or monitoring are needed. Most of them have not yet been collected and integrated in a unique data system. One of the aims of this paper is to call the attention to the importance of common data management and joint research projects between different disciplines with a methodical summary.

Keywords: risk, horticulture, climate change, product line, modeling, Hungary

1. INTRODUCTION

Safety of agriculture and food supply are very sensitive to weather and changing climate. Hungary is situated near the border of potential production zones of several plants: at the north of corn and grapevine regions, at the south of potato, rye and berries regions.
Thus even slight changes in climate can affect agro-ecological potential seriously which involves changes in land use and production structure. Survey of the expected changes of agro-ecological potential and adaptation possibilities is of high importance.
Direct and indirect impacts of climate change, however, can be very different in different sectors or even within sectors with different sites or development stages. In horticultural sectors, moreover, risk can be very variable depending on the species/varieties diversity rate as well.

2. CLIMATIC RISK TYPES AND THEIR CONSEQUENCES

In what follows the main affecting factors with high production risk of climate change are listed. There can be strong or light correlation between the factors, themselves, which makes the analysis rather complex.

2.1 Weather Extreme Risk

Production conditions and safety are strongly depending on extreme weather events. The frequency and intensity of anomalies are expected to increase in Hungary (Bartholy et al., 2007, Révész, 2008). The most important extreme events Hungary usually faced are spring frost,

---

Ladányi, M., Gaál, M., Hegedüs, A., Szenteleki, K. "Climatic Risk Analysis in Horticulture – a Methodological Approach in Hungary". International Commission of Agricultural and Biological Engineers, Section V. Conference "Technology and Management to Increase the Efficiency in Sustainable Agricultural Systems", Rosario, Argentina, 1-4 September 2009.

drought as well as heat waves and storms such as wind storms, hail and heavy rains. These events all happened in Hungary during the year 2007 causing in agriculture and forestry damages higher than 700 thousand USD (500 thousand Euros). Weather extremes involve troubles in plant development or physiological disorders (cracking, sunburn, nutrient uptake disorder) which results production deficit and/or quality defects. Injuries caused by unbalanced water supply or hail are gaps of infections that can so occur suddenly and seriously. Milder winters are favourable for pests and diseases because of less mortality in dormancy periods which can lead to greater damages in the next vegetation period (Figure 1). In fruit plantations and vineyards unfavourable weather moreover, can cause damages not only in the current but also in the following years.

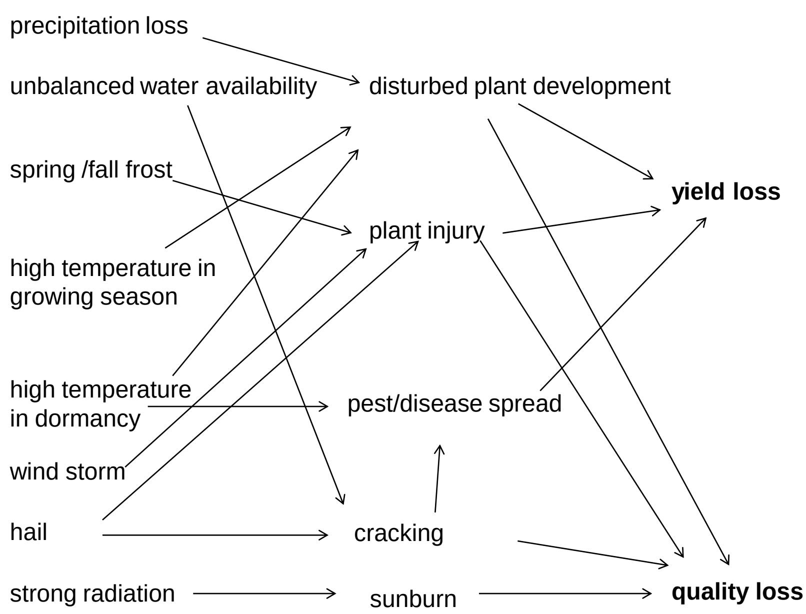

Figure 1. The most important impacts of extreme weather events.

2.2 Production Risk

Production risk is the most evident risk of agriculture. It comes from the unpredictable nature of the weather and environment which directly and significantly influences yield quality and quantity together with the production and investigation expenses as well as the production technology schedule.

Because of risk factors new types of agrotechnics can bee necessary which involves changes in production costs. Cost calculations have to contain damage prevention and mitigation as well. The issue is more on prevention because prevention costs are in most cases much less than mitigation costs. One of the most effective prevention methods is appropriate site and variety selection. Technical innovations and investments are also needed to be built in production technology which can result modified production and market structure (Figure 2).

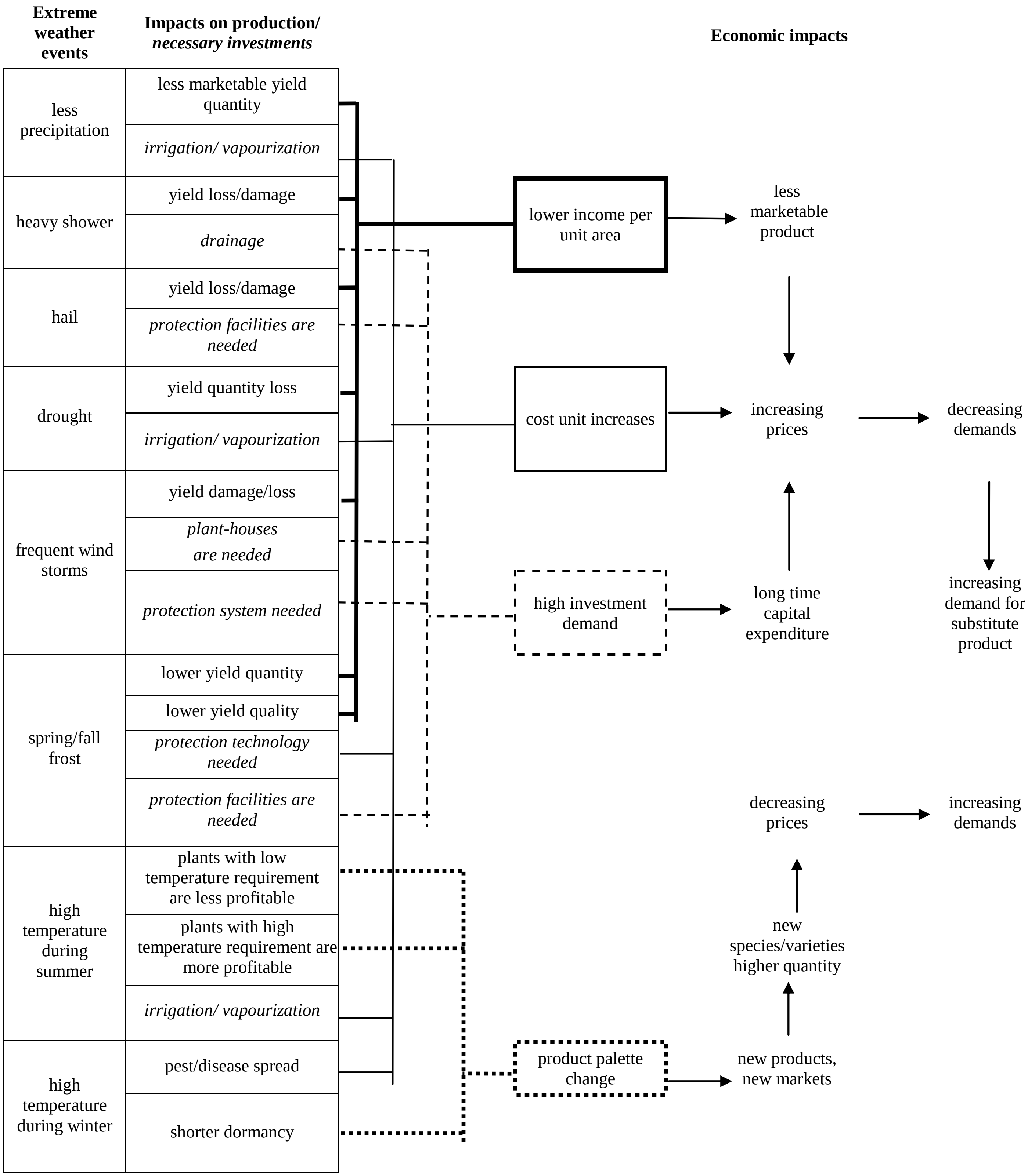

Figure 2. Risk factors and their economic impacts.

One of the reasons of production cost increase is that irrigation and vapourization become necessary even in moderately intensive cultivars as well. The yield loss caused by the expected decrease of precipitation and more frequent droughts can be mitigated this way effectively. In some regions the prevention of damages with hail and windstorm indicate expensive investments to avoid high probability yield loss. The calculations have to be executed according to site and plantation, the risk analysis have to be elicited based on observed weather, production and market data and the decision has to be made by the costs of the planned investment, too. Spring and early fall frost events should be considered as risk factors of high importance. In case of extreme high risk the ceasing of production of some varieties and/or at some sites should be deliberated.

2.3 Financial Risk

Negative effects of extreme weather events can partly be compensated by capital investments or high level technology. However, because of expensive costs, cost-benefit calculations have to be made in advance in order to decide properly on profitable varieties.

Expensive investments such as hail or wind protection or watering systems require long time capital expenditure. In most cases credit has to be raised or reserve is invoked. In both cases the liquidity of producers decreases which involves price increase. In this case the credit conditions of the bank have to be stressed much more since they are usually rather uncomfortable for the producers. This problem is expected to become more serious with economic crisis and climate change.

2.4 Market Risk

Market risks are stemming from the uncertainty of market flow, relationships and currency exchange. The point is on the local and global political and economic circumstances as well. Considering climate change in most cases its negative impacts are emphasized, however, the issue is mostly about benefit of positive impacts which involves leverage.

A way of adaptation can be the change of product palette. Sites and varieties with long time experience have to be checked whether they are suitable for production under climate change. Some varieties respond to climate change with quantity or quality loss. The question is whether producers are willing to become members of mass production market or they are able to invest for high quality productions.

Because of climate change the cost of production is expected to increase for some kinds of plants. In case in other regions these plants can be grown under more favourite circumstances with lower production costs, domestic growers can become to be at disadvantage. Porter (1979) explains that the competition takes place in a virtual ring with all the distributors of a certain product. There are four factors connected to the ring: substitution products, consumers, potential new members and producers. All the four factors are of high importance for the growers. The ring is slowly brimming and products of moderate quality level or high price level go adrift. One of the solutions in this case is to open another ring with a different product which can address a different segment of market or even gains the old consumers back. For this a very thoroughly designed system of variety and technology is needed.

In case the demand of some products decreases, the reasons can usually be found in trend or price structure. Focusing on more profitable substitution products is highly recommended in this case (Figure 2).

If the change of variety and/or technology is executed along a well-designed and thoroughly-proved decision analysis, the value of a production can increase with climate change. Despite of increasing production costs and prices productions can remain profitable if quality is highly respected.
New technology requires new approach with focusing on quality instead on quantity. Growers of products of high quality even with higher prices can manage cost and price increase more flexibly than those of cheaper mass productions.

2.5 Personal Risk

People who are involved in production can also be a source of risk. Life crises, death, prolonged illness etc. can endanger the profitability of the business. Amongst other factors, weather anomalies can also induce risk both directly and indirectly (epidemic).

2.6 Political Risk

The risk of unfavourable policy changes is of high importance for the growers, for the distributors and indirectly for the whole nation. According to an international study in which the representatives of 50 great companies were interviewed (KPMG, 2008) in most sectors the climatic risk factors concerned have not yet been recognized. The operational risk with controlling origin is considered much more important than the impacts of climate change.

3. RISK ANALYSIS IN AGRICULTURE

The fact of increasing risk caused by climate change is generally accepted though the way of risk elicitation is quite complex. The simplest way to define agricultural risk is to express it as an appropriate function of production quantity, quality or loss (Erdélyi et al., 2006). Note that also extremely high production involves market risk.
For the comparison of the rates of risk a widely used method, the so-called *E,V*-efficiency criterion can be applied. It is based on a very simple proposition, namely if there are two time series with production expectations $E_1 \geq E_2$ and variances $V_1 \leq V_2$ (where at least one of the relations is strict), than the first one is less risky. However, in most cases there is no entire ordering between the alternatives.
In risk analysis we regularly compare distribution functions by stochastic dominance criterion. We say that the first time series dominates the second one in first-degree sense if $F_1(x) \leq F_2(x)$ in each point and there is a strict inequality at least in one point x. The disadvantage of the first-degree stochastic dominance is again that in most cases the distribution functions cross each other which means, that there is no ordering between the alternatives.
The certainty equivalent is the lowest price for which the decision maker would be willing to sell a desirable risky prospect or the highest sure payment the decision maker would make to get rid of an undesirable risky prospect. In general, certainty equivalent will vary between people because people seldom have identical attitudes to risk as they have no equal rate of their risk aversion.
The best choice for the decision maker is the one with the highest expected utility which is exactly equivalent to maximizing the certainty equivalent. This criterion can be used if the estimated probabilities of the possible outcomes as well as the so-called utility function together with the value of risk aversion are involved in the elicitation.

3.1 Statistical Approach

The climatic needs of a certain plant are necessary to list specifically for varieties and phenological phases. The specialized climatic sensitivity of the plant together with the characterization of the extreme events and their distribution should also be learned. Other weather parameters such as humidity, radiation, sunshine hours, wind etc. should also be considered if they are available since the more information we use the more sophisticated result we can get. After having proved the strong correlation between climatic parameters or extremes and the respond of the plant, we can go on with the detailed analysis of the weather parameters (trend analysis, characterization of variability, the description of the (asymmetric) distribution etc.).

In climate change impacts research indicator analysis has a special advance. Instead of using weather or climatic parameters, we can construct some functions – called indicators – of them in order to find a stronger correlation between the artificial weather parameters (indicators) and the plant responses.

Multivariate statistical methods are valuable tools to find out the characteristic of low probability - high impact events, to evaluate loss functions of varieties or sites, to estimate the probability of year types with special features, to create homogenous classes of years, varieties, sites etc. or to gain information from the classification.

The risk analysis should be calculated specially for regional climate model outputs as well since we can get valuable information on what we can expect in the future.

3.2 Modelling

Simulation is of high importance in climate change research. It has the advantage that – based on information of observed data – events and consequences with less or no possibility of (further) observation can be analysed in virtual circumstances. Thus “What if” type questions can be answered and risk optimization can be made according to the risk strategies of the decision makers. In case models are completed with stochastic elements, the risk functions can be evaluated more precisely for a certain variety or region. In this way we can draw risk maps as well.

The possible impacts of the decisions can obviously be analysed easier if we can assume that those consequences would be faced in a situation similar to the past. However, we have no reason to assume this in climate change impact research. Nevertheless, if we apply simulation models and indicators in a complex approach, we can define model-based indicators with the help of which we can handle this problem more sensitively.

The results we can get this way are useful not only for growers and decision makers but also for stakeholders and insurance experts who probably should construct a new insurance-support system that can help the adaptation process. Climate change, after all, can make necessary to rebuild the whole insurance-support system and from this point of view the results of a stochastic model-based indicator analysis is of high importance.

3.3 Product Line Analysis

For cost-benefit analysis of economic impacts and for risk level set simulation models are needed that contains the relationship between product line levels and elements. A certain protection

investment can be considered profitable from a point of view while it can be labelled as unprofitable by another decision maker having unfavourable market position.
Product line analysis has been executed for vinery sector in Hungary. The base model has several levels. The economical weight of the elements and the transition probabilities should be estimated level by level. Now the product line analysis of fruit sector is going to be developed for the most important species/varieties in Hungary.

4. NECESSARY DATA BASES

4.1 Meteo-data

Daily or monthly data from the Hungarian Meteorological Service (HMS) can be used for regional analysis, only. We usually face the problem that in some years the place of the observation station was modified. We also frequently apply CRU database for the time series 1901–2000 (New et al., 2002) with high resolution (10') throughout Europe.
For the site characterization, however, we need local observations as well. Data are much more useful if they are integrated in a common data base which is impeded by the fact that data bases can be found at different owners, in different data structure and IT systems.
Climate change impacts are analysed on the basis of climate scenario data. We used for example monthly data of Tyndall Centre TYN SC 1.0 for the time series 2001–2100, with high resolution (10') throughout Europe and for several scenarios (Mitchell et al., 2004, 2005*)*.
Other climate models are under downscaling by the meteorologists at Eötvös Loránd University, Budapest, Hungary. ECHAM5 has been applied as a model to provide margin conditions for RegCM (*Halenka et al., 2006*). For the time series 1950–2100 scenarios with 25 km resolution were created which were input again for the next RegCM run of 10 km resolution. Finally data for time intervals 1961–1990, 2021–2050 and 2071–2100 are gained (Torma et al., 2008).
The downscaled data can be used for trend analysis, climate change impact description, comparisons as well as for extreme event analysis.
In order to collect, organize, manage and search databases for climate change research in a handsome and friendly way, a special data management system was developed by Szenteleki et al. (2007). The system has the capacity to filter, query and aggregate data from different aspects. The software contains several basic index examinations, all of which have been formulated and accepted at international level and precised at national level.
There are available climatic profile indicators for daily as well as monthly data by combining temperature (minimum, average, maximum), the distribution of precipitation and radiation. For special demand any kind of new indicators can be created by the user. In the case of daily data, the system of conditions can be set up by day, but for making parameters for longer time periods (weeks, for example) some values at defined dates are enough, between them linear interpolation can be applied. Both stationary and dynamic indicators can be defined and analysed which help manage the phenology shift caused by climate change.
The software is suitable for finding the co-existence or absence of several meteorological profile indicators. Applying the software we can evaluate and classify historical as well as climate model data while learning temperature and precipitation characteristics.

4.2 Other data
Soil characteristic may not be ignored while eliciting and mitigating climatic risk and increasing production quantity and quality. Production risk can only be estimated if long time data are available for the varieties. Production data contains mainly quantity and much less quality information. The comparison of weather and production data information is often impeded by data absence or irrelevancy.
Economic risks and product lines can be analysed only if data on production technology, investment costs, distribution costs, prices and market risk factors are available. Also in this situation we usually face the problem of data scarcity and/or irrelevancy.

Acknowledgements. The research was financially supported by the OM-00265/2008 and OTKA K 63065/2006 projects.

REFERENCES

Bartholy J., R. Pongrácz and Gy. Gelybó 2007. Regional Climate change expected in Hungary for 2071-2100. *Applied Ecology and Environmental Research* 5(1): 1-17.

Erdélyi, É., L. Horváth, D. Boksai and A. Ferenczy 2006. How climate change influences the field crop production II., *ECO-Conference, Novi Sad, p. 7-12*.

Halenka, T., J. Kalvova, Z. Chladova, A. Demeterova, K. Zemankova and M. Belda 2006. On the capability of RegCM to capture extremes in long term regional climate simulation – comparison with the observations for Czech Republic. *Theor. Appl. Climatol.* 86: 125–145.

KPMG (2008): Climate changes your business – KPMG's review of business risks and economic impacts at sector level. KPMG International, The Netherlands

Mitchell, T.D., T.R. Carter, P.D. Jones, M. Hulme and M. New 2004. A comprehensive set of high-resolution grids of monthly climate for Europe and the globe: the observed record (1901-2000) and 16 scenarios (2001-2100). Tyndall Centre Working Paper 55, University of East Anglia, Norwich, UK

Mitchell, T.D. and P.D. Jones 2005. An improved method of constructing a database of monthly climate observations and associated high-resolution grids. *Int. Journal of Climatolology* 25: 693–712.

New, M., D. Lister, M. Hulme and I. Makin 2002. A high-resolution data set of surface climate over global land areas. *Climate Research* 21: 1-25

Porter, M. 1979. How competitive forces shape strategy. Harvard Business Review

Révész, A. 2008. Stochastic behaviour of heat waves and temperature in Hungary. *Applied Ecology and Environmental Research* 6(4): 85-100.

Szenteleki, K., L. Horváth and M. Ladányi 2008. Climate analogies and risk analysis in the hungarian viticulture. World Conference on Agricultural Information and IT, Tokyo-Japan (8 pp)

Torma, Cs., J. Bartholy, R. Pongracz, Z. Barcza, E. Coppola and F. Giorgi 2008. Adaptation and validation of the RegCM3 climate model for the Carpathian Basin. *Időjárás* 112(3-4): 233-247.