A proposal for a modern conceptual framework for risk management in agriculture

Jacek Kulawik

Abstract

Contemporary agriculture is exposed to a variety of shocks, both negative (pure risks) and positive (speculative risks), and thus development opportunities. Therefore agriculture is affected by external threats, however, this sector generates variability downstream of the food chains. Therefore, first, the contemporary sources of risk in agriculture and their types are reviewed, emphasizing the high importance of operational and strategic risks and their classification as chains and networks. This approach allowed a shift to risk management at the level of individual farms. Since the risks are aggregated across the entire agricultural sector, and new risks appear at this level, it was necessary to analyse the problems here. Holistic/integrated risk management seems to be the best framework in this case. This combination of a micro perspective with a sector perspective is a novelty in the national agricultural economy, and thus creates scientific added value. Consequently, the main goal of the article was achieved and the assumption was confirmed.

Keywords: holistic agricultural risk management system, risk, risk in agriculture, risk management in agriculture.

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Introduction

Contemporary agriculture is exposed to numerous sources of risk, i.e. the eternal dependence on nature, weather, and accelerating climate change, as well as those of a market, political, and institutional nature. Due to the growing dependence on foreign capital to support investment, restructuring and adaptation processes as well as increasing resistance to shocks, the agricultural sector interacts with financial markets in various ways. The financial risk grows rapidly in the agriculture itself, particularly on farms leasing land. The globalized financial markets themselves, as well as the global food chains, can on one hand be a source of variability in agriculture, but may on the other hand create new opportunities for risk transfer from the sector.

The problem with risk is that researchers define it in a variety of ways. For example, a simple formulation assumes that it is simply a concretization of uncertainty. In turn, the latter is described by the ISO 31000 standard from 2009 as a state that results from the lack of complete or even partial information, understanding, and knowledge about an event, its effects and/or the probability of its occurrence. This implies that the occurrence of the risk could lead to loss of property or other damage. Therefore, attempts are made to estimate this depletion by multiplying the two types of loss by the frequency/probability of their occurrence[1].

The simplest dictionary definitions of risk emphasise that something may not go as predicted. Such a term also includes uncertainty as to the future development of things important for people, such as health, well-being, or condition of a property. The reference to uncertainty and the possibility of loss/harm is, historically, the oldest way to recognize risk. Later on, however, the distinction between uncertainty and risk emerged. The division criterion was the possibility to estimate the degree of probability of future results. Accordingly, when we have a reasonably accurate estimate, we are dealing with risk, otherwise – with uncertainty[2]. This leads us to the important division of risk into:

1. Objective, also referred to as "the degree of risk". This is the relative variability of the present loss versus the expected loss. This risk changes inversely to the square root of the number of observed cases. Its main advantage is the possibility to measure it, e.g. by means of standard deviation or the coefficient of variation. This makes it a particularly important category for property

1. M. Scharner, S. Pöchtrager, M. Larcher, *Risikoeinstellung und Risikowahrnehmung von Milchproduzenten in Österreich*, "German Journal of Agricultural Economics" 2016, Vol. 65, No. 4, p. 131–145.
2. E.G. Rejda, J.M. McNamara, *Principles of Risk Management and Insurance*, London, New York, Pearson, 2017, p. 42–43.

insurance and risk management in business organizations and supply chains, as it adheres to a high degree to the law of large numbers.

2. Subjective, or "perceived". This is understood as an uncertainty, the source of which is people's psychological characteristics or their mental condition. Therefore, this risk changes within a wide range, determined by diversity of people. However, it is generally accepted that a high level of it usually means conservative and cautious behaviour. People with such an approach are more likely to buy insurance, even when they do not need it. We may say that they are characterized by high risk aversion[3].

In view of the needs of this article, it is also important to distinguish between pure and speculative risk. The former occurs when there is the possibility of loss or not. It is the basis of non-life insurance. Speculative risk, on the other hand, allows for both losses and gains[4]. However, it may happen that sometimes even traditional insurers accept portfolios of debt securities issued by institutional investors and local governments for protection, which may bring profits as well as losses. The same happens in the case of the enterprise risk management (ERM). Of course, the insurers' interest in pure risk also stems from the fact that it behaves to a large extent in a manner consistent with the law of large numbers, and in particular it allows for fairly accurate forecasting of future damages. Speculative risk is also of great importance for society when we analyse the processes of implementing innovations. Then some of the less competitive companies that reluctantly and belatedly implement innovations may suffer losses and eventually go bankrupt. Often, however, that loss will be more than covered by the benefits of the popularization of more effective, new solutions. However, their impact on risk and riskiness is not clear, as some threats may be reduced, but new ones appear instead.

In the context presented above, the main objective of the article is to propose a modern conceptual framework for analysing, modelling, and designing risk management in agriculture. Additionally, all the considerations are subordinated to the thesis that on the one hand this management has to constitute a coherent and comprehensive system, and on the other hand, it should be specified differently at the level of individual farms and differently for the entire agricultural sector.

3. D. Guegan, B. Hassani, *Risk Measurement. From Quantitative Measures to Management Decisions*, New York, Springer, 2019, p. 10–12.
4. E.G. Rejda, J.M. McNamara, op. cit.

Types of risk in agriculture

There are many ways to systematize agricultural risks. The most primitive division is that between pure and speculative risk. The former essentially manifests itself only in negative deviations of values from the planned goals of an organization. To a large extent, they cannot be prevented. At the same time, pure risk plays a fundamental role in traditional insurance. When it comes to speculative risk, we are also interested in the positive deviations from the results obtained compared to their previously adopted levels. This risk is most often related to strategic risk of a long-term nature. It makes sense to combine pure risk primarily with operational risk, i.e. relating to constantly repeating production decisions, by definition having a short- and at most medium-term horizon.

The division of risk into economic and financial is also crucial. The latter group includes multidirectional influences of financial markets (changes in interest rates, conditions of access to foreign capital, particularly loans), product markets (loss of receivables, changeability of trade loan conditions), and liquidity risk. Very often, economic risk is further divided into endogenous and exogenous. The former includes all kinds of variability that is generated by the farm itself. In detail, these are risks: technological, performance, and personal/personnel. The source of the exogenous risk are all environmental influences that are very difficult to counteract by an individual farmer. Therefore, they include the impact of weather and climate as well as other natural events, political and institutional changes, transfer and tax regulations, etc. If we add to this the market/price risk, then we come to the category of risk for the entire farm/agricultural enterprise.

The types of risk presented above are a derivative of its factors, in other words, sources. In general, they can also be external – specified via the actions and behaviour of competitors, customers, suppliers, regulators and supervisors – and remaining, but predominantly internal. The latter group is comprised of financial, operational, and broadly understood management factors. However, all sources of risk may refer to the micro, meso, and macro scale. There are even more sources of risk in a highly detailed approach. In agriculture, for example, Meuvissen et al. identified 22 of them, and Harwood et al. as much as 35[5].

Weather and climate are a significant source of exogenous economic risk in agriculture. Weather is defined as the state and processes of the weather in a specific

5. M.P.M. Meuvissen, R.B.M. Huirne, J.B. Hardaker, *Perceptions of risks and risk management strategies, an analysis of Dutch livestock farmers*, AAEA Annual Meeting, 8–11.08.1999, Nashville, Tenessee, p. 5–15; J. Harwood, R. Heifner, K. Coble et al., *Managing risk in Farming*, USDA/ers Agricultural Economics Report, No. 774, 1999, p. 1–8.

place and at a specific time. The following meteorological parameters are primarily used for its description: temperature, precipitation, air humidity and pressure, radiation, wind speed and direction. Weather's characteristic feature is the changeability, even within one day. Climate, on the other hand, consists of the average values of physical and chemical parameters of the atmosphere for at least the last 30 years. Various climate classifications (e.g. temperate) and its scales are used, ranging from the planet's climate to the microclimate/local climate.

The weather is directly related to the weather risk. It is understood as a potential financial threat, the probability of occurrence of which is mostly independent of one's actions[6]. It is an aggregate of elementary weather risks such as heat or cold waves, torrential rains, storms, etc. Therefore, it should be included in the group of derivative/secondary risks consisting of a certain number of primary/elementary risks, which are basically the causes of failure to achieve the assumed objectives. It results in fluctuations in the economic and financial results of economic entities, most simply measured with the standard deviation and variance.

The weather risk is, in fact, also a speculative risk, as it may have a negative as well as a positive impact on the economic and financial situation of any economic entity. In agriculture, in general, it can have an effect on:

– production volume,
– quantitative sales volume,
– prices of sold products and services,
– quantities of purchased means of production,
– prices of purchased goods and services,
– additional costs or savings depending on the weather conditions[7].

The division into diversifiable and non-diversifiable risk is also important[8]. The former applies only to individuals and small groups of them, and its essence is that it can be reduced or even eliminated by diversification. Hence, it is sometimes also referred to as non-systematic or specific risk. In comparison, non-diversifiable risk is a risk that affects entire economies, or at least the most important sectors for them. Its effects, therefore, can be felt by even a whole society. Examples include wars, hyperinflation, and economic crises, as well as anthropogenic natural disasters, and pandemics, as best argued by Covid-19, and the restrictions they generate. For the above reasons, this risk is also known as the fundamental risk. Due to its size and effects, public authorities play a key role in preventing and managing it. In the case of agriculture, this risk is

6. A. Schirm, *Wetterderivate – Einsatzmöglichkeiten und Bewertung*, "Research in Capital Markets and Finance", 10.02.2001, p. 25–31.
7. D. Autier, *The main characteristics of weatherderivatives*, "Risk" 2000, Vol. 13, No. 9, p. 73–81.
8. D. Guegan, B. Hassani, op. cit.

a standard argument in favour of subsidizing multi-risk crop insurance or the need for budget-backed reinsurance and disaster assistance programmes.

The enterprise risk has already been mentioned above. It is understood as comprehensive risk management by entities oriented at markets and profits, and thus including pure and speculative risks, as well as strategic (the most fundamental financial and non-financial goals) and operational risks, i.e. relating to the current operations of companies. An important component of economic risk is also financial risk, and therefore related to changes in product prices, interest rates, money and exchange rates. Parameterizing these risks may cause the company's overall risk exposure to decline if they are not correlated. In other words, the diversification mechanisms can then also be used; however, there is a possibility that overall business riskiness will still increase. This leads us to the concept of basic economic risk. For example, an agricultural holding may purchase crop insurance, thereby reducing production risk, but an increase in other risks could cause the gross or net profit standard deviation to increase. Economic risk management is conducted within the framework of the enterprise risk management (ERM) concept, a good approximation of which at the level of the entire agricultural sector is the concept of holistic risk management, and most strongly promoted by the Organization for Economic Cooperation and Development (OECD).

Among the risks of the most general meaning and application, one should also mention systemic risk. Basically, it is understood as risk related to the conduct of monetary and fiscal policy, as well as to the functioning of financial markets. If this risk materializes, the entire economic system and, for example, banking system, may be at risk. For this reason, citizens' savings and their welfare can be seriously affected. At this point, it should be clearly added that non-diversifiable risk is quite frequently equated with systemic risk. This is a situation that occurs primarily in agricultural insurance, where natural disasters, such as severe drought, are called systemic risks.

Agriculture is exposed to many different risks, which nonetheless can be combined into the following five groups:

1) production,
2) market or price,
3) institutional,
4) personal,
5) financial[9].

9. M.A. Komarek, A. De Pinto, H.V. Smith, *A review of types of risks in agriculture: What we know and what we need to know*, "Agricultural Systems" 2020, Vol. 178, p. 61–73; B.J. Hardaker, G. Lien, *Probabilities for decision analysis in agriculture and rural resource economics: The need for a paradigmshift*, "Agricultural Systems" 2010, Vol. 103, No. 6, p. 205–217.

Production risk comes from the variability of weather and climate, the occurrence of diseases and pests, as well as changes in soil quality and fertility. It is, in a way, a natural uncertainty related to the growth and development processes of living organisms. Catastrophic events and epidemics of animal diseases as well as plant pests are particularly dangerous. In the case of diseases, the problem also lies in the fact that approx. 70% of human diseases are zoonotic[10].

Price and cost fluctuations as well as uncertain access to the selling and supply markets are a source of price risk. Of course, some of its components are closely related to the production risk. If a decrease in yields leads to an increase in the prices of the relevant crops, then we are dealing with phenomenon called a natural hedge. However, it is necessary to avoid hasty generalizations, as this effect is strongly hampered by the influence of globalization. On the other hand, technical progress means that agriculture has to use more and more industrial means of production, and their markets are to a great extent oligopolized by global companies. The modernization of agricultural production makes it strongly dependent on oil-derived fuels, and thus also on the cycles occurring on the petroleum market. Thus it is simple to notice that the price risk should be analysed and managed simultaneously with the production risk.

Unpredictable changes in agricultural and socio-economic policy and various types of regulations are the essence of institutional risk. This is also overlapped by changes in structures, systems, norms, and directly informal customs. This risk also includes the uncertainty inherent to the legal system and the rule of law. Most of the aforementioned changes in the environment take place without the option of being controlled to a substantial extent by the farmers, and in authoritarian systems – by the citizens in general.

In fact, none of us know how the health and physical and mental condition of ourselves or of our relatives will develop in the future. The same applies to farmers and their families. The resulting personal risk can manifest itself in diseases, accidents, hurts and injuries, and, eventually, death. The latter event in agriculture becomes particularly dramatic when it concerns farm managers, because then there may even be a threat to the survival of the farm itself. Moreover, let us note that personnel risk is often associated with institutional, production and pricing risks, of which the SARS-CoV 2 epidemic is a very good example. As a result of the restrictions, there has been a dramatic shortage of seasonal workers employed in harvesting fruit and vegetables almost in the whole EU. Therefore, it was quite realistic to take into account the loss of part of the harvest and the increase in prices. This

10. A. Kucharski, *Prawa epidemii*, Warszawa, Wydawnictwo Relacja, 2020, p. 43–49.

type of risk is obviously related to the goals and functioning of the Agricultural Social Insurance Fund [KRUS].

The source of financial risk in all sectors and business entities is the method of their financing, often reduced to the level of foreign capital involvement, i.e. financial leverage[11]. The uncertainty related to the costs and availability of a loan is directly expressed in the interest rates and other conditions set out in the relevant contracts. In other words, there are also non-price effects, such as differentiation of debt limits or of requested collateral. Following this train of thought, it is obvious that the decline in yields and low prices obtained for the sold agricultural products will translate into a deterioration in the creditworthiness of a farm or in a complete cessation of loan servicing. Thus, we can easily see that financial risk has various relationships with practically all the previously described types of risk.

A. Miller et al. proposed a fascinating division of risk in agriculture, according to which the two main risks are:

1) operational risk, and

2) strategic risk[12].

Operational risk is divided into two sub-types: business and financial. The former includes a somewhat artificial construction, namely an assumption that a farm is entirely financed with equity capital. The sources of this risk include the variability of prices, costs and production results, as well as the detailed determinants of the formation of these categories. Meanwhile the financial risk estimation is based on the fact that the use of a foreign capital on a farm results in fluctuations in net results. Here, the sources of risk are changes in the interest rate put at the disposal of external capital and its non-price parameters (required collaterals and behaviour of the capital recipient, debt limits etc.).

Strategic risk is related to the uncertainty as to the effects of the chosen/general focus of the organization on achieving its basic goals and increasing the ownership value. From a more aggregated point of view, the source of this risk is the socio-economic policy of the state, including the agricultural policy and the processes taking place in the agricultural sector itself. A more detailed view of this risk is shown in Table 1.

11. S.C. Gabriel, C.B. Baker, *Concept of business and financial risk*, "American Journal of Agricultural Economics" 1980, Vol. 62, p. 110–115; Y. de Mey, F. van Winsen, E. Wauters et al., *Farm-level evidence on risk balancing behavior in the EU-15*, "Agricultural Finance Review" 2014, Vol. 74, No. 1, p. 601–620.
12. A. Miller, C. Dobbins, J. Prichett, *Risk Management for Farmers*, Staff Paper 04–11, Department of Agricultural Economics, Purdue University, September 2004, p. 1–43.

Table 1. Sources of strategic risk in agriculture

Sources of risk	Concretization and examples
international	– the social unrest in other countries and regions leading to economic sanctions – the instability of financial markets restricting exports
the government's policy	– the new team completely changes the course of agricultural policy – the authorities are introducing restrictions on international trade
government regulation	– environmental law is being implemented to limit the consumption of nitrogen fertilizers – farmers are obligated to make changes in the storage of organic fertilizers
macroeconomics	– the relocation of large herd farming to other countries is encouraged – the exchange rate of the national currency is strengthening
social	– consumers turn away from animal products – agriculture is seen as a source of pollution and odours
natural	– there is pressure to reduce the use of antibiotics in animal production – urbanization limits the access of water for agriculture
industrialisation	– moral and technical obsolescence of the production systems to date – contract manufacturing restricts access to high-margin markets for independent producers
technologies	– patent protection of biotechnology innovations and intellectual property limit the development of independent producers – farmers' lack of access to databases that would allow them to assess the results of their activity
conditions of competition	– obstruction of market access by regional blocks, NTBs and private initiatives – competition for land deteriorates the position of the lessees

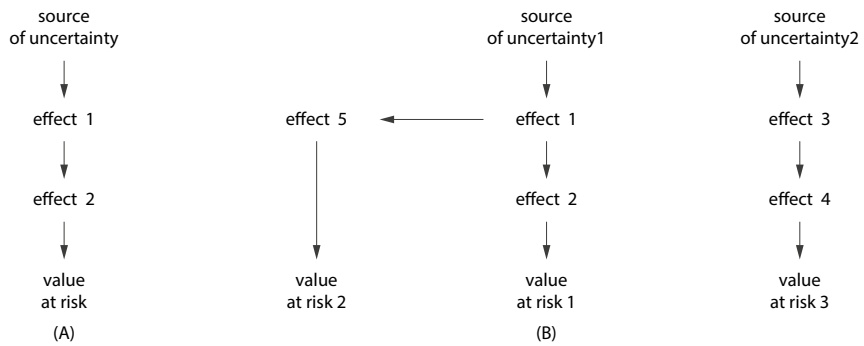
Source: Prepared on the basis of: A. Miller, C. Dobbins, J. Prichett et al., Risk Management for Farmers, Staff Paper 04–11, Department of Agricultural Economics, Purdue University, September 2004, p. 5–6.

The realization that risks are correlated prompted van Winsen et al. to address risk networks more closely. The starting point is the product of numbers (frequency and amount of damage) presented above, in which the farmers actually have problems with estimating probabilities and damages. There are four reasons for this:

1) many of them are laymen when it comes to the calculus of probability;
2) probabilities are usually not discrete values, but certain values, often with mixed distributions, which most people cannot identify; the damage also has its own separate breakdowns; on top of that, there are also very complex distributions linked to the size and frequency of the occurrence of damages;
3) probabilities and losses are context-specific categories;
4) the relationships between different stochastic events and quantities determined and exposed to losses are highly complex and interconnected.

It is the feature of the connection and interdependence of risks that is the essence of their network, and distinguishes them from the view of the chain of causes and effects, as shows Figure 1. It is worth noting that the concept of the network refers very clearly to A.G. Kelly's personal construct theory from 1963, which explains a general psychological approach to the analysis of all human behaviour. The concretization of Kelly's proposal are the "mental maps" which serve, among others, to discover individual's reasoning mechanisms, including appealing to subjective probabilities. The essential elements of mental maps are concepts, i.e. fundamental ideas, that are related by relationships that express meanings, directions, signs and intensities. The most famous risk networks are undoubtedly the holistic OECD agricultural risk management system and the World Economic Forum's Risk Response Network.

Figure 1. Recognizing risk as a chain (A) and a network (B)



Source: Adapted from F. van Winsen, Y. de Mey, L. Lauwers et al., Cognitive mapping: A method to elucidate and present farmers' risk perception, "Agricultural Systems" 2013, Vol. 12, p. 13–14.

As far as cognitive risk maps are concerned, there is no established standard for their construction so far. Regardless of this, the starting point is correct processing of the content of the interviews with a given group of respondents, which are marked with the following codes: "causes", "effects", "values at risk", "risk management". Let's briefly explain these terms.

1. Causes – they transform maps into nodes and sources of uncertainty.
2. Effects are nodes that reflect the effects of uncertain events as well the previous effects.
3. Values at stake are nodes which are important to specific respondents.
4. Risk management are nodes which are in fact instruments and strategies of this type of management.

Cognitive maps allow to conduct qualitative analyses. Their nodes can be grouped and linked together to establish causal relationships. Connecting nodes is synonymous with creating a risk network. Hence, these maps are especially useful in dealing with complex problems where human behaviour is important but simultaneously not very susceptible to quantification. Cognitive maps are most frequently reached for in the case of wicked problems, in which there are many actors and a solution is not trivial. Another area of their application is when there is access to individual people's knowledge, but its generalization in the form of scientific knowledge is incomplete. Finally, these maps can be of great use when a public intervention is needed.

Risk management at the level of farms

G. E. Rejda and M. J. McNamara have a very interesting view of the risk management, defining it as the process of identifying the organization's loss exposure and selecting appropriate techniques to deal with it[13]. The risk itself is understood as a situation or circumstances in which losses are possible, regardless of whether or not they are actually occurring. Last but not least, the idea is to include all possible exposures.

Risk management should be deliberate, both before and after losses occur. In the former case, the primary goal of risk management is to be economically beneficial, which implies the need to analyse the costs associated with the utilized instruments. The second goal is to reduce anxiety related to the consequences of risk materialization. The third goal is the organization's compliance with all legal obligations. If the loss/damage does occur, then risk management should make it possible to first of all secure the survival of the organization, the possibility of continuing operating processes, obtaining stable profits and growth rates, and functioning in a sustainable manner.

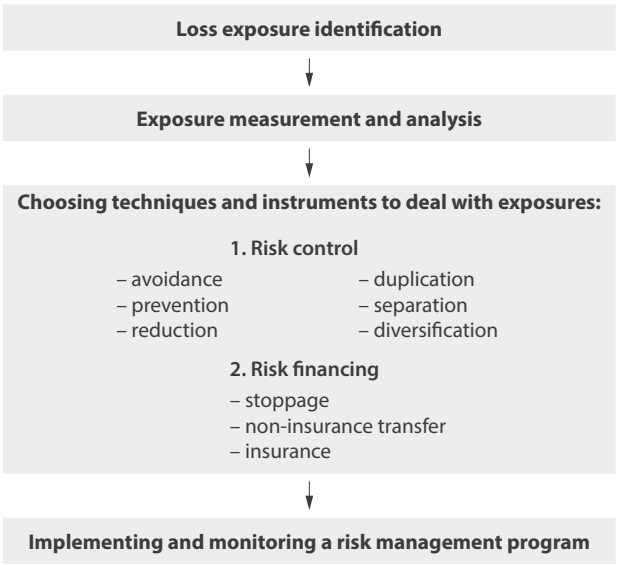
Rejda and McNamara first present the traditional risk management system, i.e. focused on dealing with pure risk, i.e. the possibility of downside risks. It is shown by figure 2.

In the phase of the loss exposure identification, as has already been mentioned, it is necessary to try to capture the loss exposure as fully as possible. Therefore, the risks to the organization's tangible and intangible assets in the form of liability and claims against employees, as well as loss of profit and non-compliance with legal,

13. E.G. Rejda, J.M. McNamara, op. cit.

administrative and regulatory obligations, have to be analysed. An early recognition of new threats as well as risks and uncertainties related to the fact that the organization operates in a particular supply chain is very valuable.

Figure 2. A clean risk oriented risk management system



Source: Prepared on the basis of G.F. Rejda, M.J. McNamara, Principles of Risk Management and Insurance, Pearson Education Limited, London, New York, 2017, p. 42–43.

The measurement and analysis of exposure to threats is the phase in which the size and distribution of potential losses as well as the probability (frequency) of their occurrence should be estimated. These losses should then be ranked according to their significance for the organization in terms of the severity of their effects. Consequently, the maximum possible loss in the assumed period and the probability of its occurrence must be assessed. It is also worthwhile to develop a standard for dealing with rare losses, which can be ommited as long as they are not catastrophic.

As shows Figure 2, risk control includes as many as six techniques/instruments. Let us present synthetically their essence as well as their advantages and weaknesses. Avoiding the risk is deliberately eliminating it by adopting appropriate practices and behaviours, for example erecting buildings in flood-free areas or ceasing risky activities. Unfortunately, this is only a seemingly simple method. After all, it is impossible to avoid all losses in practice, and risky activity can simply be very profitable. It will therefore be wiser to transform loss avoidance into loss prevention, that is, reducing

the probability of its occurrence. The logical extension of this strategy is to reduce losses when they happen. This can include mirroring certain resources, which will be activated when needed. It is worth considering isolating certain assets and even entire organized parts of the enterprise exposed to individual threats at the same time. Finally, a very good method of risk control is the well-known in agriculture subject diversification (types of activity, types of transactions, and grouping of recipients) and geographic diversification.

The oldest form of risk financing is its retention, i.e. its detention. It can take an active form (knowingly leaving some exposures) or a passive, somewhat accidental form, when certain threats have not been identified *ex ante*. According to Rejda and McNamara, three conditions has to be met in order for the retention to be effective:

1) there are no other risk management methods,
2) the greatest possible loss is not too serious,
3) losses can be predicted in a relatively easy way.

It is also imperative to specify the retention level, which is the monetary amount of the stopped losses. The easiest way is to use a percentage in relation to sales revenues, profit/income, or working capital. The next stage of retention is determining the source of financing the retained losses. It may include current income, book and cash reserves, and loans. The first three fall under the category of self-insurance. Now let's synthetize the advantages and disadvantages of retention. The former include:

1) savings in the cost of covering losses, if their current amount is lower than in the case of private insurance;
2) reduction of expenses as compared to those necessary to be incurred in the case of using insurance;
3) motivation to take preventive actions (which is also the responsibility of KRUS);
4) increased cash flow when insurance would be a more expensive option.

Retention has three weaknesses, however:

1) the losses may be higher than own shares and excesses in insurance,
2) the expenses may be higher than the cost of purchasing insurance if external advice is required;
3) income tax burdens may increase, while insurance expenses may be classified directly as tax deductible costs.

Various types of contracts, such as for example production and marketing contracts, leasing and lease, and the inclusion of other organizations in the structure of the company, are the basic instruments of non-insurance transfer of pure risk. This way one may try to transfer the uninsurable risk (sometimes in a cheaper way) unto entities that can handle it better. It is important to note that this may result in

new risks, for example legal ones in the form of precedents for which the ruling of courts has not yet been established. The entity taking over the risk may also lose its financial liquidity or even go bankrupt, which does not improve the position of the risk transferring entity at all. Finally, the insurer may not appreciate the fact that the risk has been transferred outside insurance industry and consequently refuse to offer better insurance conditions.

Deciding to buy insurance is a difficult and complex choice, since it involved deciding on a level of protection (coverage) by the provider of the service, negotiating a satisfactory contract, and submitting to various types of restrictions. As a rule, the coverage is incomplete, as the contracts include own shares and franchises as well as limits of the insurer's liability. Combined, the aforementioned contract components imply the retention of some of the risk by the insurance buyer. There are four potential benefits to insurance:

1) in general, the insured entity receives compensation relatively quickly, which allows it to continue its operation;
2) uncertainty reduction facilitates broadening of the planning horizon, which gives the opportunity to improve efficiency and productivity;
3) insurers can offer additional services in the form of risk control tools, loss exposure analysis, or loss indemnification;
4) insurance premiums are a tax deductible cost.

As a counterbalance, there are also three weaknesses/disadvantages of insurance:

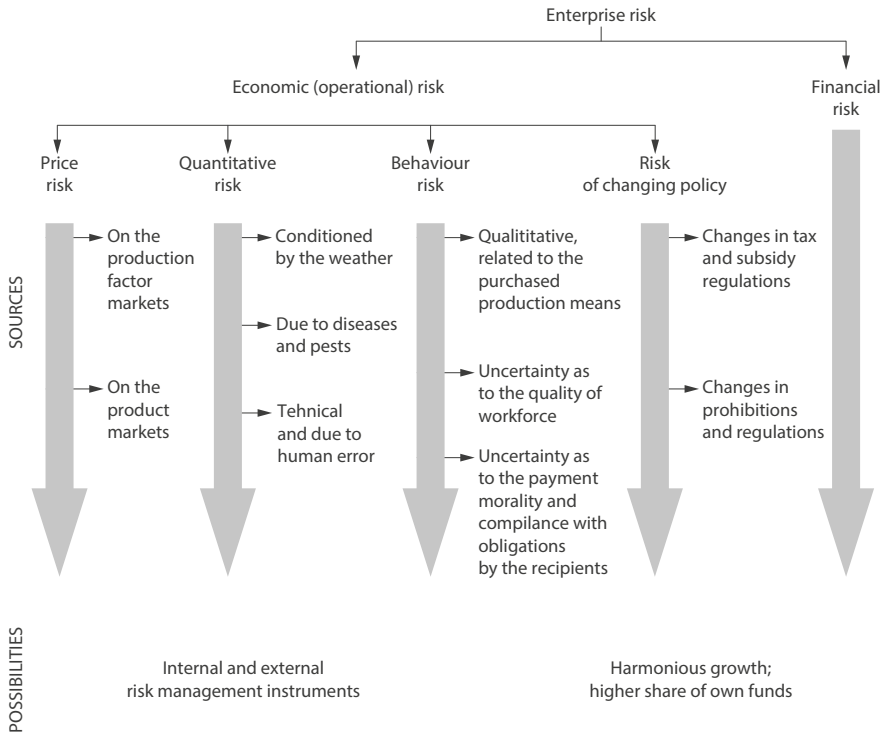
1) insurance expenses may be significant and also have an opportunity cost; however, the need to pay premiums in advance, in principle, eliminates this cost, ergo: one loses the opportunity to obtain benefits from another issue of funds for the purchase of policies;
2) a conclusion of a contract takes time and forces the entity to closely cooperate with the insurer;
3) it demotivates regarding risk control, preventive actions, and prudent behaviour of the insured.

O. Muβhoff and N. Hirschauer also start from the risk to an enterprise/farm in their classification, which shows figure 3[14]. Therefore only a few points that distinguish this system will be noted here. First of all, Muβhoff and Hirschauer use quantitative risk. It covers both production risks caused mainly by weather changeability, and negative consequences of diseases and pest infestations. However, this category includes all the unfavourable phenomena occurring between man, technology, and

14. O. Mußhoff, N. Hirschauer, *Modernes Agrarmanagement. Betriebswirtschaftliche Analyse- und Planungsverfahren*, 2. Auflage, München, Verlag Franz Vahlen, 2011, p. 281–289.

natural environment. Secondly, the two German agroeconomists named above distinguish behaviour risk, understanding it as moral hazard, which is a fundamental category for every insurance. As we know, this hazard is a derivative of the information asymmetry. More specifically, on the example of a farm, it can be indicated that the failure of suppliers to meet the means of production and the failure of service providers to meet the agreed parameters would be a symptom of this hazard. This also applies to the employees. Regarding the sale of agricultural products, the classic moral hazard practices would be non-compliance with the terms of the contract by its recipients. For the sake of completeness, it needs to be noted that farmers themselves may also exhibit behaviours within the concept of moral hazard. Thirdly, Muβhoff and Hirschauer narrow their risk management to price and quantitative risk only, which does not seem to be a reasonable solution.

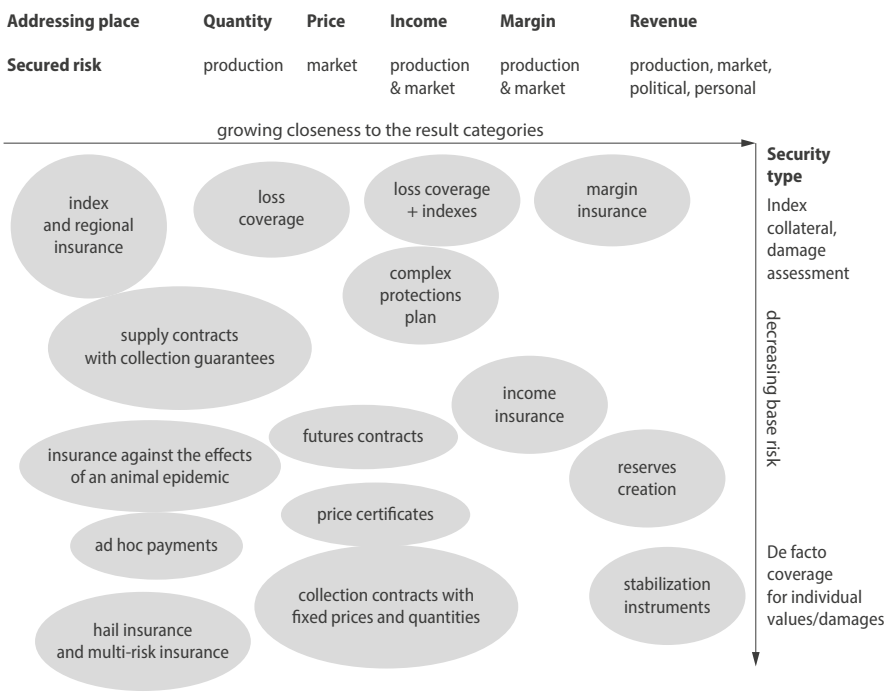
Figure 3. Risk sources and possibilities of its reduction



Source: Prepared on the basis of O. Mußhoff, N. Hirschauer, Modernes Agrarmanagement. Betriebswirtschaftliche Analyse-und Planungsverfahren, 2. Auflage, München, Verlag Franz Vahlen, 2011, p. 281–282.

Economists from the German Johann Heinrich von Thünen – Institut in Braunschweig under the supervision of F. Offermann approached the classification of risk in agriculture and ways of protecting against it in a very interesting way[15]. They considered the whole problem in two dimensions: the growing closeness to synthetic result categories, and the growing individualization of protection.

Figure 4. Place of addressing and types of security measures against risk in agriculture



Source: Based on F. Offerrmann, Ausgevählte Instrumente zum Risikomanagement in der Landwirtschaft: Systematische Zusammestellung und Bewertung, "Thünen Working Paper" 2017, No. 72, p. 5–8.

It is unquestionably necessary to agree with J. Leppälä that risk management in agriculture should be implemented as a holistic and systematic system[16]. A good starting point for further analysis can be the aforementioned ISO 31000 procedure

15. F. Offermann, *Ausgewählte Instrumente zum Risikomanagement in der Landwirtschaft. Systematische Zusammenstellung und Bewertung*, "Thünen Working Paper" 2017, No. 72, p. 5–19.
16. J. Leppälä, *Systematic Risk Managemant on Farms*, "Aalto University publication series Doctoral Dissertations" 2016, No. 17, p. 3–20.

entitled "Risk management – Principles and Guidelines, 1st edition" in 2009. It is shown by Figure 5. Its integral component should be risk mapping in the form of a matrix, in which the lines indicate the likelihood of risk materializing, while the columns show its effects (Figure 6).

Figure 5. The ISO 31000 risk management process

Source: Based on J. Leppälä, Systematic Risk Management on Farms, "Aalto University publication Series Doctoral Dissertations" 2016, No. 17, p. 16–17.

Figure 6. The essence of mapping risks

The probability of the risk realization	The consequences of the risk realization		
	small influence	moderate influence	high influence
low	insignificant risk	tolerable risk	moderate risk
medium	tolerable risk	moderate risk	significant risk
high	moderate risk	significant risk	intolerable risk

Source: Based on J. Leppälä, Systematic Risk Management on Farms, "Aalto University publication Series Doctoral Dissertations" 2016, No. 17, p. 17–18.

P. Schlieper constructed an even more complex risk matrix, orienting its columns to the amount of possible losses (Figure 7). It should be noted that traditional agricultural insurance is mainly located in the part of the matrix marked as acceptable

risk with available management instruments, and sometimes also in places where it can be significantly refined.

Figure 7. A risk matrix that highlights the size of possible losses

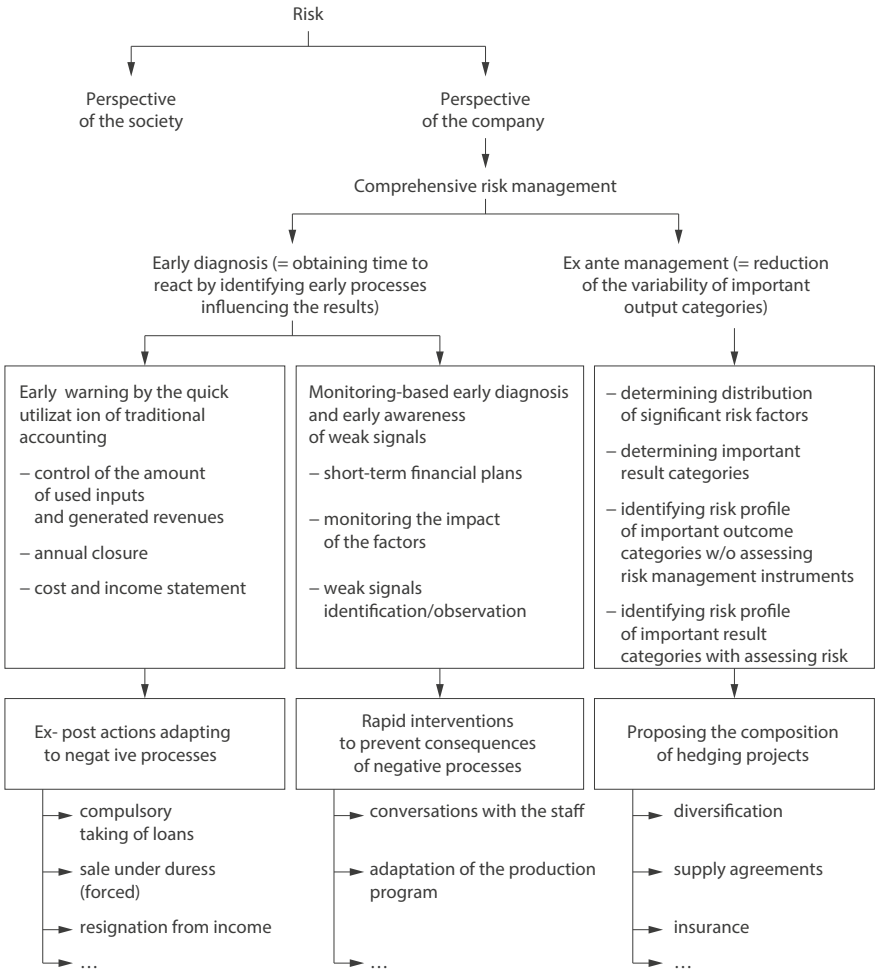
Likelihood of losses	Amount of losses					
	very low	low	medium	serious	very serious	cata-strophic
frequent						
occasional						
rare						
very rare						
low						
practically excluded						

acceptable risk
acceptable risk with available instruments
acceptable risk with advanced instruments
unacceptable risk

Source: Based on P. Schlieper, Ertragsausfallversicherung und Intensität Pflanzlicher Produktion, Wiesbaden, DUV Springer Fachmedien, 1997, p. 91–94.

All the risk management approaches presented above fall within the parameters of mainly ex post activities. The overall proposal of the above-mentioned O. Muβhoff and N. Hirschauer, presented in Figure 8, differs from them. The researchers focus mainly on the enterprise/farm perspective, although they also notice the social dimension of risk management despite not taking it into account. In the area of risk management in an enterprise, Muβhoff and Hirschauer very clearly distinguish between activities focused on early detection of threats, their explanation, correcting behaviours and procedures, intervention actions, and therefore to a large extent ex post actions, from those which ex ante should reduce the dispersion of key economic and financial parameters. The second group includes agricultural insurance.

Figure 8. Components of broadly defined risk management



Source: Adapted from O. Mußhoff, N. Hirschauer, Modernes Agricultural Management. Betriebswirtschaftliche Analyse-und Planungsverfahren. 2. Auflage, München, Verlag Franz Vahlen, 2011, p. 290–293.

Risk management on the agricultural sector level

Due to the growing exposure of agriculture to various types of risks and interactions between them, a systemic approach to managing them is needed to cover them in all their complexity and holism. This systematicity is expressed in three dimensions:

1. Mutual linking of elementary risks (production, market, personnel, institutional), since this is the only chance to reduce the overall risk of the agricultural sector. Without this perspective, the risk that a narrow focus on typically agricultural risks will result in the appearance of negative phenomena in the non-agricultural activity of agricultural households is also growing.
2. Risks are analysed on different time, spatial, and subject scales. Therefore, simultaneous operation on the farm, food chain, region, country, and global levels is necessary.
3. Dealing with the interactions between the components of the system also requires identifying determinants of their vulnerability and resistance to threats, along with the mechanisms of creating new equilibrium states, which is collectively referred to as resilience[17].

The social dimension of risk management in agriculture explicitly appeared in the OECD holistic concept[18]. Its authors referred at this point to the work of R. Holzmann and S. Jorgensen, in which six types of risk were distinguished: natural, health, social, economic, political, and environmental, and they were located on three levels:

– micro, it is a specific risk that affects only individual households;
– meso, i.e. covenant, and therefore affecting groups of farms or communities;
– macro, that is systemic, the effects of which apply to regions and even entire nations/countries[19].

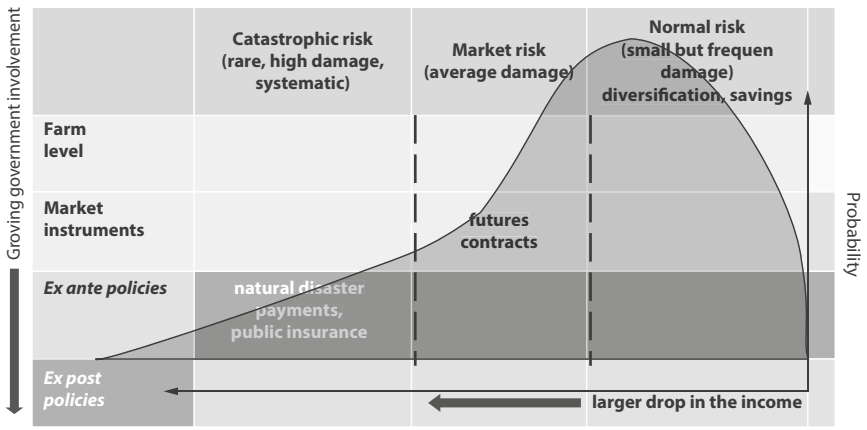
The second source of inspiration for the creators of holistic risk management from OECD was the report prepared by the organization members J. Harrod, R. Heifner, K. Coble, J. Perry, and A. Somwar entitled "Managing Risk in Farming: Concepts, Research and Analysis" in March 1999. All five of the authors were working at the time for the Economic Research Service, the economic research unit of the US Department of Agriculture. These economists analysed in great detail the

17. S. Lupton, M. Meuwissen, S. Ingrand, *Editorial introduction to the special issue risk management in agriculture*, "Agricultural Systems" 2020, Vol. 178, p. 601–605.
18. OECD, *Managing Risk in Agriculture. A Holistic Approach*, Paris 2009; OECD, *Managing Risk in* Agriculture*. Policy Assessment and Design*, Paris 2011.
19. R. Holzmann, S. Jorgensen, *Social risk management: A new conceptual framework for social protection, and beyond*, "International Tax and Public Finance" 2001, Vol. 8, p. 5–23.

sources of risk in agriculture and its measurement, and then the instruments and strategies for managing it.

OECD researchers treated their concept of holistic risk management in agriculture as a response to the traditional approach to this problem, which they called linear, sequential, or static. Its essence is that first the sources of risk in farms are identified, then farmers choose the instruments and strategies for managing it, and at the very end the state may participate through its policies to stabilize agricultural revenues and income. However, in reality the relationships between the three components are not linear. Therefore, they need to be put in a three-dimensional system to be able to undergo analysis, modelling, and design of multidirectional relationships, interactions between them, feedbacks and pre-emptors, and trade-offs, and therefore be treated as a dynamic, holistic system. What is no less important, the system combines strategies for managing various types of risks with public policies aimed at mitigating their effects (ex post dimension) and preventing them (ex ante aspect). The first generation of the above-mentioned system at the turn of the first decade of this century is presented by Figure 9. Note that the insurances appear here at the intersection of the line "market instruments" and the column "market risk". This narrowing of the scope of the insurance application can only be explained by the desire to make the drawing more transparent. On the other hand, it needs to be treated only as a certain matrix, a scheme that facilitates creation of an individual system in each country which would reflect its experience in dealing with risk and future exposure to it, as well as the competences of farmers and politicians, and its budget resources.

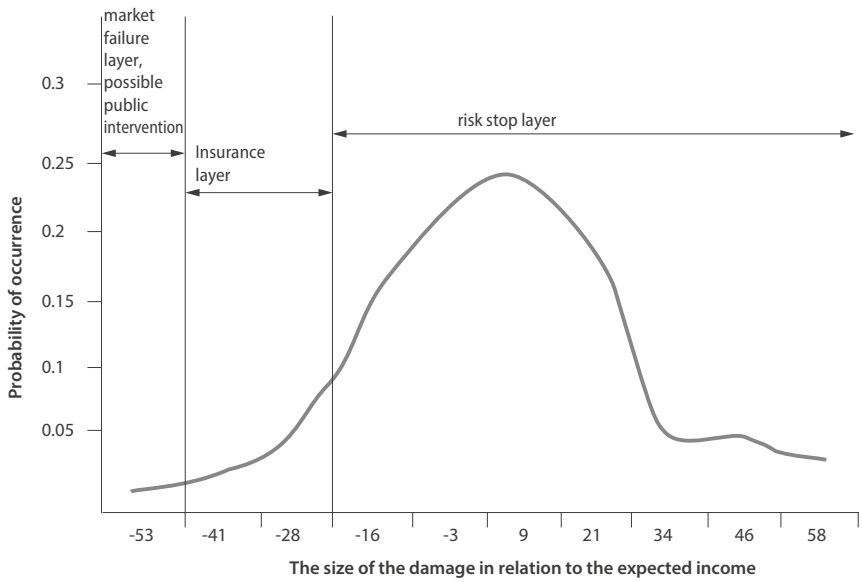
Figure 9. The first generation of the OECD's holistic risk management system in agriculture



Source: Based on OECD, Managing Risk in Agriculture: Policy Assessment and Design, Paris 2011, p. 53.

Another very interesting approach to holistic risk management is the one in which the loss distribution density function is referred to, as shown by Figure 10. There are three layers here: risk retention, its insurance, and market failure that could justify some public intervention. Of course, the boundaries between layers can be moved. Likewise, a density function can have different characteristics depending on the type of probability distribution.

Figure 10. Probability density function and risk management layers (a different view of the concept of holistic risk management)



Source: Based on OECD, Managing Risk in Agriculture: A Holistic Approach, Paris 2009, p. 25–26.

In 2013, the OECD published a publication on holistic risk management in small-scale agriculture in developing countries[20]. Another transformation of the concept of holism has been performed in it, based on the well-documented fact that there are far more market failures, especially financial and loan failures, in less developed countries than in highly developed countries. As a result, farmers in the first group of countries have fewer market instruments for risk management at their disposal, and are forced to more frequently use informal tools and (often very sophisticated) solutions created on the basis of local communities. In line with this, it

20. D. Cervantes-Godoy, S. Kimura, J. Antón, *Smallholder Risk Managemant in Developing Countries*, OECD Food, Agriculture and Fisheries, Papers No. 61, Paris 2013.

is worth paying attention to the following changes and modifications from the first generation of the holistic risk management system.

1. The risk classification[21] includes now financial risk, and legal and institutional risk, each of them considered at the micro, meso, and macro levels. The former means changes in non-farm income (micro level), informal loans and insurance (meso level), and changes in interest rates, financial asset prices, and access to loans (macro level). The latter type of new risk is the liability and civil liability risk (micro level), new local policies and regulations (meso level), and regulatory changes, environmental protection law, and regional and national agricultural subsidies (macro level).
2. In the matrix of instruments and risk management strategy[22] there is a new layer of "community/informal solutions". The ex ante activities include *crop sharing* systems, shared resource management, social reciprocity, informal insurance communities, and rotating savings/loans. Meanwhile ex post actions, i.e. mitigating the effects of risk materialisation, include the sale of assets and transfers from the joint support network.
3. Finally, in the matrix reflecting the system of holistic risk management, the new row includes "informal strategies" (at farm and local community level) and the new column includes "informal and community-related risks". At the intersection of this row and this column, informal tools, i.e. community material resources and risk pooling, are placed.

2018 offers the next edition of the holistic risk management in agriculture created by the OECD, which is quite fundamental, as evidenced by the title of the relevant report "Strengthening agricultural resilience in the face of multiple risks"[23]. The emphasis on the resilience is supposedly a result of the fact that agriculture is increasingly confronted with long-term and constant uncertainty caused by climate change and instability of markets, especially of financial products and instruments. On the other hand, any measures that increase the resilience also improve the quality of risk management. Of course, there is also a positive feedback loop that goes from this very management to the reinforcement of the resilience.

In the first part of their report, Baldwin and Gray devote a lot of space to the definition of resilience, citing the views of the Food and Agriculture Organization of the United Nations (FAO), The Intergovernmental Panel on Climate Change (IPCC), United Nations Office for Disaster Risk Reduction (UNDRR), and the OECD

21. D. Cervantes-Godoy, S. Kimura, J. Antón, *Smallholder Risk Managemant in Developing Countries, OECD Food, Agriculture and Fisheries*, Papers No. 61, Paris 2013, p. 11.
22. Ibidem, p. 11.
23. K. Baldwin, E. Gray, *Strengthening agricultural resilience in the face of multiple risks*, OECD, Paris 2018.

Council Recommendation on the Governance of Critical Risks of 2014. Ultimately, they assume that by this term they will understand "(...) the ability to plan, absorb and react to adverse events, adapt effectively to them, and at least restore the state of the system before they occur". Thinking and acting in the resilience convention is to be holistic, which fits perfectly with the same OECD approach to risk management.

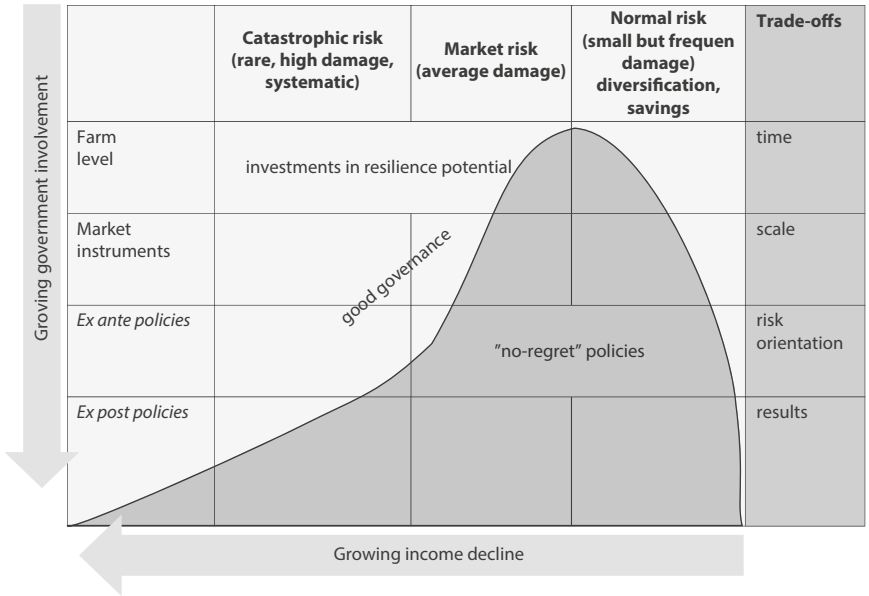
The need to modify the current understanding of holistic risk management in the context of embedding resilience into it is to result from some gaps in the holism of ex ante instruments, the costs of using all management tools, existing *trade-offs*, policy optimization, strategies used by farmers, the role of government, the potential to respond to uncertainty and ambiguity. An example of what this may lead to is an analysis of the continuation of the previous course in risk management. At this point, Baldwin and Gray refer to the phrase "business as usual"[24]. It clearly shows that the continued application of current agricultural practices will lead to a flattening of the probability density function of events lowering agricultural income, which is tantamount to shifting the burden of covering these drops by state budgets.

The revised approach that Baldwin and Gray call "Risk Management for Resilience" is based on five principles:

1. Timeframe, therefore greater focus should be on ex ante policies and prevention.
2. Trade-offs, i.e. a clearer focus on analysis of potential future outcomes of different policy concepts.
3. Participatory processes and cooperation. This implies a need for greater coordination efforts on these characteristics in strategy formulation and accountability.
4. Investing in creating a greater potential for the resilience on farms, so that the entrepreneurship of farmers and their human capital are strengthened.
5. The no-regret policy. In free translation, it means giving up on ineffective actions without regret. Instead, these policies should aim to facilitate farmers' response to uncertainty and risk, build sectoral capacity to better deal with them on the basis of the provided information, provide general services for agriculture, and create a favourable environment for farming activity. An overall view of the OECD's latest approach to holistic risk management in agriculture is shown by Figure 11.

24. Ibidem, p. 40.

Figure 11. Holistic risk management in agriculture in the context of enhancing the resilience

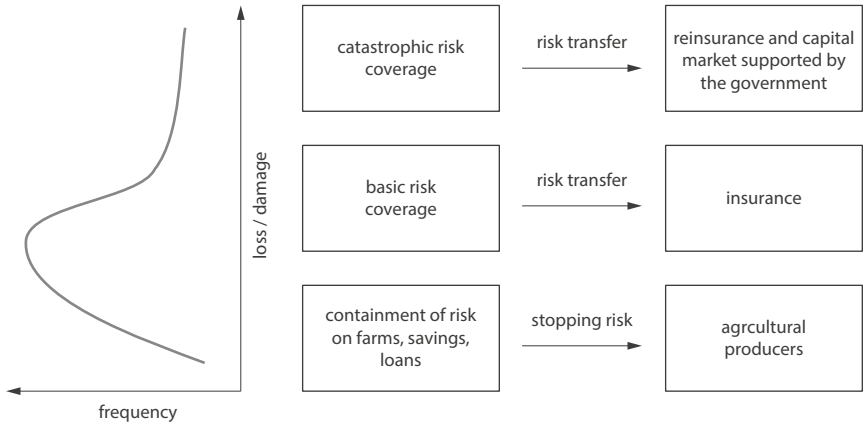


Source: Prepared on the basis of K. Baldwin, E. Gray, Strengthening agricultural resilience in the face of multiple risks, OECD, Paris 2018, p. 21–22.

In a sense, the World Bank also uses the concept of holistic risk management, albeit calling it "financing of production risk in agriculture"[25]. Its essence is shown in Figure 12. As presented, it is a three level/three tier structure. The lowest of levels includes risks that occur relatively frequently, e.g. once every five years, but pose small threats, which are often errors in the farm management. In such cases, the possible insurance would be significantly exposed to negative selection and moral hazard. Hence, it is recommended that farmers themselves deal with the risk. The middle layer includes risks that occurs less frequently, for example six times in the last three decades, but more difficult to finance by agricultural producers themselves. This is a situation where it may make sense to use a professional belayer. Finally, the highest level is the possibility of the realization of a catastrophic risk, one that has happened once in the last twenty years, for example, but its effects were very serious, most often not self-financing by farmers themselves. The remedy could be reinsurance and

25. O. Mahul, J.Ch. Stutley, *Government Support to Agricultural Insurance. Challenges and Options for Developing Countries*, The World Bank, Washington, D.C., 2010, p. 80–81.

Figure 12. Production risk financing in agriculture



Source: Developed on the basis of O. Mahul, J.Ch. Stutley, Government Support to Agricultural Insurance. Challenges and options for Developing Countries, The World Bank, Washington, D.C., 2010, p. 161.

alternative instruments for the transfer of risk to the capital market. Often, some government support is needed here, if only because farmers, due to certain cognitive deformities, may ignore such risk. Public authorities may increase the abovementioned deformations when they offer unconditional disaster aid – permanently.

Summary

Farmers have at their disposal a number of internal and external risk management instruments which they can compose into strategies and into various system and process structures. The tools of modern portfolio theory and bracketing are very useful for this. They allow, among others, to deal with the phenomena of accumulation, compensation and cascade of risks, as well as with non-linear relationships between individual risks. It is very important that political actions do not weaken farmers' motivation for widespread supersession of external instruments e.g. through subsidized external risk management tools. This risk is especially high in the case of the extended family farms, which are closely connected with product markets and labour and capital production factors, as well as with units operating in food chains with a strong pro-export orientation. For the former, if they are highly diversified in terms of products and geography, the ERM concept may be the best frame of reference for the design of individual and, at least in some part, formalized

risk management systems. The latter, on the other hand, should combine their risk management with its instruments and mechanisms located within the industry's food chains. Both types of farms must also find adequate solutions for achieving a balance in terms of high competitiveness and resistance to shocks and threats. On the other hand, all approaches to risk management in agricultural holdings should be part of a sectoral, holistic system. Poland has numerous models to pick from (OECD, PSRM, World Bank, various researchers), thus the issue is limited only to their intelligent "Polonization". Such a broad view of risk management in agriculture is a novelty in the Polish economic and agricultural literature, and therefore it can be considered an added value of the considerations. This further means, in the opinion of the author of this article, that the goal has been achieved, and the arguments are subordinated to the thesis.

Bibliography

Autier D., *The main characteristics of weather*derivatives, "Risk" 2000, Vol. 13, No. 9.

Baldwin K., Gray E., *Strengthening agricultural resilience in the face of multiple risks*, OECD, Paris 2018.

Cervantes-Godoy D., Kimura S., Antón J., *Smallholder Risk Managemant in Developing Countries*, OECD Food, Agriculture and Fisheries, Papers No. 61, Paris 2013.

de Mey Y., van Winsen F., Wauters E. et al., *Farm-level evidence on risk balancing behavior in the EU-15*, "Agricultural Finance Review" 2014, Vol. 74, No. 1.

Gabriel S.C., Baker C.B., *Concept of business and financial risk*, "American Journal of Agricultural Economics" 1980, Vol. 62.

Guegan D., Hassani B., *Risk Measurement. From Quantitative Measures to Management Decisions*, New York, Springer, 2019.

Hardaker B.J., Lien G., *Probabilities for decision analysis in agriculture and rural resource economics: The need for a paradigm*shift, "Agricultural Systems" 2010, Vol. 103, No. 6.

Harwood J., Heifner R., Coble K. et al., *Managing risk in Farming*, USDA/ers Agricultural Economics Report, No. 774, 1999.

Holzmann R, Jorgensen S., *Social risk management: A new conceptual framework for social protection, and beyond*, "International Tax and Public Finance" 2001, Vol. 8.

Komarek M.A., De Pinto A., Smith H.V., *A review of types of risks in agriculture: What we know and what we need to know*, "Agricultural Systems" 2020, Vol. 178.

Kucharski A., *Prawa epidemii [Epidemic laws]*, Warszawa, Wydawnictwo Relacja, 2020.

Leppälä J., *Systematic Risk Managemant on Farms*, "Aalto University publication series Doctoral Dissertations" 2016, No. 17.

Lupton S., Meuwissen M., Ingrand S., *Editorial introduction to the special issue risk management in agriculture*, "Agricultural Systems" 2020, Vol. 178.

Mahul O., Stutley J.Ch., *Government Support to Agricultural Insurance. Challenges and Options for Developing Countries*, The World Bank, Washington, D.C., 2010.

OECD, *Managing Risk in Agriculture. A Holistic Approach*, Paris 2009.

OECD, *Managing Risk in Agriculture. Policy Assessment and Design*, Paris 2011.

Meuvissen M.P.M., Huirne R.B.M., Hardaker J.B., *Perceptions of risks and risk management strategies, an analysis of Dutch livestock farmers*, AAEA Annual Meeting, 8–11.08.1999, Nashville, Tenessee.

Miller A., Dobbins C., Prichett J. et al., *Risk Management for Farmers*, Staff Paper 04–11, Department of Agricultural Economics, Purdue University, September 2004.

Mußhoff O., Hirschauer N., *Modernes Agrarmanagement. Betriebswirtschaftliche Analyse- und Planungsverfahren*, 2. Auflage, München, Verlag Franz Vahlen, 2011.

Offermann F., *Ausgewählte Instrumente zum Risikomanagement in der Landwirtschaft. Systematische Zusammenstellung und Bewertung*, "Thünen Working Paper" 2017, No. 72, Braunschweig 2017.

Rejda, E.G., McNamara J.M., *Principles of Risk Management and Insurance*, London, New York, Pearson, 2017.

Scharner M., Pöchtrager S., Larcher M., *Risikoeinstellung und Risikowahrnehmung von Milchproduzenten in Österreich*, "German Journal of Agricultural Economics" 2016, Vol. 65, No. 4.

Schirm A., *Wetterderivate – Einsatzmöglichkeiten und Bewertung*, "Research in Capital Markets and Finance", 10.02.2001.

Schlieper P., *Ertragsausfallversicherung und Intensität pflanzlicher Produktion*, Wiesbaden, DUV Springer Fachmedien, 1997.

Van Winsen F., de Mey Y., Lauwers L. et al., *Cognitive mapping: A method to elucidate and present farmers' risk perception*, "Agricultural Systems" 2013, Vol. 122.

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