SZENT ISTVÁN UNIVERSITY

DOCTORAL SCHOOL OF MANAGEMENT AND BUSINESS ADMINISTRATION

ANALYSIS OF DISASTER MANAGEMENT USING COST-BENEFIT ANALYSIS, MOST NOTABLY FOR TECHNICAL RESCUE AND FIREFIGHTING OPERATIONS

Summary of Ph.D dissertation theses

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1 PRIOR ARRANGEMENTS AND GOALS

When writing this dissertation, author wished to know how today's special challenges affect the system of disaster management and prevention, most notably its highest authorities (National Directorate General for Disaster Management, and county offices). Said special challenges are: economic, environmental and social processes, as is the case for all economic organisations. Analysing economic processes was conducted along investment planning and process specifics. Environmental analysis was conducted for the effect of climate change on the organisation's daily operations. Managing disaster relief, reconstruction after disaster and hazard situations, and the efficiency of restoration are also important from a social perspective. The organisation handles the security and relief of lives, critically important infrastructure, living areas, workplaces and other important things necessary for everyday life.

Conducting this highly important set of tasks has to be uninterrupted, while the state has to make sure that any and all tools and resources necessary for their operations is present at all times. Since usually, resources are in limited supply, the organisation is obliged to economise properly, and should be cost-efficient. During the analysis, the author aimed to identify the anomalies within the system, and places where further potential for development exists. There may be many opportunities in employing mathematical- statistical methods as well. The organisation wouldn't even need to bring in large volumes of new resources, as even today, precise data collection is conducted during everyday tasks. This would necessitate maybe a small change or two.

The first goal (C1) was to evaluate the adaptation level of the cost-benefit analysis (CBA) for the investments of the National Directorate General for Disaster Management (NDGDM) into organisational development. As an extension to this, author analysed the preceding project planning documentation made by the organisation. The author's perspective was the application of CBA methodology, and calculation methods usable for estimating and monetising externalities. For this goal, author's first hypothesis (H1) states that the NDGDM's usage of CBA methodology regarding development investment projects adheres to the regulations of the European Union, but by using novel planning- and forecast approaches, improvements can be made regarding the efficiency of considering externalities.

Author's second goal (C2) was to estimate the externalities within the disaster relief system, and the methods and opportunities of internalising said externalities in the future. Author conducted analysis for this goal using a special variation of the benchmarking method, which helped with

identifying the externalities hiding within the system. The second hypothesis (H2) related to this is that a multitude of external effects are generated into the operation of disaster management, due to its wide berth and operational specifics.

Goal three (C3) was the statistical analysis of fire cases and technical relief cases' number and nature between 2012 and 2017. The author was looking to adapt the results of statistical analyses and observable trends to the planning of organisational development projects affecting daily operations. This necessitated the use of various mathematical- statistical methods, such as reporting, and trend analysis to validate H3. Hypothesis 3 states that conducting damage control, and its efficiency needs to obtain a pivotal role in the future, as the effects of weather impact are becoming more and more serious, making disasters and hazards increase in frequency. Relieving these, and managing the damages caused will put severe stress on state budget in the future.

Finally, fourth goal (C4) was to identify the disasters and hazards impacting agri- and forestry as sectors of national economy. The intention was finding cause-effect relations and incorporating them into organisational planning. This process was meant to support my fourth hypothesis (H4): By integrating statistical analysis methods, the reliability of disaster management's decision assisting systems can be increased, specifically for planning the costs of technical rescue and firefighting operations.

2 SOURCE AND METHOD

In the following chapter, author would like to present the methods used for analysing the various hypotheses.

2.1 Benchmarking

Benchmarking analysis, as mentioned above, was used to identify the externalities by employing a special type of benchmark process. The main dimensions of analysis (for the area of Hungary) in light of this were the vehicle and machine fleet, constructed environment and capacity for intervention within the analysis scope. We can consider the various indicators' benchmarking results' determining effect on development potential level, or restructuring necessity of the sector's partial analysis areas a sub-hypothesis of the analyses. The author analysed the economic, technological, social and environmental indicator groups separately for all segments, by which the characteristics of intervention type and necessity were obtained. The attribute characters with a value of 0 were considered generic requirements. This made system attributes with negative values (-2 and -1) representatives of disadvantageous structure, and generate negative externalities. Attributes with positive values were deemed useful system elements which can be developed further easily, and come out as positive externalities for the analysis scope. After summarising the results, conclusions about the aspects, and within them, analysis dimensions amassing negative or positive externalities in the future becomes possible for the sector. After recording the basic tables, indicators were assigned with a state indicator and a performance indicator each. Using the indicators, the initial state and the "results" for the goals can be compared to each other, and evaluated. In the second phase of the analysis process, CBA calculations were matched to the analysis dimensions, and externalities aggregated within the sectors during benchmarking. Author primarily linked these to indicators showing extreme externality values. During benchmarking, a CBA approach to analysing mostly very disadvantageous negative (containing lots of negative externalities), or very advantageous positive (containing lots of positive externalities) attributes.

2.2 Making reports

Making reports served to assist author in validating the assumption, according to which climate change caused extreme weather and temperature conditions, which increased the number of field operations the disaster relief system had to conduct in recent years. In order to gain insight into this, author used the database of NDGDM's field work (firefighting and technical relief reports are regulated forms made on-site where the relief process took place). This database held all field operations from between 2012 and 2017. The database included all data registered during a field

operation into the report. First off, author cleaned the database, and removed all data irrelevant of the analysis. These were: type of field operation, place of field operation (county), time of field operation (year, month), nature of disaster, type of location, and nature from national economic perspective. The type of field operation may be firefighting or technical relief. In the next part of the analysis, author analysed the data of different counties. The aim was to find which county is hit with what kind of disaster the most. This necessitated the analysis of nature of disaster (this was only recorded for technical relief operations, examples are: wildlife accidents, lifeguarding, natural disaster, etc.), as well as type of location (examples: public area, public road, agricultural institution, etc.) and the nature from national economic perspective (sector of national economy hit, f.e.: agriculture and forestry, industry, transport, etc.). Reports were made using these data, which were used by author to find out how many field operations related to extreme weather conditions were conducted between 2012 and 2017 annually, who were the victims of the disaster (private individual, government and municipality, enterprise, etc.), and which sector of national economy was hit (industry, agriculture, state and municipality, transport, etc.). I wished to use these reports to get a clear picture on weather anomalies, and to find trends possibly influencing the operations of the organisation, and national economy. Finally, in order to create a model, the goal was to select a notable sector of national economy. This sector then needed further statistical analyses and cause-effect pairs to be identified in relation to it.

2.3 Pearson's correlation / analysis of relations

Author conducted the Pearson's correlation analysis in Microsoft Excel, where Pearson's correlation coefficient is calculated without r dimension (values between -1.0 and 1.0, including border values). This serves to determine the closeness of linear correlation between two data sets. During the research, author wished to find the connection between field operations of fire stations on farm and agricultural and forestry disasters and their operational areas, and the size of agricultural areas within the county in question. Similarly, I wished to find the relation between field operations and weather conditions (rain, temperature, etc.). I also analysed if there's a relation between number of field operations, and number of agricultural enterprises, furthermore, value of realised agricultural investments' performance values.

2.4 Forecasts, trend analysis

In the current analysis phase, author worked with the function of the Excel forecast, which uses known current values to result future values. The value forecast is the y parameter of the x value. Known values are x and y values, new values are obtained via linear regression. During the analysis, author prepared three scenarios from the number of field operations. The function was

later used to analyse changes in various expenditures of the budget, HR changes and resource usage changes.

2.5 Structuring the CBA model

The point of modelling is to find the most notable attributes of the system I'd like to model, and use them to create a similar system. However, I must note the system attributes which validate my model, and its framework limitations during the process.

Step 1: The first step is always to identify and describe the problem. In our case, the model attempts to answer how the organisation can adapt to the current climate, weather and economic trends, taking the opportunities of cost and benefit perspective into consideration when planning development investments. Therefore, the main problem is how the organisation's decision methodology related to their development investments doesn't necessitate the cost and benefit perspective unconditionally. This is due to how the organisation is one very important for society. However, as a state institution, the economic rationale when using public financing should be just as important as exceptional performance during conducting tasks. This will be the primary financing source of the organisation in the future, after all. Another interesting point is that cost and benefit methodology is only used in its simplified form, or with limitations for development projects financed by tenders. Therefore, we may assume that the system generates several externalities, which will turn out to be inhibitors of efficient and economically sound operations in the long-term.

Step 2: The next step in the modelling process is current state analysis, during which author analysed the main system attributes, and attempted to see into the operations of the organisation in detail, as much as possible. The experts of NDGDM were of great help in this. In order to facilitate this process in practice, a research cooperation supported by the Scientific Committee of Internal Affairs and the NDGDM was established. The author was allowed to conduct interviews with the leaders of the organisation, and access to some internal documentation. Both were used while creating the model. In this phase, processes and main components, and actors, in addition to the interval of the analysis (2012 to 2017) were all identified. To somewhat avoid the complexity trap, author found it reasonable to conduct a separate analysis of a sector of national economy (agriculture and forestry), which is the case study of this dissertation.

Step 3: The next step constitutes a more complex process, as this is where the system-specific basic function of the CBA is introduced. This includes the scope of expenditures and benefits, as well as the data related to field operations and their trends related to climate change and economic trends, for scenario structuring.

All these serve as the basis for a current value calculation, where all information impacting the three basic elements at the same time need to come together.

The basis of the C-B function = current practice (business as usual-BAU) analysis, and determining factors changing it.

Figure 1 shows the structure of the theoretic model:

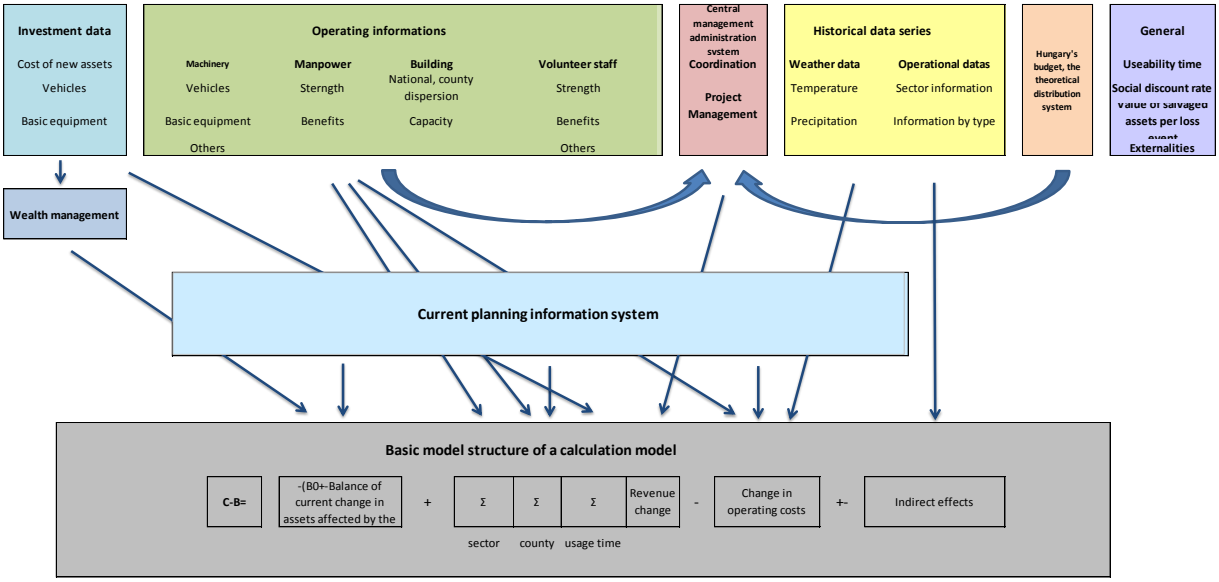

Figure 1 – Structure of the calculation model

(Source: self-made, 2019)

The function has three components:

1. The sum of all interventions and organisational behaviour that relate to long-term decisions: R+D activities, strategic paths.
2. The sum of factors influencing annual organisational operations. This constitutes a basic expenditure function, which is influenced by the annual decisions, and the decisions of the previous period. (±; C-B analysis)
3. Balance of indirect effects.

The type of the current model can be considered an economic model according to the phenomenon analysed, which aims to replace the operation of the disaster relief organisational system as a complex unit, in a simplified form. Also, due to certain similarities, it could be used to analyse the organisation as well. As it attempts to take various random factors into consideration, it's stochastic, whereas due to the volatility of the time dimension, it's dynamic – a system changing at the same time. Fundamentally, the system is process-oriented, as it's based mostly on cause-effect relations and mathematical equations.

3 RESULTS

In this chapter, analysis results for the various hypotheses will be introduced.

H1 was: The NDGDM's usage of CBA methodology regarding development investment projects adheres to the regulations of the European Union, but by using novel planning- and forecast approaches, improvements can be made regarding the efficiency of considering externalities. In order to analyse this, author used project documents and professional material using document analysis, and came to the conclusion that there's points to improve the cost-benefit analysis methodology from the perspective of managing externalities. The analysis of H2 comes in right away, which states: a multitude of external effects are generated into the operation of disaster relief, due to its wide berth and operational specifics. The benchmarking analysis' results on this are shown in Table 1 below:

1. Table: Summary of the benchmarking of indicator group on transport, vehicle and machinery fleet

No.		**Transport, vehicle and machinery fleet**	
		Analysis period (2012-2017)	**Future period**
Technological / Social	1	-2	-1
	2	-1	0
	3	-2	-1
Environmental	4	-1	0
	5	+2	+2
	6	-1	-2
Economic	7	-1	-1
	8	-1	-2
	9	+1	+1
Net positive externalities ∑ (1;9)		**-6**	**-4**
Total externalities ABS (1;9)		**12**	**10**
Effect of net positive externalities within total external effect		**0%**	**0%**

(Source: self-made, 2018)

In terms of the analysis conducted, main system attributes of the **transport / vehicle fleet** were as follows (Table 1): In light of the analysis of the specific analysis of the energy mix

used, the author states that these indicators generally show an almost exclusive use of fossilised energy sources. The next period likely won't change much in this regard either. The generic quality level and usability of the technical tools and machinery is overall low, though the recent tender project for vehicle hoses caused a significant improvement within the system.

The usage of renewable energy resources may bring change for the fleet serving the human resource, in case this is also a priority target for development and strategic planning. The average age of the vehicle fleet shows an improvement in tendency, however, still unsatisfactory. The usage of development resources is the most notable in this area though. This is due to having to take the future conservation of quality level into consideration as well, and the aim is to keep this economically as sustainable as possible (parts and components are manufactured in Hungary).

Thanks to procuring new vehicles, the emission of hazardous materials in the sector decreased significantly, which also suggests further improvement in the future. It's important to note that the extreme weather conditions generated by climate change increased the ratio of conducted field operations significantly. The acclimatisation strategy of the disaster relief sector is sufficient in this regard. There is also significant demand for life- and property preservation systems, which generated strong incentive to invest in recent years. This, however, may decrease in the following period, if the pace of realisation is kept. Introduction of new systems has a positive effect on labour market processes, since continuous demand for labour is generated.

Furthermore, the development of current human resource is also continuous, thereby creating quality expert employees. However, it's important to note that this part of the organisation only received state financing to the point where needs aren't met, as such, the organisation needs to apply alternative methods. An example is the presence of volunteer firefighter communities. These communities, just like those operating in other relief sectors (volunteer reserve system in the military) conduct field operations that the capacity of the organisation is insufficient for. This also reduces their expenditures.

2. Table: Summary of the benchmarking of indicator group on constructed environment

No.		Constructed environment	
		Analysis period (2012-2017)	**Future period**
Technological / Social	1	0	0
	2	-1	-1
	3	-1	0
Environmental	4	-1	-1
	5	-1	0
	6	-1	-1
Economic	7	-1	-1
	8	-1	0
	9	+2	+2
Net positive externalities ∑ (1;9)		**-5**	**-2**
Total externalities ABS (1;9)		**9**	**6**
Effect of net positive externalities within total external effect		**0%**	**0%**

(Source: self-made, 2018)

In terms of the analysis conducted, main system attributes of the **constructed environment** were as follows (Table 2):

As usual, the first indicator (similarly to the previous group) is the ratio of using non-renewable energy sources. Thanks to the organisation's Sustainability Plan, more and more elements related to this are within the system. Selective management of waste is continuous, so is recycling. These are conducted in cooperation with other authorities (police, institutions of judicial system). However, the usage of renewable systems is not frequent, which serves as a concern for the future, as preparation for cases where there won't be subsidiary sources for operational and other expenditures is a must. However, there are interventions in this area intending to increase efficiency in this area as well. State institutions need the improvement of securing supply, where one of the most efficient method would be to prepare these institutions and organisations to be self-sufficient (f.e. installing solar battery systems, finding cleantech

solutions, etc.). The usability and technical quality level of buildings are rather low, however, is improving following the availability of resources. It would be best to plan these investments while taking the abovementioned perspective into consideration as much as possible, which would also improve the amount of positive externalities.

According to the Sustainability Plan, this area also showed notable improvements in terms of energy efficiency and recycling. The ratio of these improvements are also expected to increase in the future (building operation / upkeep developments). These initiatives have an effect on the opportunities for decreasing emission rates related to the specific system element. Using the abovementioned green systems, this could be made significantly more efficient in the future. In the organisational management of disaster relief, communication elements supporting sustainability initiatives are already present. Recycling and selective collection of waste is already a focus, all institutions within the sector encourage their employees to use these systems every day.

The increased rate of field operations in this system element also generates various demands that similarly to the case of the vehicle park, means excess loads on the organisation's, and by extension, the state's budget. However, each and every realised development improves this ratio, as operating the newly created systems is much more economically efficient due to the increased efficiency – which also helps the optimisation of expenditures.

In this case, we can consider the fact that these developments are inevitable positive, since the demands of society for systems created and efficiently operated for life- and wealth security significantly increased. The current systems are out of date to support this. This is basically a self-sustaining process, as demands generate investments, for which the European Union and the state habitually offer subsidy, after which the installed modern technological solutions and infrastructure help cost-efficient operation within the disaster relief sector, thereby optimising the ratio of costs and benefits.

3. Table: Summary of the benchmarking of indicator group on intervention capacity

No.		Intervention capacity, operational processes	
		Analysis period (2012-2017)	**Future period**
Technological / Social	1	-1	-1
	2	-1	-1
	3	-2	-1
Environmental	4	-1	-1
	5	+1	+1
	6	+2	+2
Economic	7	+1	+1
	8	-1	-1
	9	+1	+2
Net positive externalities ∑ (1;9)		**-1**	**+1**
Total externalities ABS (1;9)		**11**	**11**
Effect of net positive externalities within total external effect		**0%**	**0%**

(Source: self-made, 2018)

The third indicator group analyses a complex system attribute, by evaluating the main characteristics of **intervention capacity and operational processes** (Table 3).

Similarly to preceding research, this analysis method also resulted in that climate change increases the number of field operations of disaster relief significantly. The two have a strong correlation with each other, to which the organisation attempts to adapt in various ways. One example is to rethink the national risk evaluation systems, and developing their technological background. The human resource necessary to relief-, restoration- and reconstruction work shows some inadequacy in numbers currently, but taking the trends into consideration, the labour force can be optimised. This is where the employment possibilities of labour leaving the education system should be considered. Education courses where people capable of filling in for the empty positions should be preferred.

The current volunteer system helps with finding people to take up the slack, but this isn't a solution in the long-term. As the organisation conducts its activities for the state (which

activities are getting more numerous and complex due to climate change and other trends) focused at securing and protecting human life and infrastructure of critical importance, it needs a professional competence. No errors are tolerated, since a small error or miss may result in more and more serious consequences.

Though Hungary is a low-risk and disaster level area, the industrial disasters happening in relation to economic growth, and environmental causes can't be neglected. In the future, the number of these is assumed to increase. In order to monitor this trend, the risk diagram of Hungary is made annually as part, and a cornerstone of the risk evaluation system. Being an element of the disaster relief system, the freshly developed risk management system employs a variety of modern information technology tools, as such, the efficiency of this system element is also constantly increasing. As a direct effect, intervention capacity and operational processes are also constantly improved.

Therefore, the efficiency of the organisation in reducing the environmental effect of disasters is currently on an acceptable level, and further improvement can be expected in the future. In order to further increase the efficiency of disaster relief systems, the various security systems also have a pivotal role. These are constantly being made and cover more and more of our natural and constructed values. In summary, we can state that resources for prevention are increased consistently, thanks to the relevant European Union and national strategic programmes. But at the same time, the severity of disasters is also increasing constantly, as gradually degrading tendencies are hard to follow for the pace of realising investments. This means we're at a constant disadvantage here, and sadly, natural processes always have an edge. The civilian protection mechanism of the European Union is based on the principle of joint responsibility, which also takes its part in increasing the security levels of various Member States. The legal basis for joint disaster relief cooperation is the 196.th paragraph of the Treaty of Lisbon. In accordance with the treaty, the European Union extends the capacities of Member States as necessary, helps with coordination, and increases the efficiency of joint intervention. By improving the preparation level, making preparatory interventions, subsidising development related to these, assisting cooperation and creating a joint financial foundation, the European Union contributes to the rationalisation of Member States' disaster relief systems.

The disaster management system is a very important and complex target from all perspectives, which is why author made it the topic of this dissertation. When the analysis was

begun, author had several ideas on its operation, defined from the perspective of a non-expert individual. However, as the analysis kept going, author received information en-masse which were gathered during the deep interviews, the expert meetings and the analysis of organisational data and literature on the topic that made author think the topic over once again. It's interesting how an organisation operating on such an important area isn't free of externalities either, even more so as the system has a large amount of them, a fact proven by the results of this dissertation's expert benchmark analysis. In conclusion, we can say that for the disaster relief system, there are smaller 'system errors' we can observe. In accordance with the rest of the governmental budget's organisations, everyday operations are planned along specific perspectives. This includes possibly development paths as well. This often happens out of their control, as many an external process affects the system, which are hard to immediately adapt to. Furthermore, as Hungary is a Member State of the European Union, the scope of subsidy sources is also a given. This means that actualising system development plans isn't always constant, and though attempts to adapt to the trends at the time, often development is being made in areas that have a subsidy source to begin with. These processes are further highlighted by how the time to adapt to changes brought by climate change is getting shorter and shorter as well. This first needs a European Union-level strategy created, after which national action plans have to be created. All these have a long and bureaucratic process that needs to be finished prior. However, if acclimatisation initiatives only begin that late, there are often various changes that concluded in the meantime, within the natural and the social environment, thereby generating even more externalities within the economic systems.

3.1 Analysis of correlation within data related to agriculture and forestry disasters (Pearson's correlation)

This part is related to the fourth goal (C4), which is to identify the disasters and hazards impacting agri- and sylviculture as sectors of national economy. The intention was finding cause-effect relations and incorporating them into organisational planning. This process was meant to support my fourth hypothesis (H4) stating that by integrating statistical analysis methods, the reliability of disaster relief's decision assisting systems can be increased, specifically for planning the costs of rescue and firefighting field operations. The disaster prevention organisation system is a complex area in and of itself, but the processes of analysis are further complicated by the complexity of national economy sectors affected. Due to this, in this phase of the analysis, author found it reasonable to handle sectors that make the

identification of cause and effect relations easier separately. In accordance with author's education and previous professional experience, author chose to analyse the disaster occurrences that hit agri- and sylviculture. Another reason was that the sector has a large share within economic systems.

One of the pillars of modelling is to correctly identify the fundamental relations, which needs mathematical statistical methods. Of these, author chose Pearson's correlation method, as after conducting this analysis, the ratio of correlation between factors and the effect (negative or positive correlation) as well. This is signified by the correlation coefficient (r). Author also checked the value of determinacy coefficient (r^2), which shows how the change in one factor changes the other's value, which aids in creating the forecast processes. As such, for example: for an r=30 value, r^2=0.09, meaning forecasting the dependent from the independent variable is only possible to an extent of 9%. The importance of this fact is not to be underestimated, as one of the main goals of the model to be made is to possibly adapt forecasts into the planning system. During the research, author aimed to find the relationship between the field operations of fire stations related to agri- and sylvicultural areas and their operative locations, and the size of agricultural areas within the county. Furthermore, another target of correlation analysis was between field operations and weather conditions (rain, temperature, etc.). Furthermore, author analysed if there's a relation between the number of field operations and agricultural enterprises, and the performance values of investments realised in the sector. In order to conduct the analysis, author used data of the MIA NDGDM's database, and the database of the HCSO. Both databases offer precise and reliable data, which makes the results of analyses conducted using them the same. It's important to note that during the research, author only analysed on the field of disasters impacting agri- and sylviculture, not all disasters. Therefore, in the following part, when using the term "field operation", only the cases mentioned above are relevant.

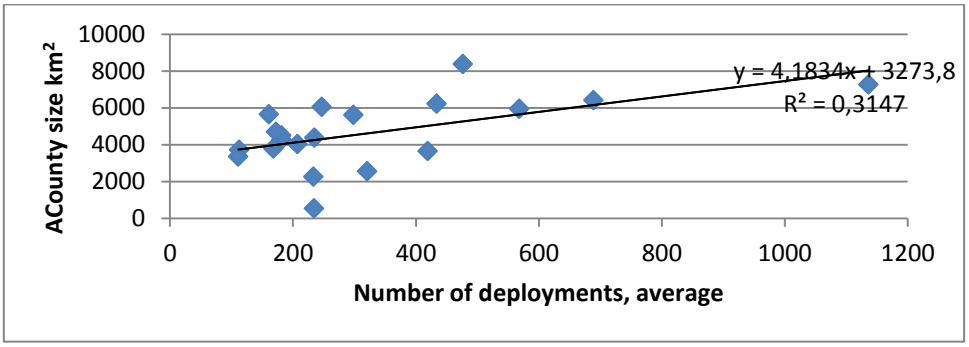

Figure 2- Analysis of county size and field operation numbers' correlation

(Source: self-made, 2019)

Pearson's correlation value: 0,560988154 r^2=0,3147077

This analysis was meant to evaluate the correlation between the size of the county in question, and the field operations conducted within it, after author calculated averages for the field operation data between 2012 and 2017. We can see (Figure 2) that in this case, the correlation strong, but has a relation with the next analysis element because the size of counties also has a strong correlation with the size of agricultural area within the given county.

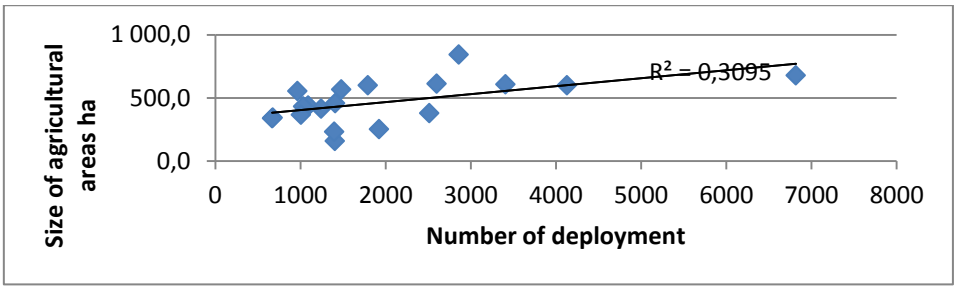

Figure 3- Analysis of county agricultural areas' size and field operation numbers' correlation

(Source: self-made, 2019)

Pearson's correlation value: 0,556343748 r^2= 0,309518366

According to author's prior assumption, the larger a county's agricultural areas' size is, the more the disasters impacting the local agriculture are. This assumption is correct, according to the results of Pearson's correlation analysis, due to the strong relation between the two variables (Figure 3). This means that in counties where agriculture is a dominant sector, prevention of fires impacting the agriculture should be treated as a priority.

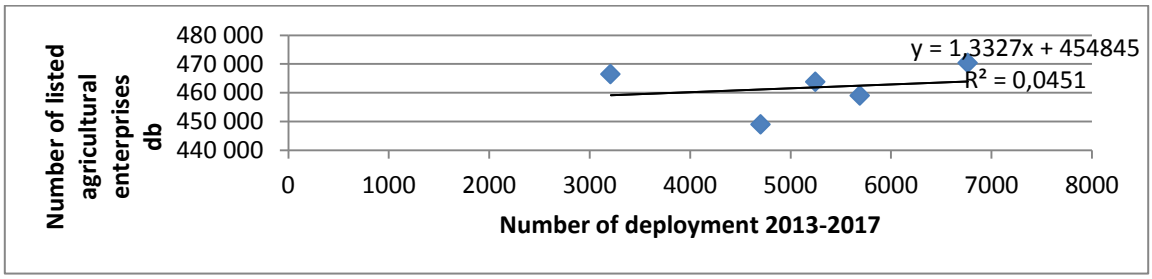

Figure 4- Analysis of number of listed agricultural enterprises and field operation numbers' correlation

(Source: self-made, 2019)

Pearson's correlation value: 0,212282117 r^2=0,04506369

When analysing this correlation, author first thought that there might be some kind of connection between the two variables, however, as seen on results, this is extremely weak (Figure 4). The reason is that not only classic farmers belong in this group, but the entirety of the agribusiness sector, which also encompasses the trade units and the export-import enterprises. These deal with agricultural produce, however, have no relation to the disasters impacting the sector, treated under a different categorisation in the NDGDM database.

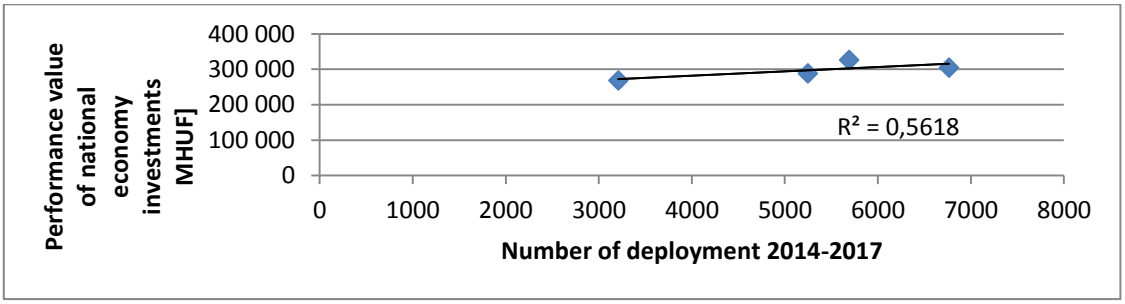

Figure 5- Analysis of performance value of national economy investments and field operation numbers' correlation

(Source: self-made, 2019)

Pearson's correlation value: 0,749503892
r^2= 0,56175608

According to author's speculation prior to the analysis, a strong correlation was assumed, which turned out to be true. However, author was somewhat surprised at the underlying reason. The results of the analysis (Figure 5) necessitated some further information gathering, as author thought that the result of the correlation between the two variables will be negative. After author checked on the cause and effect relation, surprisingly, disasters themselves generate new investments, meaning instead of preventative development being done, a post-fact replacement of the tools and properties hit by the disaster is happening. However, author believes that after a while, this relation will turn itself around, once a certain technological development level is reached. This means that once the more secure and efficient technological solutions are available, the number of agricultural fires will decrease.

Correlation between amount of rain in given area and the month's highest temperature values, and the number of field operations

The analysis of the following correlation was conducted by taking the average of the measurement stations in three counties for three years (2015 – 2017), to which field operation data was normalised with the same method. The values resulting for the analysis are listed below (Figures 6 and 7):

Rain:

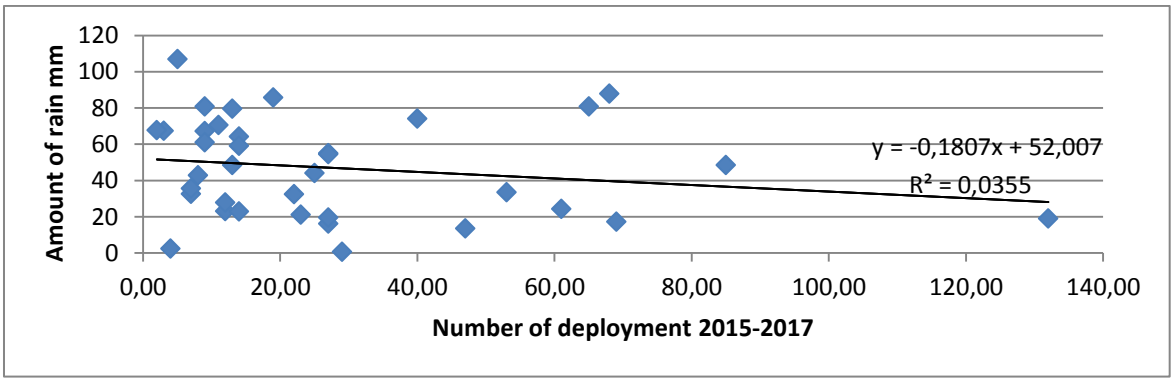

Figure 6- Analysis of amount of rain and field operation numbers' correlation data
(Source: self-made, 2019)

Pearson's correlation value: -0,188386 r^2=0,0355

Temperature:

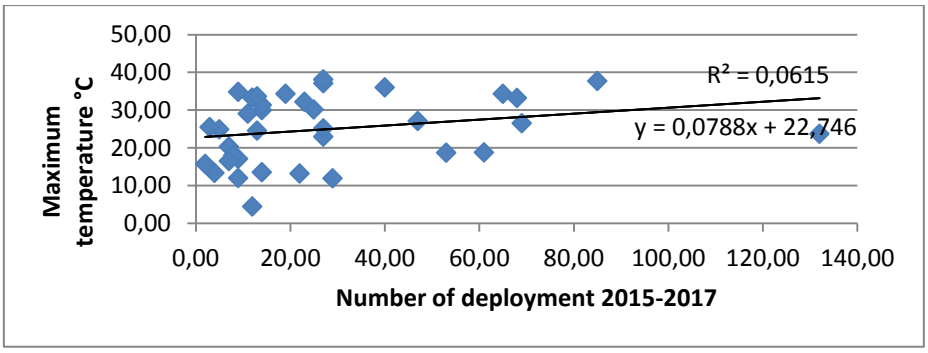

Figure 7- Analysis of temperature values' and field operation numbers' correlation
(Source: self-made, 2019)

Pearson's correlation value: 0,2480308 r^2= 0,06152

According to author's opinion, the result where the more rain in the given area, the less cases of fire can be observed is no surprise. This means the two variables correlate inversely. However, in spite of how this seems evident, the analysis showed a really week correlation in this area. However, the exact opposite happens for the temperature variable, as a strong correlation between the hot temperature days and the number of agricultural fires can be observed. This is where we need to note the determinacy coefficient, which shows that temperature data can be used to forecast firefighting cases in 45%.

In the next analysis phase, a smaller, more exact analysis area was separated. In this part, the budget data of the Bács-Kiskun County Disaster Management Office, and the agricultural and forestry firefighting cases and technical relief operations' numbers were taken into the analysis. The notable data on incomes and expenditures came from official data from the budget reports. The analysis still concentrates on the input data necessary for the modelling process, and acts as support in identifying relevant relations.

Investments, renovations

The analysis of correlation between investments and renovations brought the following results. The value of r^2 shows us that using the change in number of cases, we can forecast the necessity of investments to roughly 40%. Therefore, we can similarly determine the necessity of increasing or decreasing subsidy required for this process. Though these processes are not always so obvious, and an increase in subsidy sources isn't always possible either, it seems that the organisation aims to supply their own demands.

Pearson's correlation value: 0,631355478
r^2= 0,39860973

Next, author similarly analysed the correlation between processes in terms of the various system elements as well.

Machinery, tools, appliances, vehicles

In the case of the abovementioned objects, the results obtained by author are completely logical. It is obvious that due to their nature, these elements have a long life cycle, and may not follow the number of field operation cases. Naturally, the positive nature of the correlation is obvious, as the higher the use ratio, the higher the level of amortisation, and there are parts and units within some machinery which are subject to routine replacement, which have to be replaced after each field operation. However, the expenditures in this area are usually calculated as fixed costs.

Pearson's correlation value: 0,072208043
r^2= 0,005214

Manpower

In the case of manpower, author analysed the various employment levels separately. It's clearly visible how the table of the leading personnel is constant to a certain level, however, the increase in field operation number also necessitates the increase in leading personnel

numbers (Table 4). The reason for this is that when trying to handle more and more complex challenges, you need to have leading experts with lots of experience to coordinate. The decrease of non-leader employees and public servants can be attributed to the number of field operations and personnel allocation, and the optimal design of a proper technological mix.

Table 4- Correlation between employed number and field operations

	Employed number and field operations (Pearson's correlation)
Leader	0,996989906
Non-leader	-0,274189185
Civil servant	-0,996989906

(Source: self-made, 2019)

Properties, and related financial rights

In terms of properties, the correlation analysis resulted in a negative weak relation. This clearly mirrors the truth, because we can say that the subsidy the organisation can receive is limited. Meaning, in order to finance the increased expenditures due to the number of field operations increasing, they need to retrieve the resources from a different department. As the state of properties has no direct impact on the completion of field operations, similarly to many other cases, the renovations on said buildings are postponed. Growth can only be achieved and observed in case some other sources can be introduced (tenders, other subsidy sources). In other cases, property management compels the lease or selling of properties.

Pearson's correlation value: -0,131116782 r^2= 0,01719161

Volunteer organisations

For volunteer organisations, author evaluated various elements separately, since the financing of said organisations is mainly done from tender sources offered to them by the NDGDM. Maintaining volunteer organisations is a very cost-efficient solution for them, which is why the number of said organisations is increasing. This means that in smaller, less hazardous cases, instead of the professionals, volunteers can be sent on-site. This, on the one hand, helps manage the lack of personnel, and on the other hand, by creating these volunteer organisations, optimal dislocation can be worked out as well. In the table below (Table 5), we can see the financing framework of recent years for the volunteers of Bács-Kiskun. However, this isn't the full financing framework, author only highlighted the elements which have a direct connection to conducting field operations. These are system elements which increase in

proportion to the increase of field operations. We can also see this in the results of the correlation analysis, which means that if we present the result using the value of r^2, the change in field operation number can be used to forecast the necessity of these tools in 100%.

Table 5- Correlation between VOs' financing sources and number of field operations

	Financing for fire truck machinery, repair and evaluation, BM HEROS Co. Ltd.	**Firefighting technical tools**	**Suction- and pressure-side equipment**	**Handheld tools and other equipment**
2016	0	2382560	2181981	3688760
2017	3057265	2513060	2372046	2199190
Pearson's correlation value	1	1	1	-1

(Source: self-made, 2019)

To summarise the results of this chapter, we can say that determining the fixed and varied costs is important, as much as taking them into consideration during budget planning. In the model made by author, these specifics were implemented, however, the deeper we deconstruct the costs, the more precise our results will be in the end. In the following chapter, author wishes to deal with the adaptability of currently available results into the model, and the introduction of possible scenarios, and changes in trends.

3.2 Specifics of the CBA model, practical applicability

The main goal of modelling is to assist the cost economising and decision making processes of the organisation, by mapping the connection systems of the correlations between each other. The most notable perspectives within the model made by author consist of the following:

- *Specifics of the intervention area:* For separate offices, analysing the main specifics of their intervention areas is advisable. Such are their local area, geographic map, weather conditions, state of infrastructure (quality of roads, average quality of buildings, etc.), population density, ratio of populated and unpopulated areas, etc.
- *The local economic specifics:* Due to the complexity of disaster management's tasks, the national economic specifics of field operations may differ, which means it's important to note the economic structure characteristic of the county in question. This means that while some places have high amount of industrial production volumes (hazardous institutions, factories), other places in Hungary have higher production in

f.e. agriculture. These specifics should be identified, as they determine the specifics of field operations, and we may even use them to forecast disasters.

- *Location of most notable danger zones:* Identifying these helps with optimal dislocation. Furthermore, by noting the important danger zones, we can also determine what may inhibit disaster relief related to them, which makes the organisation capable of planning preventative measures.
- *Excess cost of necessary investments:* An important goal of the CBA is to determine the ratio of excess costs related to investments compared to the so-called no project scenario, and, if the organisation profits better from realising the investment, or postponing it.
- *Life expectancy of tools:* This is a highly important pillar of investment economic benefit analysis, as a new tool, infrastructure has costs, which have to be calculated for the relevant period.
- *Excess costs of employed technological system, and balance with savings:* We have to evaluate when the costs of introducing a new technological solutions will generate a return, which can be done by comparing to our savings.
- *The effect of the new investment on completion of field operations:* In case of a development project, the efficiency of the organisation's task conduction being better always has to be a focus target (things like the decrease in landing time could be mentioned here).
- *Indirect economic effects of development projects:* When mentioning indirect effects, we can think about optimisation of number of employees, which can f.e. be decreased in case there's a toolset modernisation. This is also where other external effects can be categorised (conservation of protected natural environments, protection of human life and critically important infrastructure, etc.), which need to be internalised.
- *Area of usage:* On this, mentioning how a technological development for a given unit may or may not have an effect on the units operating on neighbouring units is important. In some cases, even their loads can be reduced indirectly.

Goal three (C3) was the statistical analysis of firefighting cases and technical relief cases' number and nature between 2012 and 2017. The author was looking to adapt the results of statistical analyses and observable trends to the planning of organisational development projects affecting daily operations. This necessitated the use of various mathematical-statistical methods, such as reporting, and trend analysis to validate H3. Hypothesis 3 states

that conducting damage control, and its efficiency needs to obtain a pivotal role in the future, as the effects of weather impact are becoming more and more serious, making disasters and hazards increase in frequency. Relieving these, and managing the damages caused will put severe stress on state budget in the future.

The analysis of literature, and the processes of recent years, and the professional information services' data helped author in determining the expected trends. Though during prior analysis, it seemed possible that climate change will cause extreme weather conditions, however, this only relates to a noted timeframe within the tasks of disaster relief (day-week-month). This also makes it more complicated the organisation's planning and optimisation, as it doesn't validate sustaining a persistent, higher capacity of system elements from an economic perspective.

However, at this point, the theory of bottlenecks is interesting. Using this theory, we may determine the resource which may cause a problem during a hazard situation, and we can also identify which is present in excessive quantity for when the number of tasks possibly reduces. Therefore, the basis for trend analysis within the model came from the changes in field operation number, which can also be used to forecast the changes in cost elements' ratios.

For simplicity's sake, author determined three scenarios, first with the decrease of field operations, second with the stagnation of field operations, and third with the increase of field operations forecasted.

In order to introduce this, author will present the calculation tables for number of employed and costs (Tables 6 and 7), as follows:

Table 6- Forecasting employed numbers by changes in field operation number

				Forecast of employee numbers		
	2015	2016	2017	S1	S2	S3
Leader	34	34	35	33,2189839	34,84182288	36,05895211
Non-leader	497	534	509	523,3533815	508,7610784	497,816851
Public servant	101	101	98	103,3430483	98,47453136	94,82314367
Total number	632	669	642	659,9154137	642,0774326	628,6989468
Field operations	302	291	419	200	400	550

(Source: self-made, 2019)

When analysing the number of employed forecast Table, we have to think back to the results of the correlation analyses, where the main connections were identified during the evaluation

of results. More specifically, as we can also see it in this case, for those in leading positions, the relation shows proportional logic, which means that more notable field operations need more, whereas less notable ones need less experts. In terms of non-leaders, the results change, the analysis basically shows inversely proportional logic. The reason for this is, on the one hand, the wide array of technological developments from recent years, and on the other hand, the increase in field operation conduction efficiency. In case the organisation follows this trend for investments (as this is a theoretic model, we can accept this as a fact), the abovementioned results hold true (however, if we also analyse other data, we must mention the lack of human resource as well, in other words, retired employees and quitters, but for the current Table, we shall leave these out of the analysis). In the next part, we'll take a look at the basis of our trend analysis, through the cost calculation seen in the next Table (Table 7).

Table 7- Forecast of human resource-related expenditures based on the number of field operations conducted

Cost forecast (HUF/person annually)						
S1	S2	S3	2015	2016	2017	
6620294,539	8475484,531	9866877,024	7180726	7816974	8684875	Leader
3051921,847	4234112,361	5120755,247	3640648	3602790	4347640	Non-leader
1045259,146	1019375,924	999963,5075	1114328	958283	1009847	Public servant
10717475,53	13728972,82	15987595,78	11935702	12378047	14042362	Total number
200	400	550	302	291	419	Field operations

(Source: self-made, 2019)

Author calculated the average costs of human resource categories from the financial reports of previous years, where the wages are precisely determined. Author used these to calculate average values, within each category of employees per capita. This is basically a simple calculation, as with changes in employment numbers, the related costs will follow in a proportional manner.

Due to text size constraints, author doesn't show the rest of the examples, but the analyses were conducted for all system elements. However, the point is to link the various elements, by which the process of the bottleneck theory already starts to work. There are several opportunities to analyse this. It's possible to start from the constant availability of the subsidy framework. However, we might also identify parts like the number of employees or the tool assets, which are hard to optimise.

In relation to the vehicles and machinery, there are smaller deviations when evaluating the various scenarios. The upkeep of some tools and machinery in the system may be advised in case we calculate with an increased number of field operations. Since though the developments of recent years generated a higher efficiency rate, we also have to take note of the possibility where even this won't cover the needs of conducting field operations. If we don't take this into consideration, redesigning or selling some tools could generate some income, or establish some savings by simply not maintaining them. We also have to keep in mind that it's assumed that during the next few years, there won't be sources to finance procurement in these areas. Therefore, using what the organisation has will be necessary. Old machinery, tools, and other may prove to be great components, in case keeping them in operation and using them for field operations is completely out of the question.

For the development of building assets, the decrease of field operations could mean a positive effect, since in this case, savings could be made from the varied costs. This could make it possible to spend financing on renovation and state conservation of these buildings. However, taking past trends into consideration, this is the least expected scenario. Thus, this will have to be solved using a different financing source. Tender opportunities proved to be good solutions before, however, even these are in short supply. Yet, we can say that even if the volume is not notable, renovation of stations is continuously underway. The location of the operational area could also be advantageous in this case, as the larger the demand for the station existing, the wider the berth of external financing sources at hand is (municipalities, enterprises, other sponsors).

As such, in summary, we can clearly see that we may obtain interesting results by analysing system elements separately, or by handling them as a complex unit during the analysis of various scenarios. As the field operations of disaster relief related to rescue- and firefighting is conducted among severe uncertainties, sadly, it's impossible to generate perfectly assured forecasts. However, the use of the analyses isn't necessarily in here either. Identifying correlations, finding the partial units which, when handled together as a single entity, may increase the efficiency of economising, or even on the field of conducting operations may prove a better result.

3.3 New scientific results

In this chapter, author presents the new scientific results of the analyses, which may aid the NDGDM and county offices in rethinking their CBA methodology related to their future development processes, which will also help them increase their level of acclimatisation and their operational efficiency.

E1- After analysing the project documentation of the NDGDM, and conducting analyses together with the project manager experts of the organisation, we can state that the CBA methodology used as part of the organisation's decision assisting system is sufficient for basic cost efficiency concerns. However, in case it's shown in relation to the operational area and system complexity of NDGDM, there is an opportunity for further developing it.

E2- The benchmarking's result helped author in identifying the external effects within the system. Most of these are negative externalities. This means that without the internalisastion of said effects, they will continue to inhibit the efficient operation of the system in the future. The management of positive externalities is similarly important to realise an efficient and successful operation, as these can generate collateral advantages for the organisation.

E3- During the analysis of landing data, the constant increase in field operations is obvious, which makes the increase in costs related to field operations for the disaster relief system as such as well.

E4- During the development of decision assistance systems, focus should be on to use complex analysis methods to assist decisions with.

4 CONCLUSIONS AND SUGGESTIONS

The analysis of Hungary's disaster management authority system was a very complex and interesting task. During the analysis of the MIA NDGDM and the county offices, and the volunteer organisations, author discovered special system attributes at the analysis of the decision assistance systems of investment and development processes already. The special operational environment also made research exciting, similarly to the analysis of cost factors in various system elements.

Author's first suggestion concerned the constant increase of the organisation's field operation number, caused by the extreme weather conditions increasing in number due to climate change. This was proven true, both according to literature analysis, and to reports, statistical analyses. Based on this, author concluded that the proper operations of the organisation will generate a higher cost in state budget.

The next analysis phase related to this was the analysis of using CBA. Author mainly wished to understand what the organisation does in order to make their economisation system as efficient as possible. Author made the conclusion that though the work of experts is very high quality for the organisations in question, today's cost economising systems may adapt relevant assets from a special approach. As an example, following the main elements of externality economy, the external effects hiding within the system, unaccounted for prior were identified by author. These can cause the results of decision assistance analyses to be distorted. While creating the model, author aimed to keep various system specifics, the adaptation of the Disaster Risk Evaluation methodology created by MIA NDGDM, and the implementation of new approaches (analysing on sector level) in consideration.

Furthermore, author suggests assisting the implementation of further statistical planning methods by the organisation on the following two areas. Author suggests using the database recording landing data for field operations with an extra element: determining the nature of firefighting or technical relief operation. Specifically, if the case is a fire that has an effect on the agriculture and forestry sector of national economy, the main attribute of it (f.e. forest fire, drought fire, agricultural machinery fire) be recorded. Statistics related to this may help with prevention and the development of fire security interventions. The categorisation author used is based on official educational material of firefighters, therefore, all the employees should be familiar with it. The recording of an additional data onto the data recording sheet (TMMA)

constitutes no extra work. However, it may prove extremely useful to conduct analyses for this kind of categorisation.

Author's final recommendation is based on the fact that the analysis of complex systems can only happen in a satisfactory way when using complex analysis methods tailored specifically for them. Due to the text limitation of this dissertation, author only analysed the fire and disaster cases related to agriculture and forestry, however, author suggests conducting similar analyses for the other notable sectors of national economy as well, such as industry, transport or properties. Author's opinion is that we can obtain useful results from creating these analysis framework systems, which is important due to how most disasters are generated on these three areas. Due to their high relevance, these are the areas where prevention should be stressed the most, and excess financing be turned towards, in order to free the state budget of large disaster management and repair costs, and prevent the degradation of various sectors' economic results.

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