General direction of research: Emergency Logistic Management Problems for Disaster Zones in Response & Recovery Stages.

Construction of Emergency Management Supporting Systems

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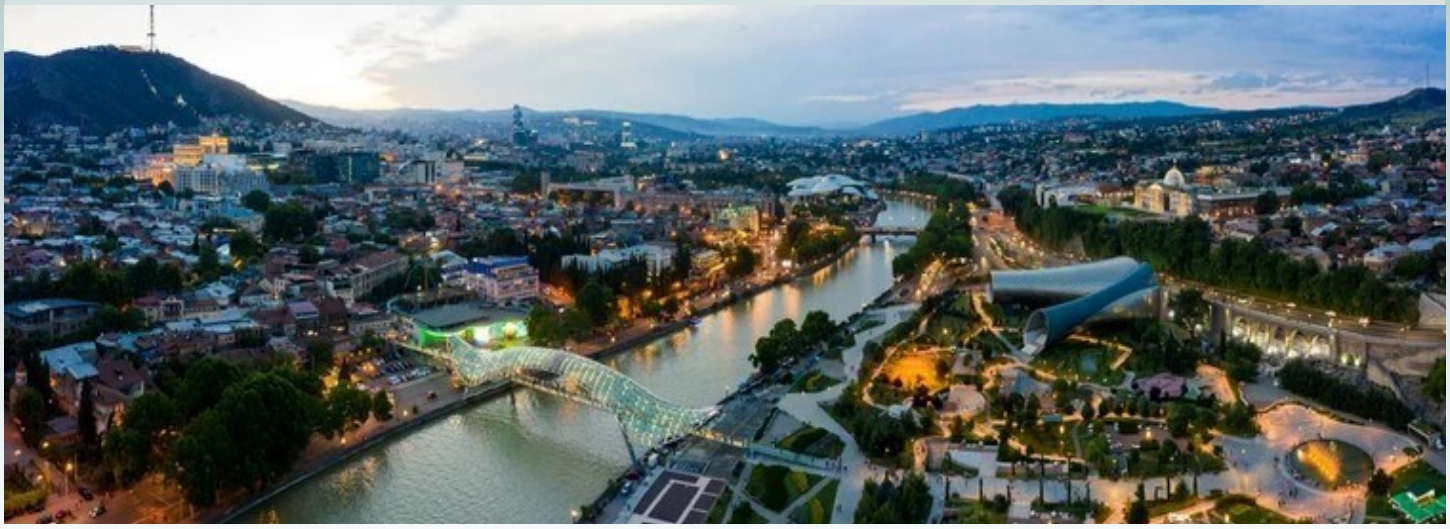


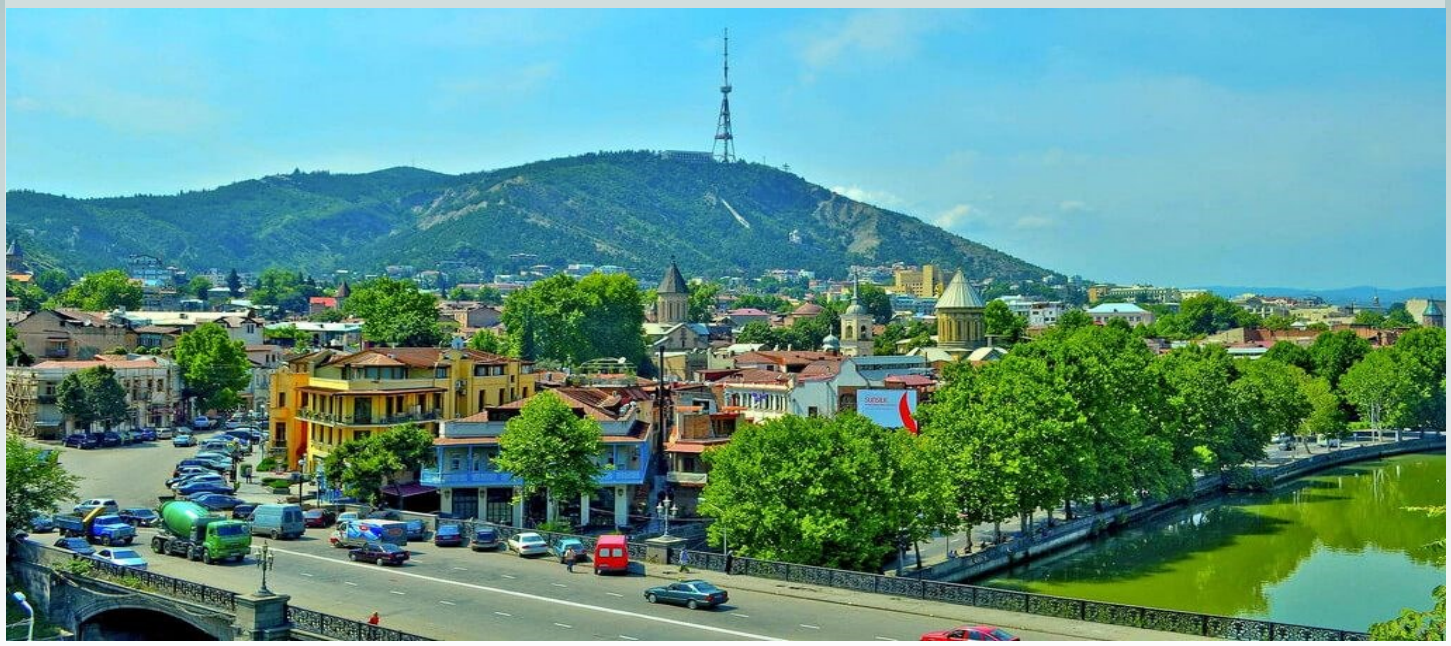
Tbilisi, Georgia

General direction of research: ***Emergency Logistic Management Problems for Disaster Zones in Response & Recovery Stages. Construction of Emergency Management Supporting Systems***

Short abstract. Recent years have seen a significant growth in human life losses and material damages caused by natural disasters such as earthquakes, flooding, tsunamis, tornadoes, and others. In its 2020 Annual Report, released in May 2021, the Centre for Research on the Epidemiology of Disasters (https://cred.be/sites/default/files/CredCrunch62.pdf) reported that "In 2020, 389 natural disasters were reported in EMDAT killing 15,080 people, affecting 98.4 million others and costing 171.3 billion US$. Apart from the COVID-19 pandemic, the year was dominated by climate related disasters". Since predicting catastrophes is practically impossible, they can cause severe and lasting damage to countries. Of all events, *earthquake* is the major reason for deaths. This has impelled researchers from different fields to intensively investigate the problems of emergency management. Emergency management is commonly divided into four main phases: *mitigation, preparedness, response, and recovery.* In our projects' models we consider the response phase. This is the mobilization and deployment of emergency services within the affected region in order to protect people and reduce the human and material damages. As in the result of earthquake or any natural disaster infrastructures would be ruined, the aid supplies and logistics services would be highly requested. *Processes in emergency after disaster should be planned in such a manner that they can respond to the needs of victims and allocation and protection of important facilities as fast as possible, also victims evacuation and important facilities transportation to a safe place*. Humanitarian logistics plays a significant role in facilitating disaster management processes by evacuating victims from affected areas to safe places, and by planning, storing, and distributing relief supplies to assist victims at the right time, right place, and right cost . Furthermore, humanitarian logistics also involves selecting proper locations for relief facilities such as shelters, medical centers, distribution centers, warehouses, garbage dumps, etc.

Determining facility location-allocation for coping with disaster onsets should be carefully considered by decision-makers. In our project models we studied propose multi-objective optimization models in efforts to improve efficiency of humanitarian or emergency relief logistics. These facilities include shelters, medical centers, warehouses, distribution centers, disease control and prevention, and waste disposal. The proposed models incorporated necessary data, such as locations of affected areas and candidate facilities, number of victims, important facilities, relief requirements, and available resources.

The most of project results propose multi-objective optimization models to improve either monetary or non-monetary criteria, such as minimizing the number of facilities and solving the model by our exact algorithms, minimizing the total cost of facilities location-allocation by employing genetic algorithm or machine learning approaches, maximizing decision-makers' satisfaction and solving the formulated model by weighted goal programming, etc. Based on our projects' results intelligent supporting systems were developed for the emergency management logistics problems.



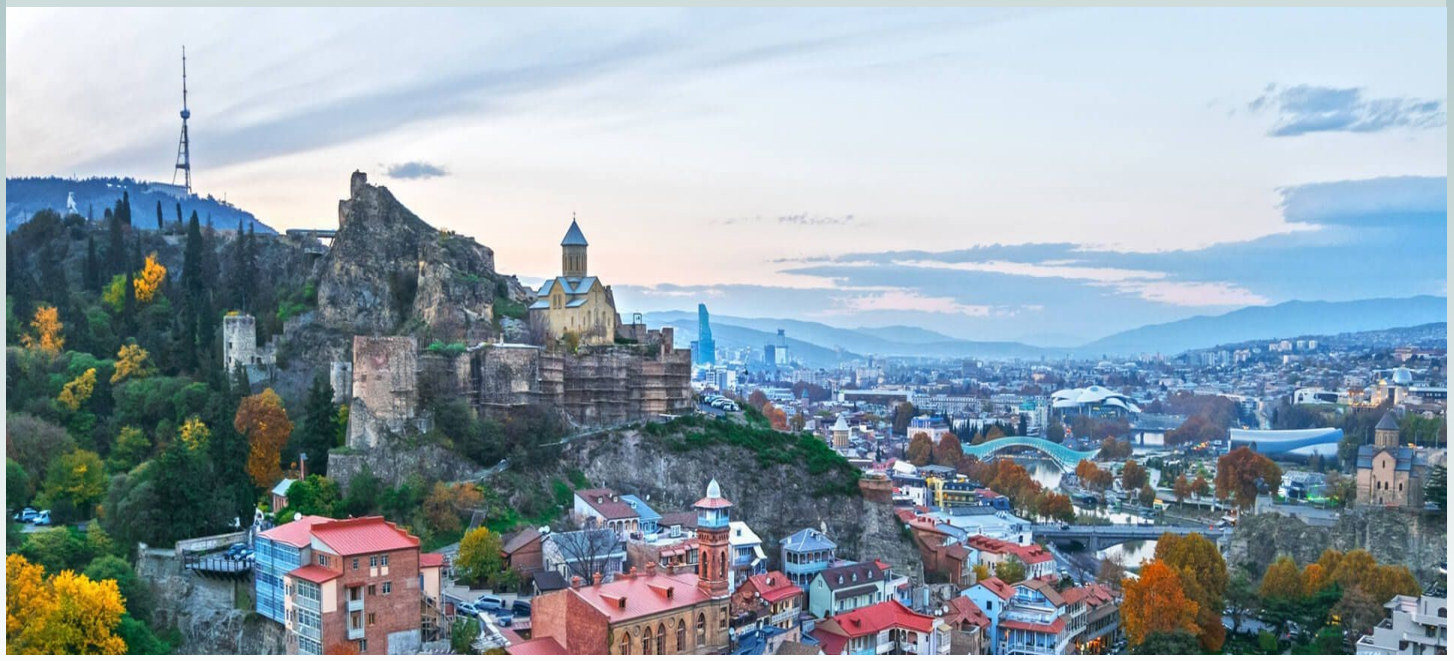
Compliance of the research infrastructure with the implementation of the research aims and objectives

The leading organization of our project is Iv. Javakhishvili Tbilisi State University(Georgia), which is the leading university in Caucasus region. The applied direction of the project aims to create *the intelligent decision support system*. The software will be developed in Iv. Javakhishvili Tbilisi State University, in a Computer Laboratory of Faculty of Exact and Natural Sciences. The Laboratory has the computer classes for scientific research and its infrastructure fully satisfies the technical requirements of the project. The laboratory will be used for the tasks of all stages of our future projects.

International and local collaboration in frame of our project or/and institutional collaboration

We have the experience of international collaboration on fuzzy programming, fuzzy optimization, fuzzy decision making and other problems of similar topics on our projects. Our institutional collaboration groups are consisted by:

1. Intelligent Systems Laboratory of Systems Research Institute of Polish Academy of Sciences, Head, Polish academician, Prof. Janusz Kacprzyk (https://en.wikipedia.org/wiki/Janusz_Kacprzyk).
2. Department of the Intelligent Systems Group of the Basque Country University (Spain), Head, Prof. Antonio Jose Lozano (https://scholar.google.com/citations?user=lhzoWpwAAAAJ&hl=en, http://www.bcamath.org/en/people/jlozano).
3. Different state and military agencies, which are responsible for delivering different kinds of goods in extreme and difficult situations are interested in the research as well. The interest is shown from military education institutes as well. This can be confirmed by our collaboration in similar research with two NATO military academies from Greece: Hellenic Army Academy, and Hellenic Naval Academy (collaboration with Prof. N. Mastorakis and Prof. N. Bardis).
4. Several international software companies are interested in our developing results. It is planned in future, to involve them in our new projects. We will systematically provide them with information on the progress of execution in the direction of software development and receive recommendations from them.
5. Georgian Emergency Management Agency (GEMA) always participate in the collection of input data of our projects and involvement in the projects of experts, with whom the details of the task and the conceptual model will be agreed. GEMA will be actively involved in our future project implementation process at all stages of its implementation. GEMA will help us to test the results, obtain data for the simulation example, and form a team of experts (transportation, routing and deployment dispatchers, managers, etc.).



Dissemination of the research outcomes (dissemination, communication) development of interdisciplinarity

1. About 30 Georgian companies are interested in the commercialization of our projects'products. The models of our projects are useful for them in recovery phase to restore facilities location (service centers and others) in the distribution network for the extreme environment. Our modified system will help them to locate the service centers at first stage and at the second stage for the future planning of transportation routes for goods delivery from service centers to customers. For the Georgian Consumer Market our products will be the only and unique.
2. For our future projects' financing, our group plans to create in our university environment - "Emergency Management Research for the Extreme Phenomena Response and Recovery" LTD, which will develop the projects' results and serve the Georgian distribution networks in the operation and management of infrastructure damaged and managed by extreme events.
3. Among other entities which may be also interested in the results of our research we can also indicate the software development companies which have experience in routing, facility location and transportation planning software development in extreme conditions (such as): 1. "IBM Tririga Strategic Facility Planning", http://www-03.ibm.com/software/products/en/ibmtrirstrafaciplan; 2. EURO working group on vehicle routing problem and logistics optimization – VeRoLog, http://verolog.deis.unibo.it/flp-spreadsheet-solver and others. Future Projects' results will be sent to them regularly at the end of each reporting period.
4. Different companies, state and military agencies may be interested in the research as well, which are responsible for optimal planning of emergency logistic management problems in extreme and uncertain environment.

Project efficiency in the long-term perspective for the country's socio-political, societal, cultural and commercial companies technical progress

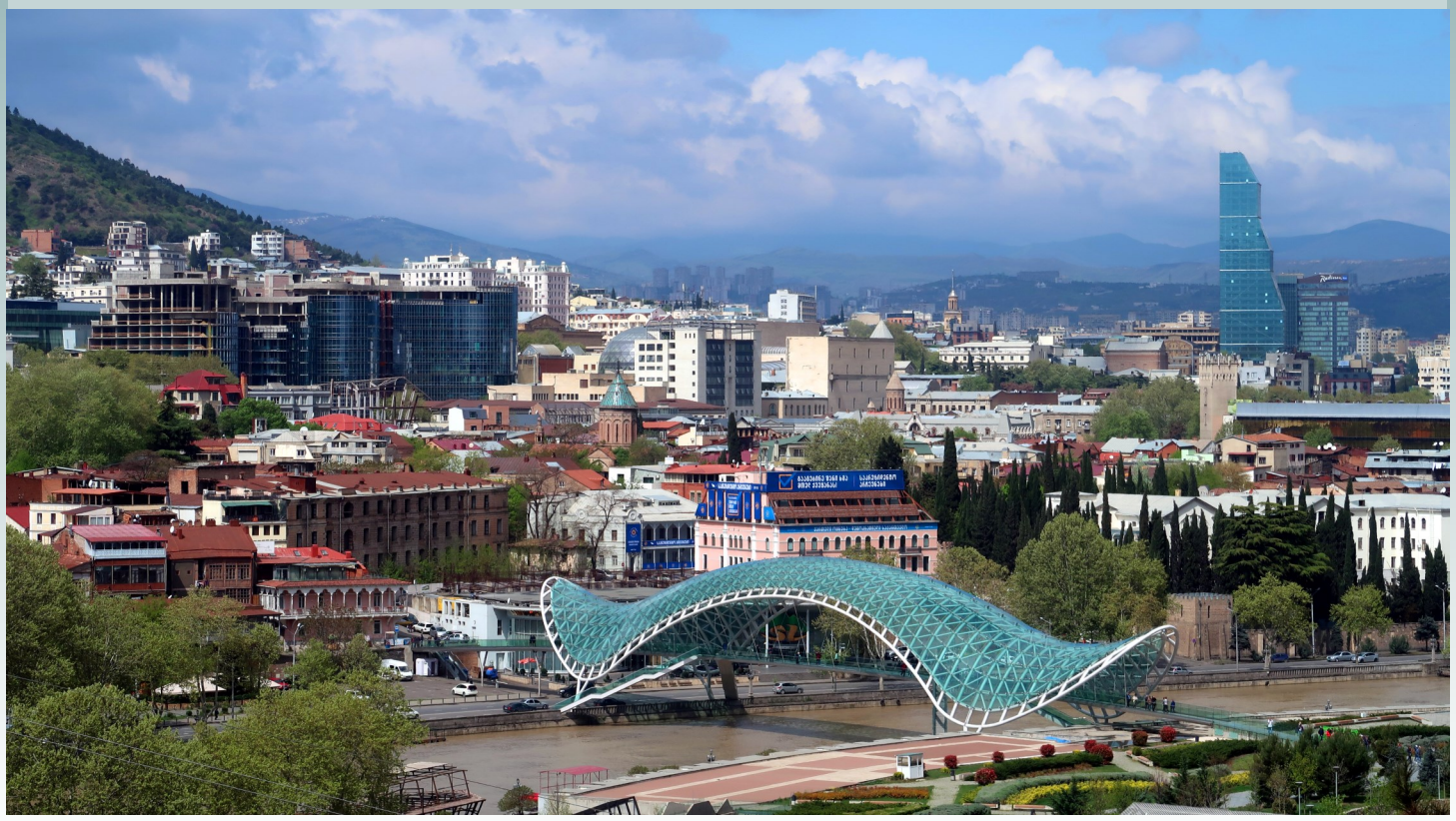
It should be noted that the models and software implementations created in our projects can be easily transformed into a tool to support the optimal planning of facility locations in service networks for the extreme situation. Although our country is not distinguished by a large number of service networks in terms of shipping and distribution, there are medium-sized distribution and other companies with their own service networks. The authors of our projects have a long history of collaboration with similar companies. They have completed several commercial, state and military projects related to Facility Location-Transportation Problems (FLTPs). By using such a software product, companies got an economic effect - reducing the cost by 8-12%.

There are still additional resources to improve this indicator, especially when they are available today and in the presence of disruptive factors in the future. Our country is a mountainous country and consists of potential disaster zones (earthquakes, heavy rains, floods, lack of visibility due to heavy fog and other reasons, icy and snowy roads, etc.). The often interferes with the implementation of routing, facilities location, transportation, and the normal functioning of urban infrastructure.

Research experience and productivity of the leader principal investigators for our projects

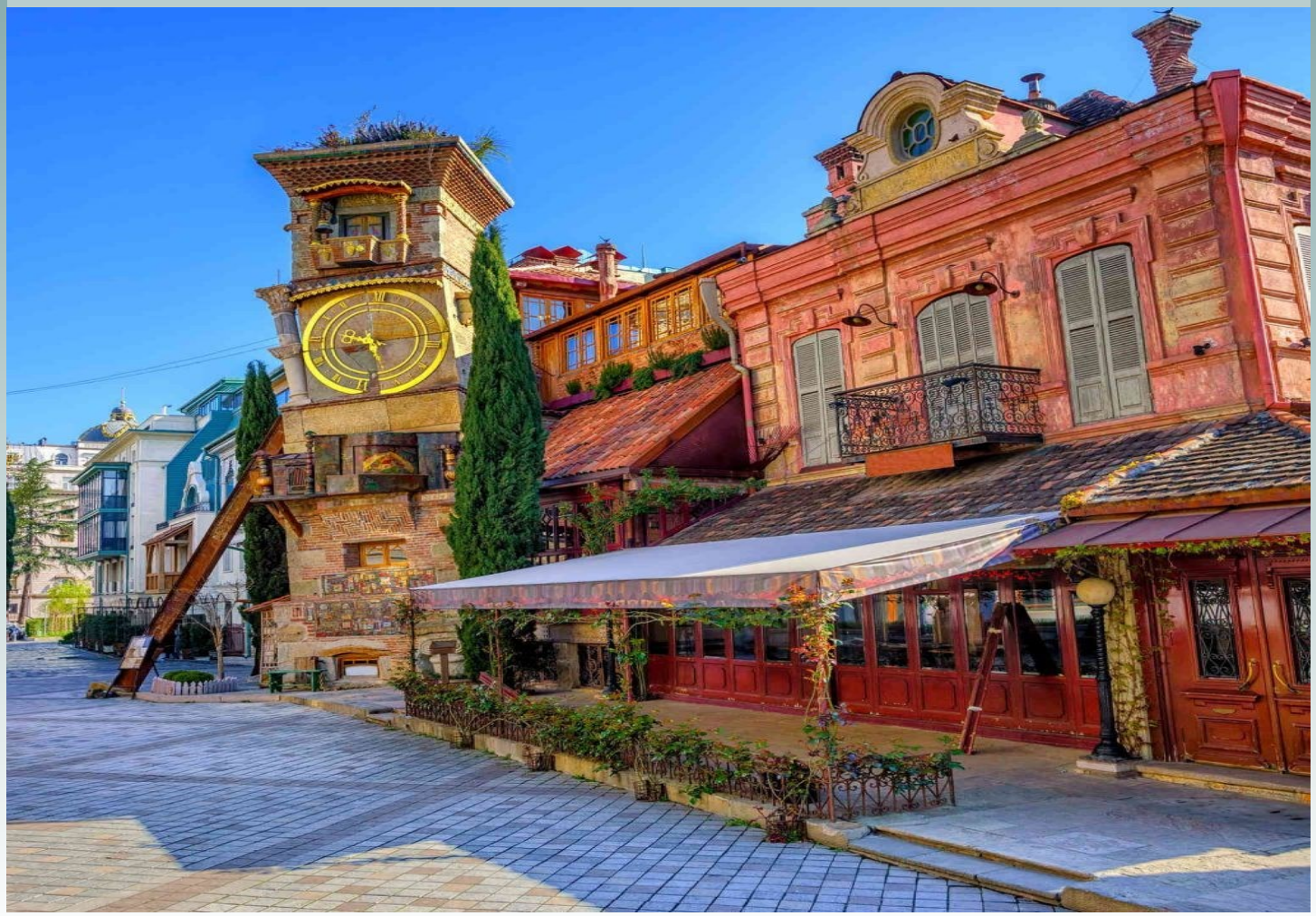
Janusz Kacprzyk, is an academician of the Institute of Systems Researches of the Polish Academy. Prof. J. Kacprzyk is involved in the international collaboration of the project management. He was the head of many international high quality grant projects in the management and planning of complex processes. As an EU consultant, he participated in the three latter from five grant projects headed by prof. G. Sirbiladze and funded by Shota Rustaveli National Science Foundation and Science & Technology Center in Ukraine (more details see below). He is an experienced and world-class researcher not only in the field of project themes, but also in general, in the direction of the basics of the study of imprecision and uncertainty in the complex systems' modeling, "soft" computing, intelligent analysis of expert data, and more (see https://en.wikipedia.org/wiki/Janusz_Kacprzyk, https://scholar.google.pl/citations?user=TbaynVoAAAAJ&hl=en, https://www.ae-info.org/attach/User/Kacprzyk_Janusz/CV/cv.pdf). J. Kacprzyk is also considered in our future projects as an expert in data processing and aggregation analysis. In the project, he will work on building methods for evaluating the facility location-selection reliability index and developing new projects' models. Clearly, J. Kacprzyk's high qualifications and experience will greatly help in effective project management and obtaining high quality results.

Gia Sirbiladze (https://old.tsu.ge/data/file_db/faculty_zust_sabunebismetk/CV_English_Sirbiladze.pdf), is a head of "Extreme and Complex Process Research Group" of Ivane Javakhishvili Tbilisi State University (Georgia). He is a professor at the Department of Computer Science, Head of a Chair of Applied Informatics. From his research in the direction of the study of extreme processes, a monograph is noteworthy, which brings together the solution of all current tasks of analysis and synthesis of expert knowledge flows (management, filtering, identification, classification). Important directions of his research are information aggregation technologies of fuzzy multi-attribute decision-making, discrete fuzzy optimization, fuzzy modeling, uncertainty, and imprecision analysis in systems modeling and others.



His main research objects in the project are: construction of fuzzy aggregation operators for the facilities location and selection problems, construction of expert functions based on expert knowledge for our projects' optimization models. Here are five grant projects he has completed in recent years that have some relevance to the project presented here: Vehicle Routing Problem (VRP) and Location / Transportation Problems (LTP) for disaster regions. These projects are: 1. "Intelligent Support System for Optimal Route Planning for Transportation of Goods" (MTCU/23/4-102/13), (#5891), (2014-2015) - Funded by Shota Rustaveli National Science Foundation and Science & Technology Center in Ukraine. 2. "The New Models of Vehicle Routes Planning in Extreme and Uncertain Environment" (AR/26/5-111/14), (2015-2017), funded by Shota Rustaveli National Science Foundation. 3. "Planning of Facilities Location and Goods Transportation in Extreme Situation" (STCU-2016-04), (#6297), (2017-2018), funded by Shota Rustaveli National Science Foundation and Science & Technology Center in Ukraine. 4. "Fuzzy Aggregations in Emergency Location-Transportation Planning" (FR-18-466) (2019-2021) and 5. "Fuzzy model of planning humanitarian aid distribution centers location and goods transportation routes in the disaster-stricken zones" (FR-21-2015) (2022 -2025), funded by Shota Rustaveli National Science Foundation.

Antonio Lozano (Intelligent Systems Group of the Basque Country University (Spain)) works on approximate solution methods of complex model optimization problems with mainly heuristic and meta-heuristic approaches. They are distinguished by machine learning approaches to combinatorial optimization problems. He has extensive experience and high-quality scientific publications in this field. A. Lozano's research interests include: machine learning and heuristic / meta-heuristic approaches to combinatorial optimization problems, evaluation of distribution algorithms, computational neuroscience, probabilistic-graphical models, bioinformatics, and more (see https://scholar.google.com/citations?user=lhzoWpwAAAAJ&hl=en, http://www.bcamath.org/en/people/jlozano). A. Lozano is considered by our future projects to be an expert in solving large-dimension optimization tasks. As an EU consultant, he participated in the latest grant projects headed by G. Sirbiladze.



Nearest completed or ongoing projects dealing with presented problems field

All grant projects were designed by the leader prof. Gia Sirbiladze and researchers from the Department of Computer science of Ivane Javakhishvili Tbilisi State University, Georgia.

1. "Humanitarian relief logistics' fuzzy model for the shelters' location in the disaster-stricken zones and evacuation of population" (perspective project)
2. "Intelligent Support System for Optimal Route Planning for Transportation of Goods" (MTCU/23/4-102/13), (#5891), (2014-2015) - Funded by Shota Rustaveli National Science Foundation (Georgia) and Science & Technology Center in Ukraine.
3. "The New Models of Vehicle Routes Planning in Extreme and Uncertain Environment" (AR/26/5-111/14), (2015-2017), funded by Shota Rustaveli National Science Foundation(Georgia).
4. "Planning of Facilities Location and Goods Transportation in Extreme Situation" (STCU-2016-04), (#6297), (2017-2018), funded by Shota Rustaveli National Science Foundation and Science (Georgia) & Technology Center in Ukraine.
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6. "Fuzzy model of planning humanitarian aid distribution centers location and goods transportation routes in the disaster-stricken zones" (FR-21-2015) (2022-2025), funded by Shota Rustaveli National Science Foundation (Georgia).

All grant projects were designed by the leader prof. Gia Sirbiladze (gia.sirbiladze@tsu.ge, +995 599 588658) and researchers from the Department of Computer Science of Ivane Javakhishvili Tbilisi State University, Georgia.