Dissemination Workshop, 22 May 2019

The GCRF-OSIRIS Project

Optimal Investment Strategies to Minimize Flood Impact on Road Infrastructure in Vietnam

Report
June 2019

Background

The GCRF-OSIRIS dissemination workshop was convened towards the end of the project, in May 2019, in Hanoi, arranged by the project's key Vietnamese partner agency, the Asian Management & Development Institute (AMDI). Participants included members of the team from the universities of Kent and Nottingham, the Director of the British Academy Cities and Infrastructure Programme, Professor Caroline Knowles, and representatives from city and national level from a wide range of Vietnamese government, academic and civil society stakeholder institutions, as well as international participants from neighbouring Southeast Asian countries with an emerging interest in the potential of Operational Research (OR) to resolve development challenges.

The objectives of the workshop were:

- To share the research results with a range of stakeholders from Vietnam, and also with potential stakeholders from other Southeast Asian countries – Malaysia, Myanmar, Laos, Thailand and Cambodia
- To present the key findings, obtaining feedback and comments to improve the model and to identify other areas of related research and development
- To support the developing capacity for Operational Research among academics and other stakeholders from Vietnam and Southeast Asia.

Morning Session

1. <u>Welcome by Ms Be Hoang Yen, Asian Management & Development Institute (AMDI)</u>

Ms Yen welcomed the participants, and introduced the purpose of the workshop, highlighting the following points.

- The research aims to contribute to the reduction of flood impacts in Hanoi, and to raise awareness and understanding of Operational Research among stakeholders in Vietnam and Southeast Asia.
- The Vietnamese context is one of rapid urbanization especially in the two largest cities – Hanoi and Ho Chi Minh City.
- The serious nature of urban flooding, and its impacts on infrastructure and lives
- The demand for optimal investment strategies to minimize the impacts of flooding on urban infrastructure and communities
- The roles of stakeholders: Kent Business School, Kent University in the UK, with the Asian Management & Development Institute (AMDI), the Institute of Transportation Strategy and Development (TDSI), IMHEN, VAST, the University of Nottingham in the UK, to build the OR model to prioritize investments to mitigate flood impacts
- Summary of the agenda for the workshop.

2. *<u>Representative of the British Academy, Professor Caroline Knowles</u>*

Professor Knowles provided information about the Global Challenges Research Fund of the British Academy. She introduced other global research initiatives being supported by the Academy, showing how these supported most vulnerable groups in cities. She expressed her strong impression of the diversity of partnerships involved in the GCRF-OSIRIS research in Vietnam, which includes government agencies such as the Ministry of Transport, TDSI, AMDI, IMHEN, VAST as well as the Kent Business School.

3. *<u>Representative of OSIRIS Project: Professor Paola Scaparra, Kent Business School, Kent University</u>*

Professor Scaparra provided an introduction to OR in general and specifically the GCRF-OSIRIS project.

- <u>OR:</u> is the discipline of applying advanced analytical methods to help make better decisions. There are learning societies and regional groupings such as the International Federation of Operational Research Societies (IFORS), the Institute of Operations Research and the Management Sciences (INFORMS), the Association of Asian-Pacific Operational Research Societies (APORS) which share lessons and practices.
- <u>Business Analytics Hierarchy:</u> based on complexity and competitive advantages, the hierarchy has three types of analytics: Descriptive, Predictive and Prescriptive. Descriptive Analytics has the least competitive advantage and complexity. It answers the question about real situations - "What is going on?". To solve the question, it uses methods of Scorecards, Dashboards, and Reporting. The second type, with higher levels of competition and complexity, is Predictive Analytics, which answers the question

about the future – "What's going to happen?". Methods used are Simulation, Forecasting, Regression, and Data Mining. The type of analytics with highest competitive advantage and degree of complexity is Prescriptive Analytics. It answers the question of reaction - "What should we do?". Some methods used to solve this question are Optimisation, Heuristics, and Decision Trees.

- Methodologies mentioned: optimisation and heuristics, simulation modelling, decision analysis, big data analytics, performance management, data envelopment analysis (DEA), multi-methodology, and 'Soft OR' (which considers that people's perceptions of the world will vary, so their preferences may also differ, thus modelling needs to take account of the different ways in which different stakeholders may frame the issues). The 'methodology circle' is as follows: Problem Formulation -> Construct Mathematical Model -> Deriving Solutions from the Model -> Testing the model -> Establishing controls over the solution -> Implementing the Solution -> Problem Formulation.
- ParkerSteel is an example of effectiveness of applications of OR. ParkerSteel is the main steel processor and distributor in southern England, with two processing sites with different source materials and capacities, and two satellite depots (for delivery).
- Rural road network connectivity: OR has also helped to identify most cost-effective ways to upgrade and rehabilitate transport connections in rural areas with limited availability of funds; how to pave gravel roads with optimal set of links while satisfying budget constraints. Two criteria used to measure effectiveness are a) connectivity measure (traffic/volume paved) and efficiency measure (speed between connected villages). Two scenarios were presented: one covering 96% of total traffic flow, the other covering 80%, but reducing vehicle-kilometers traveled by almost 50%.
- Port of Dover Research: a simulation model analyses the processes of goods transferred through a Traffic Access Protocol (TAP) queue, buffer zone, check-in queue, assembly area (prior to embarkation) and being taken aboard. In just two years, the Knowledge Transfer Partnership (KTP) has delivered capital investment and staff cost savings above £1 million, with profits expected to be up to £1 million. Reduced queues are operating with greater efficiency (in 2015, TAPs occurred approximately every 2 days, reduced to every 5 days in 2016). There were fewer reshuffles, reduced travel (saving time and money), and improved air quality.
- Application areas: government (defense, prison services,…), healthcare (nurse/care staffing, patient flow,…), transportation (flight scheduling,…), logistics (vehicle routing, facility location,…), education (capacity planning, predicting student numbers,…), manufacturing (production planning,…), disaster management (mitigation, response, recovery operations,…)
- OR for disaster management: cycle of four factors: a) mitigation (land use control, protection planning, risk analysis, insurance tools, control on rebuilding), b) preparation (warehousing, early warning system, supply procurement), c) response (relief delivery, evacuation activities, shelter location, casualty transportation), d) recovery (road rehabilitation, clean up, infrastructure rebuilding).
- OSIRIS Aim and Methodology:
  Aim: Reduce the impact of floods on Vietnam's urban road networks, and build a decision support tool to optimize long-term investments in flood mitigation measures.
  Methodology: OR (optimisation), integrated with other disciplines (e.g. social science, transport economics, climatology, hydrology).

4. *Dr Nguyễn Văn Hiệp, VAST, and Mr Nguyen Duc Chinh, IMHEN*

Dr Nguyễn Văn Hiệp presented the following aspects of the rainfall model.

- The Weather Research and Forecasting (WRF) regional models, developed by NCAR, NOAA/ESRL and NOAA/NCEP; used for both operational weather forecasting as well as research; open source code; a community with thousands of users.
- WRF regional model used for: atmospheric physics/parametric research, real time weather forecasting, heavy rainfall simulation, research of wind energy, research and forecast of environmental pollution, studying seasonal and climatic timescales, global simulations.
- WRF Modeling System Flow Chart
- Model configuration
- Data assimilation
- Model verification
- Model simulation

Mr Nguyen Duc Chinh presented the flood maps of Hanoi as follows.

- Flooding situation of Hanoi, and methodologies of flood modelling in the research for eight districts; flood maps for eight districts under different scenarios of climate change and rainfall from 2016 to 2035; results of flood simulations for Hanoi based on these rainfall scenarios, provided by VAST and AMDI.
- Flood simulations were run based on four groups of investment projects in eight districts of Hanoi, covering both flood depths and transport networks/roads, according to the climate change and rainfall models provided by VAST.
- The research and flood simulations are based on the design of the University of Kent research team, with data provided by AMDI and TDSI.

5. *Ms Dang Thu Phuong, Kent Business School, University of Kent, and Ms Nguyen Thi Chi, Asian Management & Development Insitute (AMDI)*

Ms Dang and Ms Nguyen presented the socio-environmental and economic impact assessment which had been carried out to support the modelling process. Objectives of the assessment were: a) construct a database of situations and gender differentiated social, economic and environmental impacts of flooding on urban communities in Hanoi; b) generate data to serve as input for the research model; c) to provide recommendations for floods mitigation and improvement of gender equality for relevant stakeholders.

The survey focused on the perceptions of the respondents on the causes and impacts of flooding. Respondents were divided into two main groups: residents, many of whom were people trading from home, and visitors working on a daily basis as street vendors, motorcycle and taxi drivers. The survey was carried out in Dong Da, Nam Tu Liem, Hoang Mai and Ha Dong Districts in the summer of 2018.

The main perceived reasons for flooding were the aged drainage system (44%), torrential rain (36%), low awareness among communities of the importance of proper waste disposal, to not block the drainage system (17%), the limited capacity of the drainage system (17%), low-lying residences (10%), over-urbanization (4%), road construction (4%), and the covering of natural reservoirs for construction (1%).

The greatest economic difficulties facing trading households during flooding were the increased prices of cooking ingredients (37%) especially fresh vegetables, meat and fish, which arrive in city markets from outlying rural areas, along with increased prices from wholesalers, and general scarcity of goods and raw ingredients needed for household businesses/trades. Damage to houses caused further economic impacts, as illustrated in the chart below.

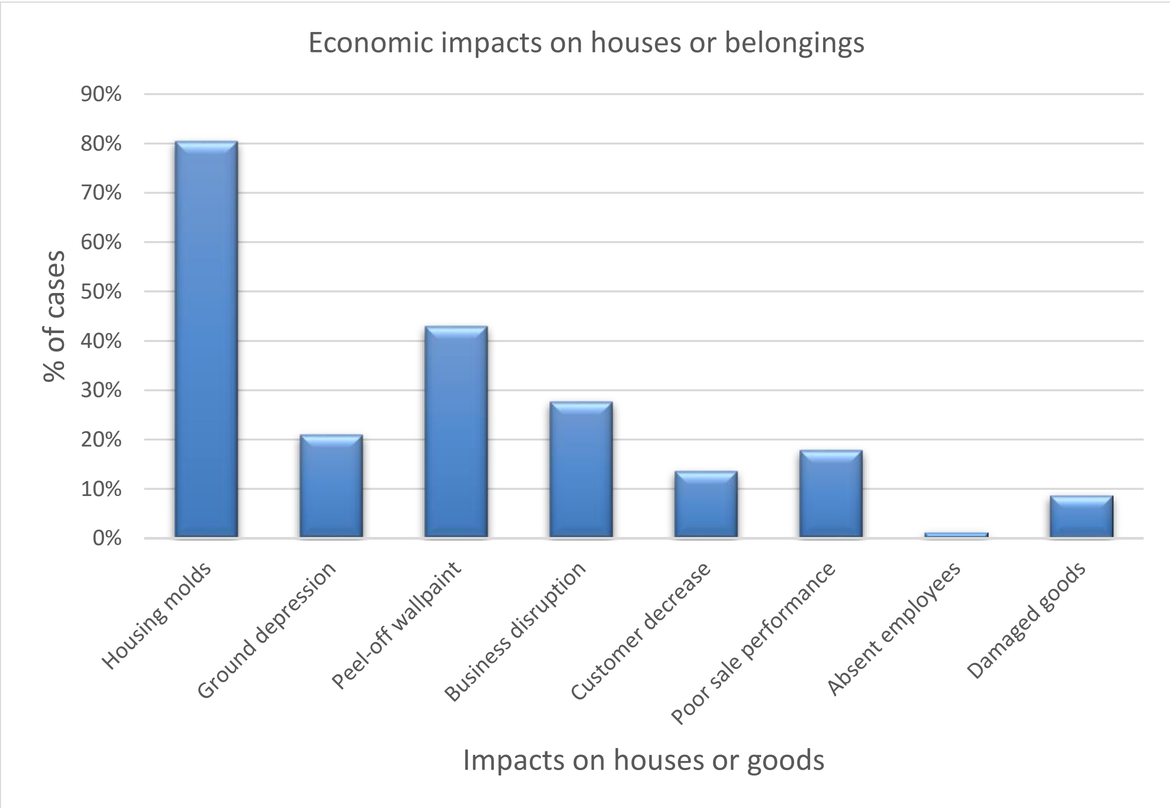


Figure 1. Perceived Economic Impacts on Households and Businesses

Damage to household goods and appliances also had an economic impact on households. Most important was damage to the household motorbike, which often suffered engine damage from flooding. Other items damaged included refrigerators, washing machines, other electrical appliances, furniture, and perishable items.

Perceived environmental impacts of flooding were pollution to the living environment (human and animal waste, drains overflowing with polluted water), related increases in disease/sickness (skin rashes, diarrhoea, respiratory diseases, dengue fever from mosquitos), related increases in healthcare costs, gradual death of green trees, and increasing infrastructure-related risks such as submerged potholes, fallen trees, and damaged electricity wires.

Social impacts were perceived as the most critical of all, mainly due to the prolonged traffic congestion during periods of flooding. This impacted both residents and visiting tradespeople, who spent a long time in traffic, or were blocked by traffic, while trying to carry out their daily activities.

Women were assessed to be under greater stress than men, due to their multiple roles in shopping, cooking, caring for vulnerable family members, running businesses from home (residents), or street vending (visitors).

Some street vendors do not go out to sell during flooding, meaning they have no immediate income. Others go out to sell, but have difficulties in traffic, and face possible loss of their perishable goods in floods and intense traffic jams. Going out to sell/work in these conditions resulted in significant reduction of time to care for vulnerable family members at home, increasing costs for broken vehicles (usually motorcycle engines), longer working days due to longer travel to work site, reduced income, and lack of availability of usual market food. These impacts effected women street vendors disproportionately more than male taxi drivers.

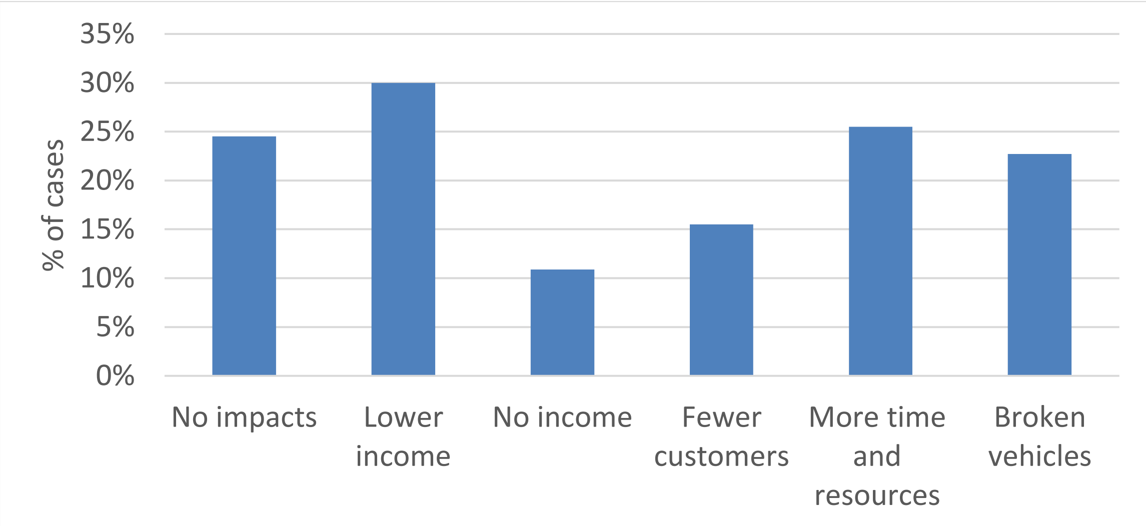


Figure 2. Impacts of Floods on Street Vendors, who are mostly women

Some women running residential businesses could not cook food because of flooded kitchens. Reduced incomes lead to lack of immediate funds for household expenditures and children's tuition fees. Costs are incurred to repair household goods and motorbikes damaged by floods. Family conflicts tend to increase as a result of these combined impacts of flooding.

Overall, the differentiated impacts of floods on women and men, were notable. Women have more additional tasks than men, before, during and after flooding, including tidying (48%), cooking spare food or storing food prior to floods (19%), washing more dirty clothes (23%), replacing broken household appliances with new ones (3%), and taking care of children and grandparents (7%). But despite women doing more work, most decision-making regarding household flood mitigation is done by men.

Many measures were proposed by residents and visitors, to mitigate the impacts of flooding, as shown in the chart below.

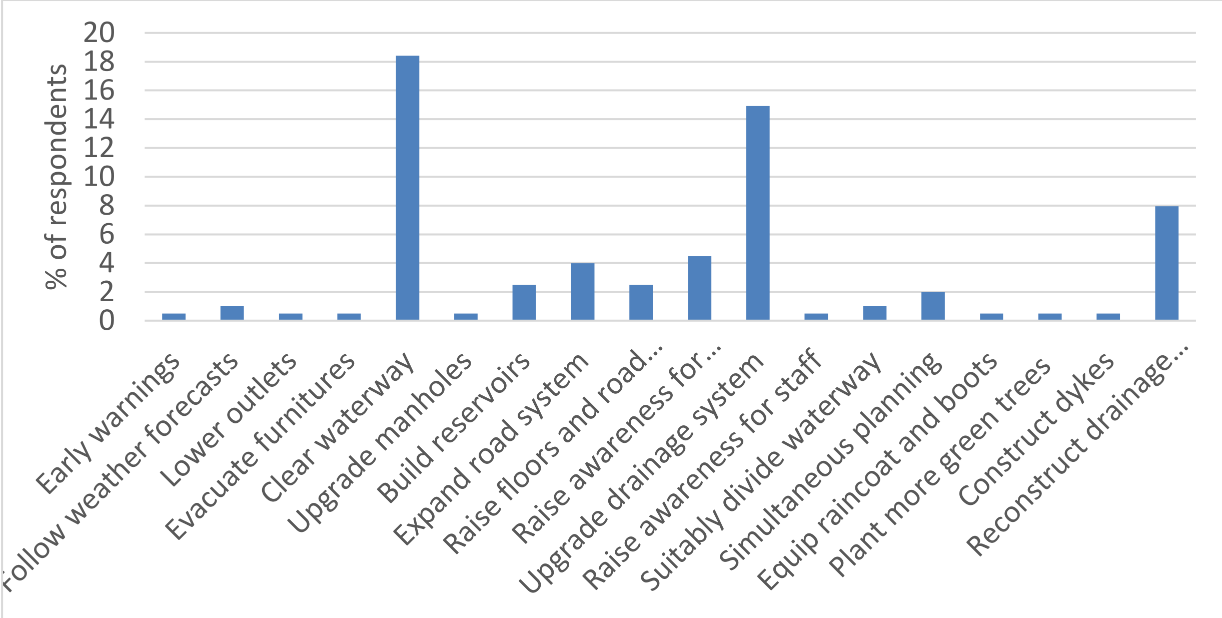


Figure 3. Proposed Measures to Reduce Impacts of Urban Flooding

Main recommendations arising from the assessment were as follows.

- Women and men should have equal workloads before, during and after flood events, and should have equal decision-making regarding preparation for floods and mitigation measures at household level.
- Awareness needs to be raised among both residents and visiting street vendors and tax drivers, on ways to prevent flood damage. Prevention measures should not be limited to infrastructural interventions – government agencies regularly focus on roads, pipes and drains – but need to be expanded to include communication and behavioural change, for example in reducing build-up of garbage or building materials which can block drainage systems.

6. Dr Siao-Leu Phouratsamay, Research Associate, University of Kent

Dr Phouratsamay described the technical process of creating the optimization model, as follows.

- The Decision Support System (DSS) tool, including optimisation model for long-term investment decisions for mitigation projects with a limited budget
- The main goal being to help decision makers and urban planners to decide which mitigation projects to implement and when to implement them, so impacts of floods under different flood scenarios for the eight focal districts of Hanoi are minimized.
- Based on IMHEN flood maps, the team considered two flood scenarios: 1% (less frequent but devastating) and 5% (more frequent but less devastating).
- Based on the impact assessment in Hanoi from AMDI, the team focused on the minimisation of damage and congestion level, on mitigation projects for upgrading the current drainage system.

- The input data used in the optimization model included predicted flood variation from IMHEN, Hanoi's road characteristics from TDSI, a list of mitigation projects from the drainage system master plan 2030-2050 and a planning horizon of 20 years.
- After reviewing the master plan with AMDI and TDSI, the team identified 25 drainage system mitigation projects to include in the case study.
- A damage function, designed for Hanoi, was used to estimate the damage due to flood, and the well-known BPR (Bureau of Public Roads) function to estimate the congestion level based on vehicle speed during flood events, provided by TDSI.
- Due to the lack of information, the team assumed that the available budget over the planning horizon corresponds to a percentage of the total cost of the projects.
- In the case study, it was found that, if investments are optimized, 50% of the maximum possible reduction in damage and congestion (obtained when all the projects are implemented) can be achieved by investing only 25% of the total cost of all projects.
- Minimizing both damage and congestion improves them by 13.8% and 15.8%, whereas only minimising the damage improves it by 14.8% and only minimising the congestion improves it by 16.3%.

Next steps are:

- To complete the data collection to have additional mitigation projects, and to identify the budget allocated to flood mitigation and surveys
- To extend the model to other cities in Vietnam (possibly the Mekong Delta)
- To include additional objectives (e.g. impacts on agriculture and/or food production)

Question: is the damage function used in the optimisation model, accurate for Hanoi?
Reply: Yes, the function was designed based on survey data in Hanoi for residential and non-residential areas, and has been proved mathematically to be accurate for Hanoi.

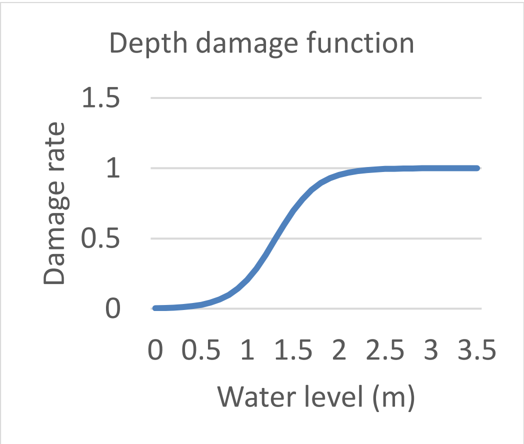
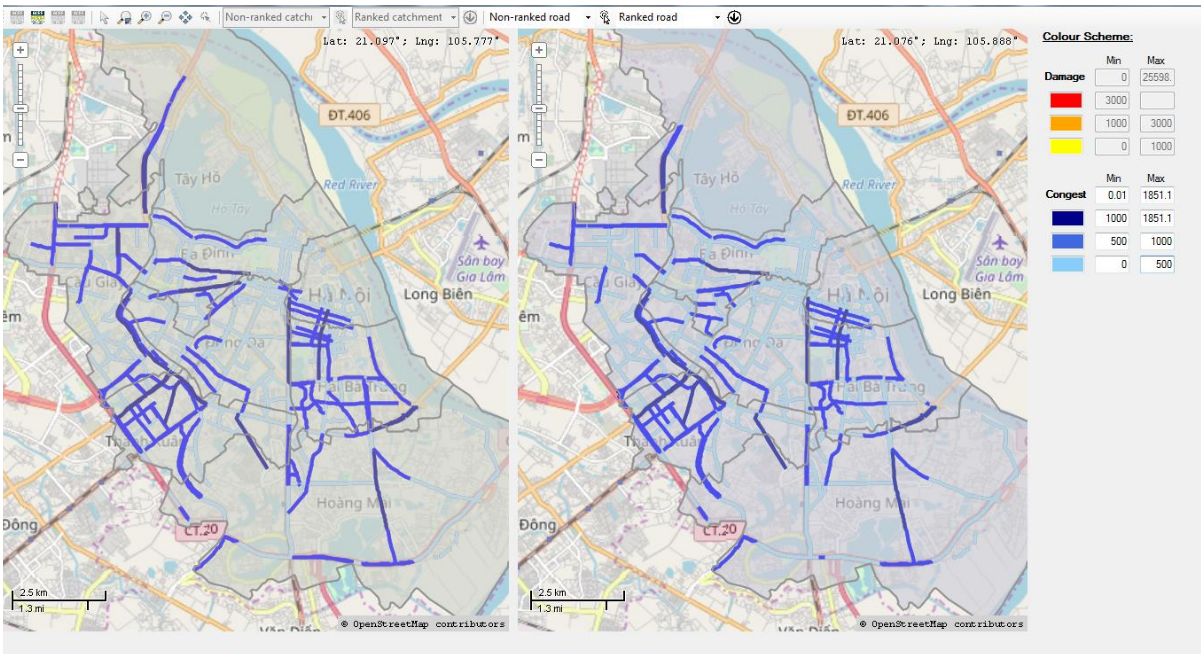
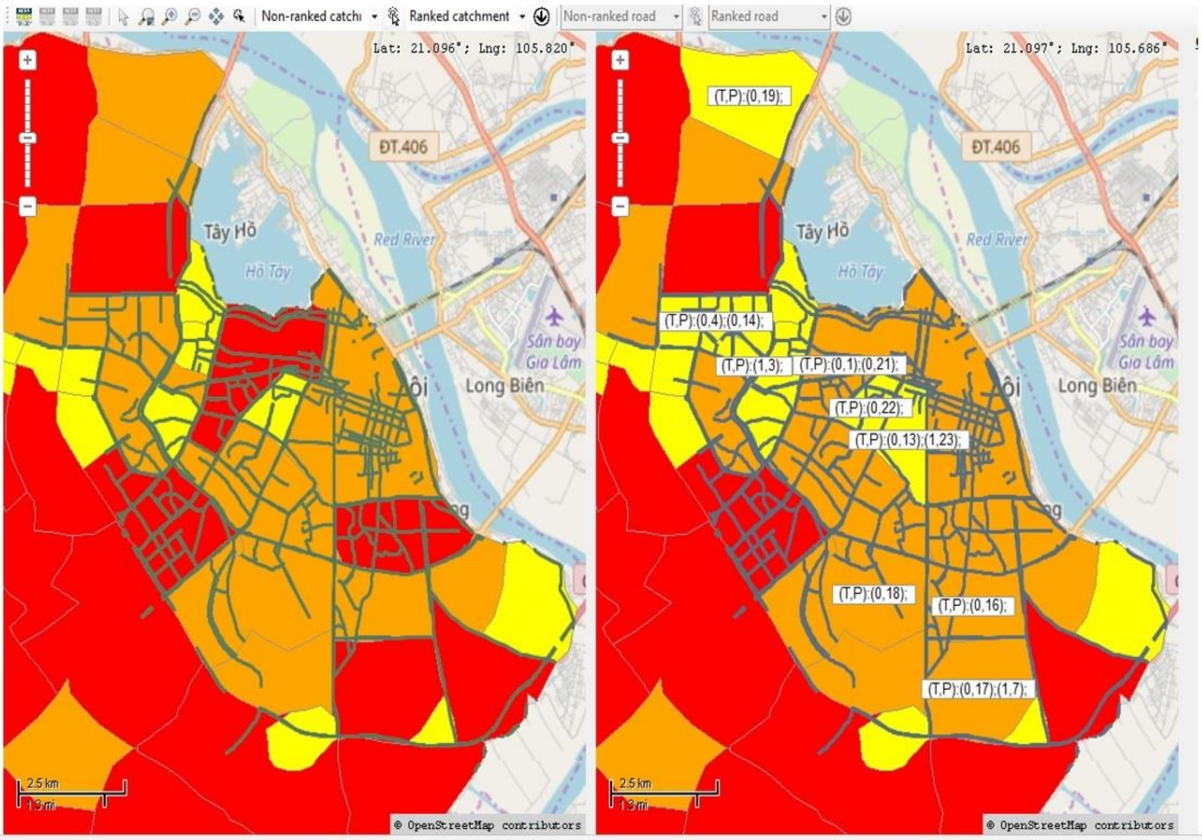


Figure 4. Damage function used in the optimization model



Before *After*

Figure 5. Visualisation of Congestion before and after the implementation of the mitigation projects found by the optimization model (1% scenario)



Before *After*

Figure 6. Visualisation of Damage before and after the implementation of the mitigation projects found by the optimization model, (1% scenario)

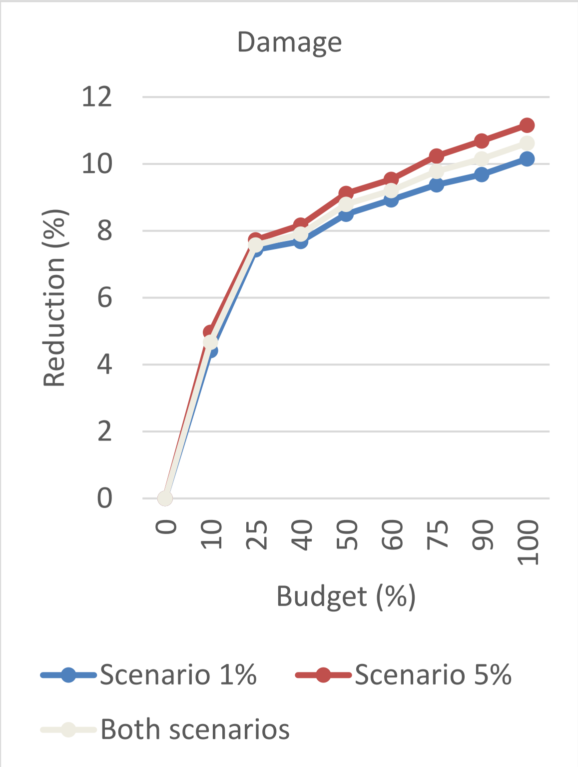


Figure 7. Analysis of the damage reduction with different budget availability

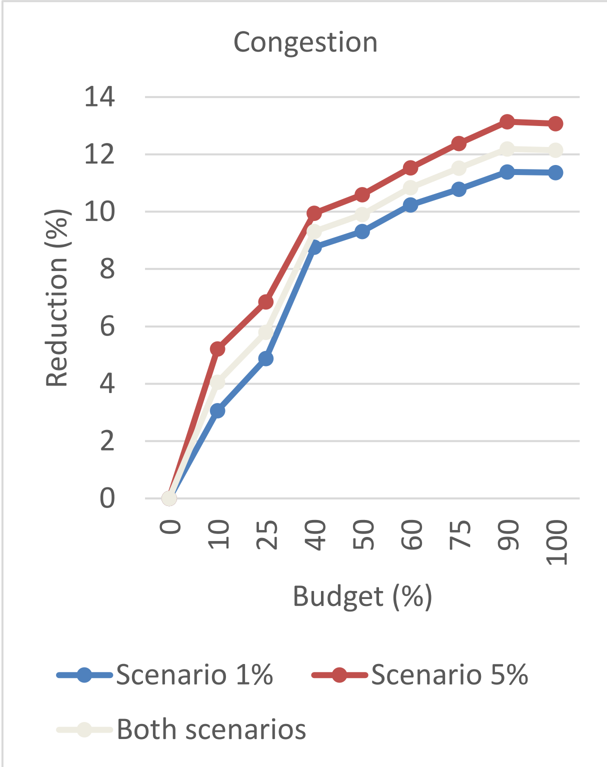


Figure 8. Analysis of the congestion reduction with different budget availability

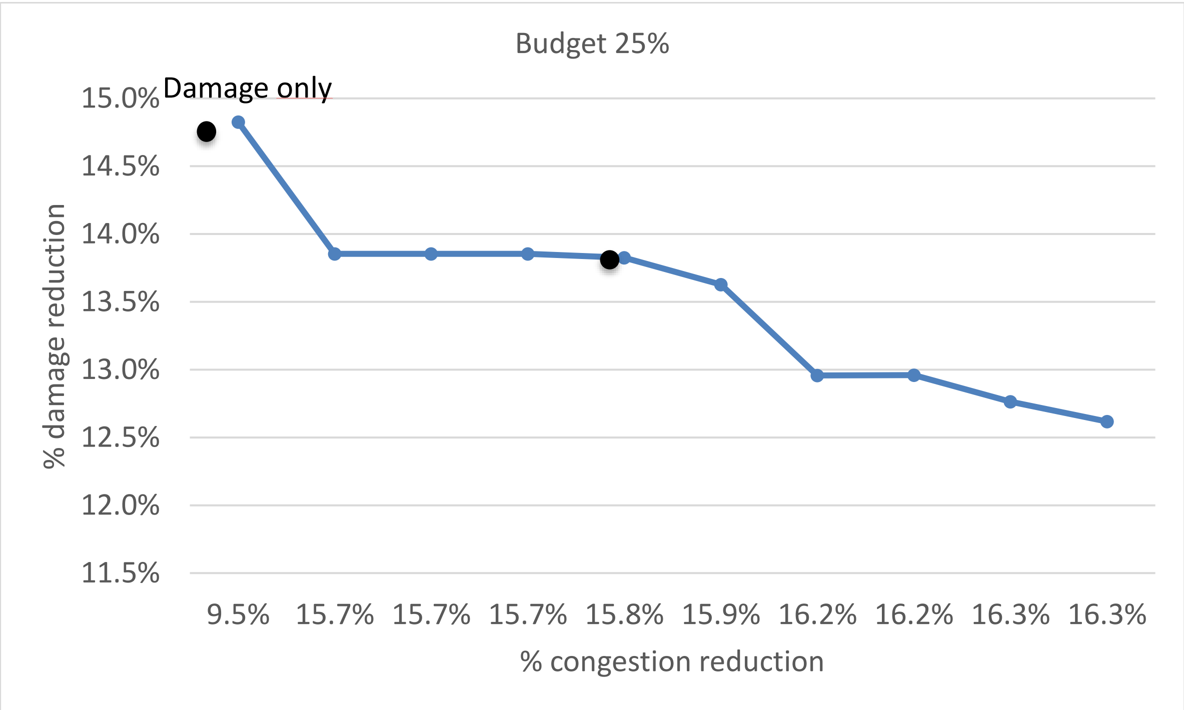


Figure 9. Trade-off between damage and congestion

7. Dr Trung Hieu Tran, University of Nottingham

Dr Tran provided further detail on preparation of the optimization model, noting that:

- A graphical user interface (GUI) was used to integrate the mathematical model and GRASP (Greedy Randomized Adaptive Search Procedures) heuristic, to solve the problem of minimizing flood impact on road infrastructure, and for visualising the optimal investment strategies.
- The GUI was designed using programming language C#, including Login form, Optimisation form, Graph form, Catchment form and Road form.
- The GUI aims to support policy makers or strategic planners (without deep knowledge of mathematical modelling and optimisation) to use the model and to visualize solutions.

8. Mr Nguyen Ngoc Thuyen, Vietnam Ministry of Transport

On behalf of the Ministry of Transport, Mr Nguyen shared insights from the research findings as follows.

The research is very practical, for solving two burning issues in Hanoi: flooding and congestion. Flood impacts are a critical issue in Hanoi, and this research project is very valuable, as it results in a decision-making tool for investment. The Ministry hopes the project and its full eventual outcomes can be disseminated to districts, the media, and government agencies who may be in a position to follow up the recommendations of the model. Private investors are also key infrastructure developers, for example *Vingroup* is engaged in construction in Hanoi, therefore they should also be involved in learning from and applying the research results.

The results need to be customized to improve the understanding of a broader range of stakeholders. The Ministry of Transport is grateful to the UK government and to the University of Kent for supporting the research, but requests further support for the follow-up steps. There are remaining questions/concerns on how to further customize the results for Hanoi. TDSI should summarise the research results, and disseminate a suitable document for different audiences to gather further feedback. Anther next step should be to identify supplementary research needs for support to Hanoi and Mekong Delta urban areas. The links between flooding and congestion are critical, because they lead to economic, social and environmental losses. The research results should be passed up to the Hanoi People's Committee, in addition to suitable dissemination for private investors who can put the results in practice.

Afternoon Session

9. *<u>Group Sessions</u>*

Workshop participants divided into three groups to focus on different aspects of the project.

Group 1 comprised the international participants, from the UK and from Southeast Asian countries, to discuss OR application in their country contexts. Results were:

- In Thailand, OR is already established at academic level, but still lacking at industry/practice level. Regarding disruption management, there is lack of awareness, preparedness and knowledge – when floods occur, people simply don't know what to do.
- For Cambodia and Laos, the group focused on the lack of infrastructure. OR could be applied to road surfacing, and to supply chain management for sustainability of public utilities (electricity, water). The group also discussed how to collaborate on capacity building for OR.
- Regarding Malaysia and regionally, food production and security was discussed as an issue for transnational collaboration with OR.
- Finally, the group discussed how to get involvement from key stakeholders, especially government. This can be done through initial engagement with international agencies and NGOs who might be keener to collaborate, and who have existing collaborations with government agencies. In Laos, engagement with government was not considered challenging, as the government has clear protocols to engage.

Group 2 comprised staff of key Vietnamese government agencies and some academics from Vietnamese universities. Key content of the discussion was around how to improve the model and develop required capacities when the model is completed.

Regarding '*what do we need to improve our model?'* emerging answers were:

- The graphical user interface can be improved, i.e., using Google Earth map, 3D development, or integrating with MIKE URBAN for flood simulation.
- A specific training programme is required for users who are not familiar with mathematical optimisation, as well as users from other sectors, (not TDSI).
- Land prices for the 'damage function' in the model, can be obtained from the Ministry of Environment and Natural Resources.

Question 2: What are other areas that our model can apply for?

- Apply for land use planning (i.e., rural planning), since there are significant difference of flooding impact on urban vs rural (e.g., focusing congestion on urban, but agriculture loss on rural, etc.)
- How to integrate other pillars (e.g., social , environmental and economic issues in the survey) in the model.
- Apply for Mekong Delta River with river and road infrastructure and salt-water instruction issue.

1. The third group: Discussion of OR in different thematic areas.
    - OR should be applied in the area of environment monitoring including air and water quality. OR research can contribute to the location of the monitoring stations and maximizing the precision and impacts of monitoring stations to control environment pollution.

- OR can be also applied in conservation planning with how to build/main species while developing infrastructure
- OR can be applied in the case of Hanoi for more transport related issues
- OR can also be applied in the Mekong delta to provide better transport system while ensuring foods security and trading in the region.

10. Media

A news media report of the workshop, by VTC14, is available here:
https://youtu.be/ZM7Rh1A2-Jw

11. Closing words, Professor Scaparra, University of Kent

- Thanks to all the participants for attending the workshop and for being actively involved in the discussions
- The research results and products will be shared by email to the participants for further comments and learnings
- Thanks to AMDI and the team for excellent workshop management
- We will pursue further OR modelling in Vietnam not only in Hanoi but also in other regions such as the Mekong Delta.