（ 続紙 1 ）

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論文題目	Coastal Flood Risk Assessment and Dynamic Adaptation under Climate Change Uncertainty （気候変動の不確実性下における高潮氾濫浸水リスク評価と動的適応策）		

（論文内容の要旨）

Coastal flooding is a frequent and devastating natural hazard caused by a coastal process. Climate change poses significant challenges and impacts on coastal communities. Efficient adaptation strategies are crucial to address future flood risks. This thesis aims to assess coastal flood risk under climate change and identify optimal decisions of structural adaptation strategies to minimize flood risk. This thesis developed an integrated modeling framework that couples stochastic tropical cyclone model, storm surge model, inundation model, climate change projections, coastal defenses, and adaptation measures. This model incorporates scenario analysis, risk assessment, and cost-benefit analysis to quantify the flood damage and the effectiveness of adaptation strategies. Moreover, considering the uncertainty of climate change, this thesis proposed a dynamic adaptation decision-making model for coastal protection systems by minimizing coastal flood risk to identify optimal investment timing and the size of the structural infrastructure. Furthermore, this thesis investigated homeowners' preferences for coastal flood risk mitigation under ambiguity by coupling flood simulations and stated preference experiments with decision models.

According to this research, some findings are derived. First, the results show that coastal flood risk will increase dramatically as combined impacts of intensified storm surges and sea level rise, due to climate change. Without adaptation measures, the damages and casualties from flood have the potential to increase several folds in the coming decades. Second, despite the predicted decrease in future population numbers in Osaka Bay, the number of flood casualties is expected to grow due to the increasing aging. Therefore, it is important for governments and communities to take the specific needs and vulnerabilities of the elderly population into account when planning and implementing flood risk management and adaptation strategies. Third, the results indicated that raising the height of existing dikes can reduce flood risk effectively. The benefits and costs depending on

the elevated height and the discount rate. Using a traditional cost-benefit analysis, this study has shown that that upgrading by 1m the height of existing dikes to adapt to climate change is the most cost-effective strategy for Osaka Bay. Fourth, uncertainty about climate change and the time lag of adaptation measures pose significant challenges to adaptation decision-making. The results indicate that a dynamic adaptation decision model is more effective in decreasing annual coastal flood risk costs than a static one in the context of climate change uncertainty. Under the RCP 8.5 scenario, the dynamic model decreases annual risk costs by 5-10% compared to the static one. Furthermore, the critical threshold of the adaptation investment highly depends on time lags and discount rates. As the time lag increased, the benefits of adaptation measures significantly diminished. Fifth, the analysis indicates that an ambiguity premium is not negligible in economic efficiency or cost-benefit consideration of risk mitigation policies. Rather, they are distributed extremely in some areas of higher expected loss from coastal inundation. This suggests that ambiguity premiums should be measured for planning and implementing coastal flood risk mitigation policies.

While the research focuses on Osaka Bay, the methodology developed in this thesis contributes to coastal flood risk assessment and dynamic adaptation under climate change uncertainty. And some of the findings apply to other coastal regions threatened by storm surges and sea level rise.

（続紙 ２ ）

（論文審査の結果の要旨）

本研究は、気候変動の不確実性を考慮した上で、高潮氾濫リスクの増大の影響を経済被害の観点から定量評価し、最適な適応政策を提案する枠組みの構築に貢献している。気候変動の不確実性に対処するために各種の気候変動シナリオを想定し、大阪湾岸エリアを対象に高潮氾濫シミュレーションを実施してその経済被害を試算した。また、費用便益分析に基づき、将来の高潮氾濫の経済被害を軽減するための最適な堤防嵩上高さについて検討している。また、気候変動の進展状況を観察しながら、堤防嵩上の計画立案から整備完了による効果発現までのタイムラグを考慮したもとで、最適な堤防嵩上の規模とタイミングを求める研究手法を構築している。これらは、海岸工学と経済学の知見を融合させ、社会的に重要な課題解決について有益な研究成果を得ている点で高く評価される。さらに、高潮氾濫リスク予測に伴う不確実性に対して、曖昧性下の意思決定モデルを適用することで曖昧性プレミアムとして定量評価している。それにより、高潮氾濫リスク予測の不確実性を無視すれば、適応政策の経済価値を過小評価してしまうことを明らかにしている。この研究は、リスク評価に不確実性がある場合、期待被害額による評価では不十分であることを具体的事例で定量的に明らかにした点で学術的貢献が大きい。これらの研究は、気候変動に関する一流国際ジャーナルであるClimatic ChangeとEarth’s Futureに掲載されている。

このように、本研究は気候変動の不確実性を考慮した上で、高潮氾濫による経済損失リスクの定量評価と、それに対する最適な適応策を明らかにする一連の研究手法を構築している。それにより、学術的だけでなく社会的にも重要な貢献を果たしており、博士（情報学）の学位論文として価値あるものと認められる。また、令和5年2月20日、論文内容とそれに関連した事項について試問を行った結果、「合格」と認めた。

なお、本論文は、京都大学学位規程第１４条第２項に該当するものと判断し、公表に際しては、（令和7年3月31日までの間）当該論文の全文に代えてその内容を要約したものとすることを認める。

要旨公開可能日：　　年　　月　　日以降