国際共同研究（課題番号：30W-01）

課題名：Integrated management of flash floods in wadi basins considering sedimentation and climate change
(土砂堆積および気候変動を考慮したワジ流域のフラッシュフラッド統合管理)

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研究場所：Oman

共同研究参加者数：12 名 (所外 4 名，所内 8 名)

・大学院生の参加状況：5 名（修士 4 名，博士 1 名）（内数）

・大学院生の参加形態 [現地調査への参加，論文執筆]

研究及び教育への波及効果について

Sultan Qaboos University (SQU) 大学とは，ワジのフラッシュフラッドの研究を 2015 年より共同で実施してきており，2017 年に第３回国際会議（The 3rd ISFF）をマスカットで開催した際にもホスト機関の一つとして重要な役割を果たしている．今回の国際共同研究のテーマは，マスカット近郊の Wadi Samail およびオマーン南東部の Wadi Mijras の２つの対象流域を対象に，G1. 降雨ー流出モデル開発，G2. 気候変動影響評価，G3. 土砂生産とダムへの土砂堆積の３つのテーマについて集中的に検討を行い，特に，Wadi Samail においては VTR 画像からの洪水水理量の推定手法の確立，Wadi Mijras においては，経時的なダム堆砂量の調査とその間の洪水発生の相関分析，さらに，Google Earth や InSAR を用いた上流河道の河床変動量の評価手法の開発など，新規性・有効性の高い手法の確立に貢献する成果をあげることができ，今後も共同研究をさらに発展させることで大きな国際貢献が期待される．教育面では，本課題に引き続き大学院学生（修士，博士後期課程）を参加させることで，学生の海外経験の促進が期待される．

研究報告

(1)目的・趣旨

Currently, devastating Wadi Flash Floods (WFFs) are frequently happened in the Arab Region. For instance, in Oman, severe flash floods occurred as Gonu 2007, caused 50 fatalities and 3.9 billion USD of economic losses, also Phet 2010 & Ashobaa 2015 cyclones. The main questions on integrated flash flood management are how flash flood intensity and frequency will change under changing climate, how to store flood water with retention dams to reduce flood damages and how to utilize stored water for groundwater recharge. However, flood water will transport huge amount of sediment which causes loss of dam storage volume and deposit on the river bed gradually losing infiltration process. Based on this background, goal of this project is to uniquely combine assessment of sedimentation process with wadi rainfall-runoff models considering the Climate Change (CC) impacts, therefore, the project objectives are:

1. To couple both field investigation and numerical modeling to predict water discharge and sediment transport.
2. To study the impact of climatic change on increasing WFFs extreme events in arid regions.
3. To study the impact of sedimentations on the dam reservoir and infiltration process.

The research project includes three groups: **G1. Rainfall-runoff modeling, G2. Climate Change impacts, and G3. Sedimentation**. The research activities are discussed in details as follow:

(2)研究経過の概要

平成 30 年度 実施結果（FY2018）

In the first year, we have conducted the following topics.

1- Collecting the data for modeling (e.g. rainfall, flow discharge, sediments data, etc).
2- Summarizing our previous efforts especially about rainfall runoff modeling.
3- Using Climate Circulation Models to conduct the climate change scenarios in order to know future situation of extreme flash floods events at Wadi basins.
4- Developing the sediment transport module to be combined with the existing models (RRI and HydroBEAM).
5- Evaluate the sedimentation impact by models and field investigation on the dam efficiency and infiltration.

Two field investigations on Dec 2017 and Sept, 2018 were conducted at Wadi Mijlas and Samail in Oman. Some measures have been conducted including (wadi channel leveling, sedimentation Pedon analysis, detecting of flash floods marks, drone survey, infiltration tests, and field questionnaire about flash floods).

令和 1 年度　実施計画（FY2019）

Additional two field investigation were conducted in Mar 2019, and Aug. 2019 Wadi Asserin Dam in Oman in order to investigate and measure the sediments at Asserin Up Dam, Wadi Mijlas. The study area has nineteen measurement bars distributed within the reservoir area used to monitor the sediments. Topographic data from UAV imaging help in understanding the distribution of sediments along the reservoir because the high resolution developed DEM. The sedimentation volume at the reservoir was calculated from the sedimentation measure bars which were already installed in the reservoir before the dam constructions. Also, the sediment thickness in the reservoir was estimated based on the identified sediment layers (from 2011 to 2017) at the three pedons conducted in the field surveys on Dec. 2017.The sedimentation volume was estimated about 37198 m3, which was accumulated over 9 years (from 2011-2019). Additionally, the deposition and erosion map along wadi channel was estimated.

(3)研究成果の概要

Based on field survey and data analysis, the following results have been obtained.

(1) The field survey such as UAV survey, pedon analysis, soil sampling and infiltration test was conducted to understand sediment transport characteristic and infiltration process. The results of this field survey and its analysis revealed the following:

1) Infiltration rate in the recharge dam is influenced much by its particle size distribution.

2) Hydraulic conductivity of the original bed decreases much by fine sediment clogging inside the original bed soil.

(2) Rainfall-runoff simulation was conducted by using Rainfall-Runoff-Inundation (RRI) model. The purpose of rainfall-runoff simulation is to detect the flood events which caused sedimentation in Aserrin Up down and to use the outcomes discharge as input in TELELMAC model for sediment transport modelling. The results revealed the following:

1) The distributed hydrological model such as RRI is applicable to arid regions which has unique characteristics such as the rapid increase in its discharge from its zero-flow status to the flood peak and the high spatial and temporal variability of the surface runoff. The model is calibrated and validated at Wadi Mijlas.

2) Hydraulic conductivity and roughness coefficient control the peak of flood discharge

(3) We adopted a new method to estimate the transported sediment from the volume and distribution of accumulated sediment by calibration of sediment concentration with acceptable correlation of all events. Sediment transport simulation in Aserrin II dam was conducted by using TELEMAC- SISYPHE model. The results revealed the following:

1) Sediment transport modeling in the recharge dam reservoir was conducted using TELEMAC-SISYPHE model in arid regions and calibrated by data of sediment deposition (Fig. 3).

2) Estimated sediment concentration is 34.45 (g/l), which means quite large volume of sediment is transported in arid regions.

(4) Infiltration simulation in Aserrin II dam reservoir was conducted using Hydrus-1d model. The purpose of this simulation is to assess the effect of the dam sedimentation based on the field survey data. The results revealed that the recharge volume decreases by about 10 percent due

to the impact of sedimentation since the dam construction.

Based on this project, it is recommended to continue for further field monitoring and research collaboration as follows.

1- More detailed analyses of total sediment volume in the reservoir by continuous monitoring to understand more the relation between sediment transport and discharge.
2- Installing additional sediment bars along wadi channel, in addition to install sediment flow monitoring system, as well as increasing monitoring stations such as rainfall, discharge and groundwater level to develop practical model.
3- Analyzing the extreme events that identified by GCM to understand the frequency and magnitudes changes of WFFs.
4- Testing the sedimentation effects on reducing water storage capacity and evaluate the degradation of groundwater recharge due to clogging of the fine sediments. This will be done by measuring the infiltration rates at different stages of sedimentation.
5- Evaluating the sedimentation impacts on the flash floods generation in terms of disaster.
6- Using Satellite data of InSAR to quantify sediment volume in Wadi basin, to determine the morphological changes in the Wadi Channel, and consequently to assess the trapping efficiency of existing structures.

(4)研究成果の公表

We have organized the 5th International Symposium of Flash floods in arid regions. It was held in February 25-28, 2020, at Kyoto University, Kyoto, Japan. Professionals, Researchers, students, and decision makers from Universities, Governmental agencies, and private companies have attended the event from many countries of the MENA region. The next ISFF will be held in Jordan, 2021. As outcomes of this ISFF2020. Two ISFF publications will be published by the end of this year, the springer book, and special issue of (ISFF) at Earth Systems and Environment Journal (https://www.springer.com/journal/41748/updates/17551576).