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Field Investigation on Wadi System in Arid Regions: Flash Flood Indicators and Sedimentation Impacts

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Synopsis

Wadi flash floods in arid regions are still not fully understood, especially in terms of climate change and sedimentation. In this paper, we present the outcomes of the field survey (from Nov 27 to Dec. 2, 2017) conducted by Kyoto University Team to both Wadi Samail and Mijlas in Oman, in order to show some implication of flash floods management and the impacts of sedimentation. Two field survey were conducted on Dec. 2017 and March 2018. Several measures have been conducted such as flash floods marks identification, wadi channel morphology changes, topographic leveling, sedimentation Pedon analysis and sedimentation measures at two dams (Assarin up and Assarin Down). The study conclude that understanding wadi flash floods phenomena for reasonable water and sediment management requires detailed field investigations. Based on the field survey, we proposed an integrated approach for sediment yield assessment based on numerical modeling and satellite data such as InSAR with validation of the field investigation outcomes.

Keywords: Wadi Flash Floods, Oman, field survey, Sedimentation, InSAR data, numerical modeling, satellite data, arid regions

1. Introduction

In arid regions, Wadi flash floods are frequently happen, especially during the last decade resulting in great devastating for human properties and environment. For instance in Oman, however, they have established a great structures for flash floods management and disaster protection in several wadis, they did not consider the sedimentation issues. Therefore, recently they are facing a great problems to manage the sediments on the reservoirs.

As consequence, we started international collaboration projects to investigate the sedimentation issues in several wadis in Oman such assessment of sediment yield, transport and reservoir sedimentation. In this paper, we are focusing deeply on the importance of field investigations to enhance the numerical approaches to assess the sediment transport and validate the satellite data to estimate the sediment yield. We are working on several approaches.

Several studies have been conducted on Wadi flash floods to understand behaviors and characteristics (Saber, 2010, Saber et al., 2015) and water management and harvesting (Abdel-Fattah et al., 2015). Water management and mitigation strategies by using rainfall-runoff models in arid regions is highly recommended (Kantoush, et al., 2011, Sumi, et al., 2013). Abdel-Fattah et al. 2015 studied and compared different mitigation scenarios for better management and risk reduction at Wadi Samail, Oman.

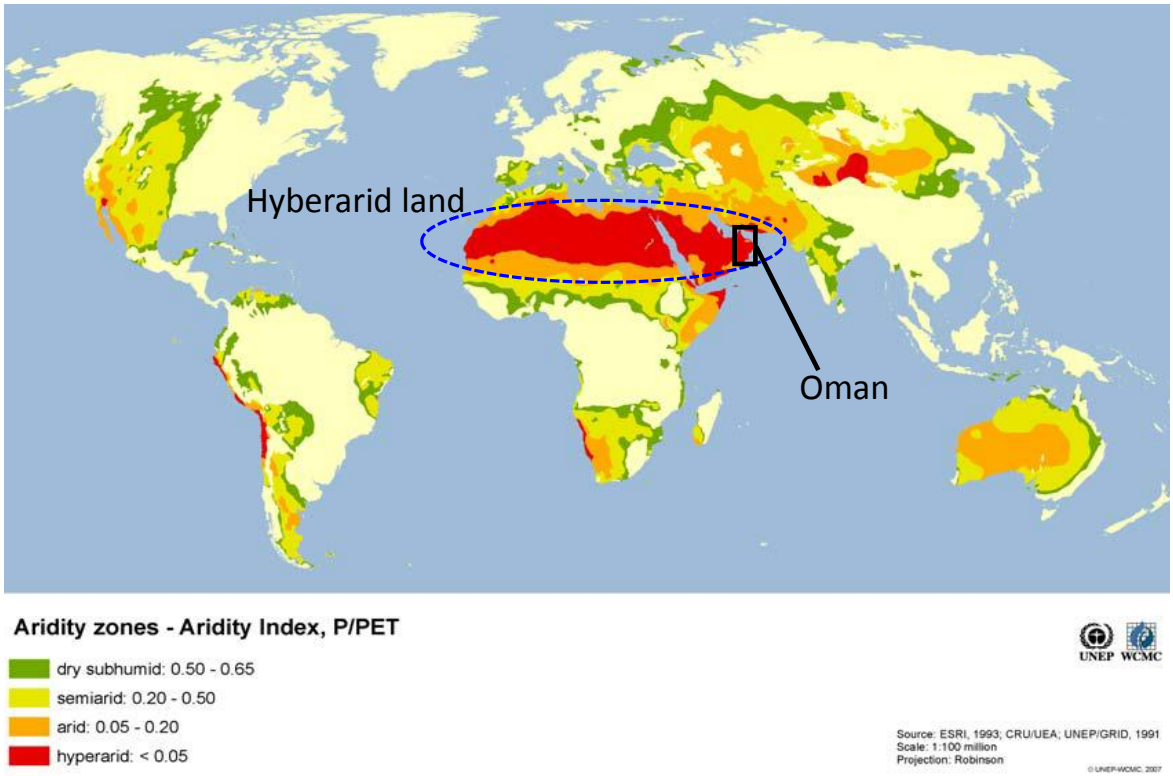

Fig. 1 The world drylands Sörensen, L. (2007). (http://www.fao.org/fileadmin/user_upload/newsroom/docs/full-map.png). It shows that the Arab reigon is mainly located in the hyperarid zone.

Additionally, morphometric and hydrological approach to understand flash floods in arid regions was developed by Abdel-Fattah et al. 2017, and validation of Satellite based rainfall estimated was done by Saber and Yilmaz 2018. The main objective of this work is to highlight the importance of field survey for wadi system for better understanding the real physical conditions of wadi flash floods phenomena and mainly for the sedimentation issues in Oman.

The paper is highlighting the main challenges in arid regions in section 2. The study area and sites for investigation were described in section 3. Section 4 is focusing on the field survey for wadis in Oman with detailed investigations. Discussion and future plan and prospective are addressed in section 5.

2. Problematics and challenges in Wadi basins

Oman is one of the most hyperarid countries is located in the Arab region (the largest hyperarid zone over the world) as shown in the developed map (Fig. 1) by UNEP-WCMC using a special analysis approach to the global delineation of drylands areas (Sörensen, L. (2007). As stated by Saber and Habib 2015 that arid regions are suffering from three problems: 1) limited hydrolopigcal models due to lack of monitoring network, 2) Shortage of water resources, the available surface water is limited due to the paucity and high variability of rainfall events, and subsurface water is very important but suffers from quality problems and depletion due to the mismanagement. 3) Disaster of wadi flash floods or drought conditions. These problems bring practical difficulties in arid areas for water resources management, planning, and development.

Recently, Wadi Flash floods is frequently increasing and occurring in arid regions, for instance in Oman, there are four cyclones happen within the last ten years, Gonu 2007, Phet 2010, Ashobaa 2015, Mekunu 2018. A great damage in infrastructures, hosing, agriculture lands are recorded from Gonu Cyclone (Fig. 2b). Figure 2a shows rainfall totals around the Gulf of Oman

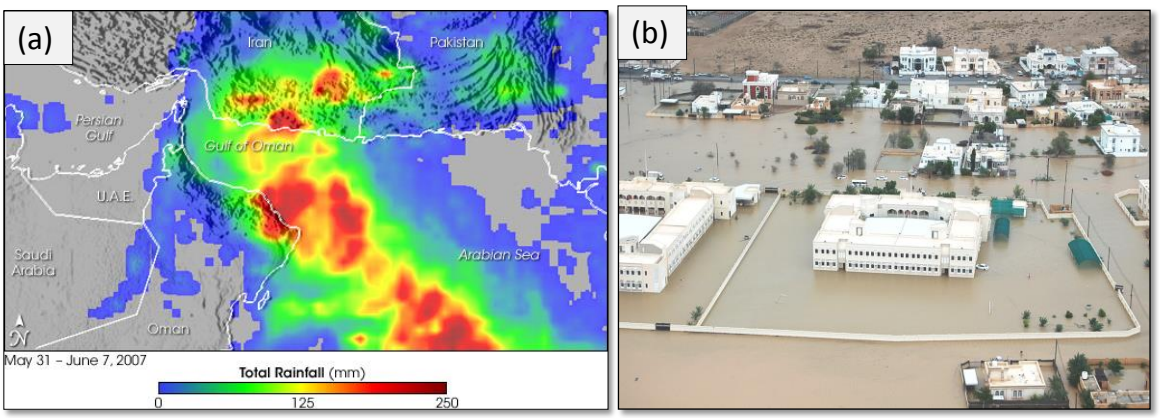

Fig. 2 (a) Total rainfall of Gonu Cyclone in Oman between May 31- June 7, 2007 (http://earthobservatory.nasa.gov/NaturalHazards/natural_hazards_v2.php3?img_id=14295), (b) resulting Damage in Muscat City (Albarawny 2015).

between May 31 and June 7, 2007 (Gonu Cyclone). The red areas show where rainfall exceeded 200 mm (8 inches).

3. Study Area

Wadi Samail and Wadi Mijlas in Oman were selected for this study (Figure 3) due to the availability of the observational data and great disaster impacts by the previous flash floods. Most of the previous studies were conducted on Wadi Samail, but in this study, we are deeply focusing on Wadi Mijlas as one of the most important wadis in Oman and also the most affected one during Gonu

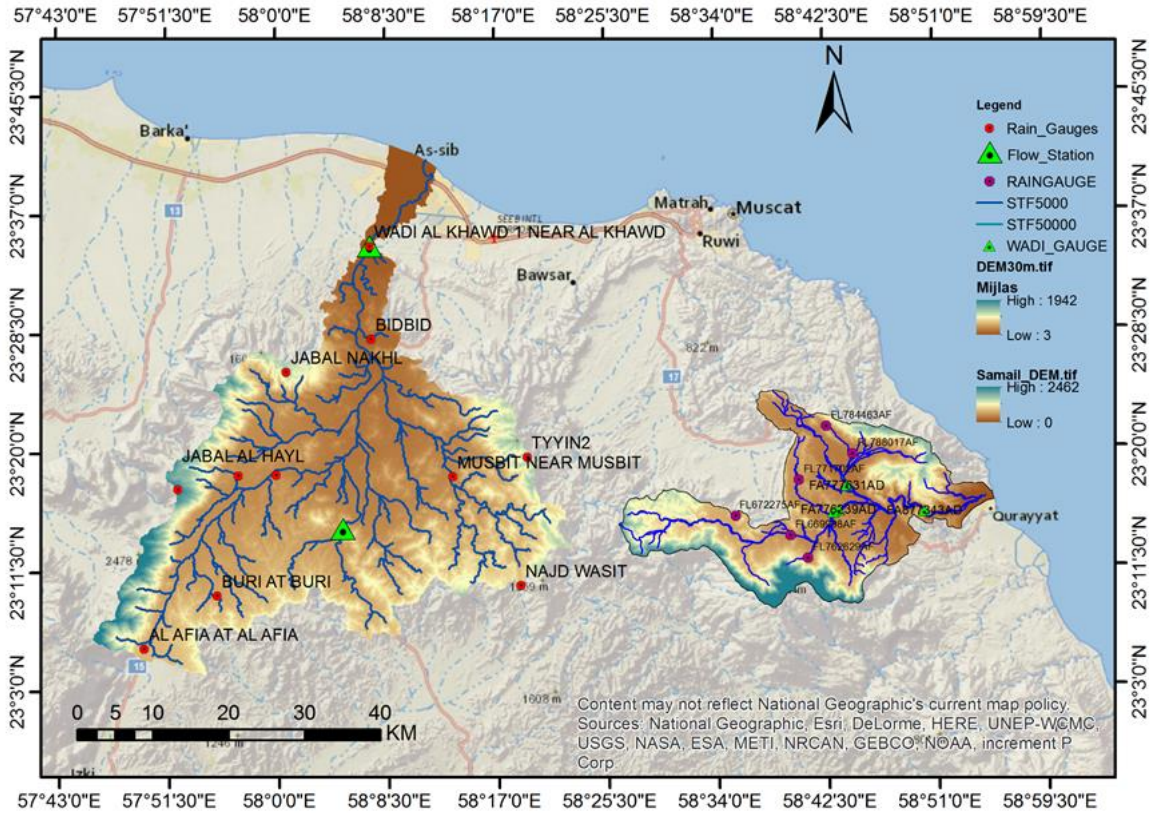

Fig. 3 DEM and watersheds of Wadi Samail and Wadi Mijlas in Oman.

and Phet cyclones. The government installed several rain gauges and wadi gauges which would be very useful for the model calibration and validation.

4. Field survey

During the time period from Nov. 27-Dec. 2, 2017, we have conducted the field survey to Wadi Mijlas and Samail (Fig. 4) in Oman in order to study the sedimentation impacts on the reservoir and identify the flash floods marks. The investigation was mainly focused on both Dams along Wadi Mijlas (Fig. 4) (Assarin Up (dam 2) and Assarin Down (dam 1)). Several measures (Fig. 5) have been implemented such as (wadi channel leveling, sedimentation Pedon to study the vertical layers of sedimentation at the reservoir by collecting sediments samples for further lab analysis, and detecting of flash floods marks).

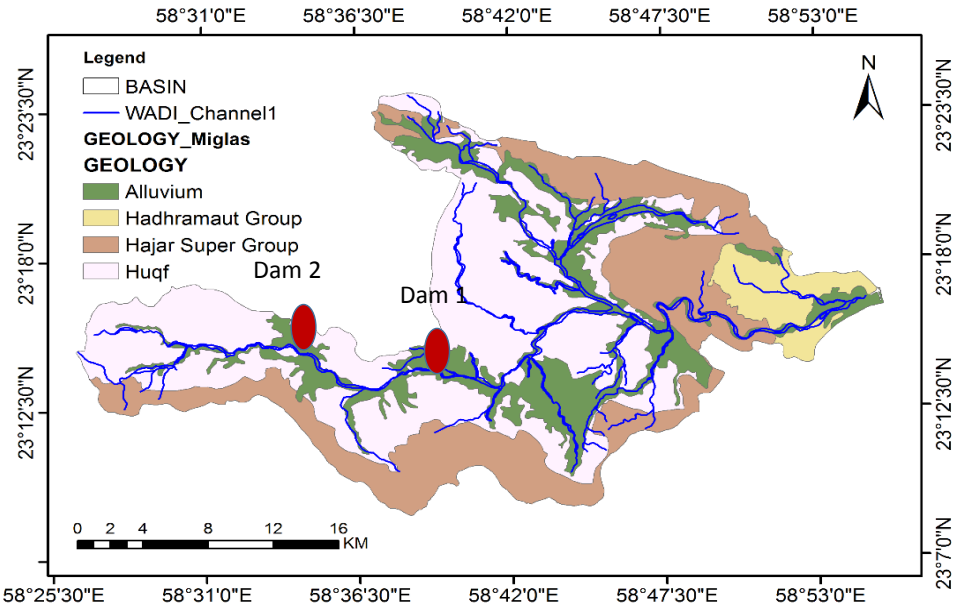

Fig. 4 Wadi Mijlas showing the geology Wadi Mijlas and Dam 2 (Al-Sireen Up) & Dam 1 Al-Sireen Down,).

Fig. 5 Field Survey for Wadi Mijlas and Wadi Samail in Oman Nov. 29-Dec. 2, 2017 conducted by Kyoto University Team (*Field Survey by Kyoto University Team, Nov. 29-Dec. 2, 2017*).

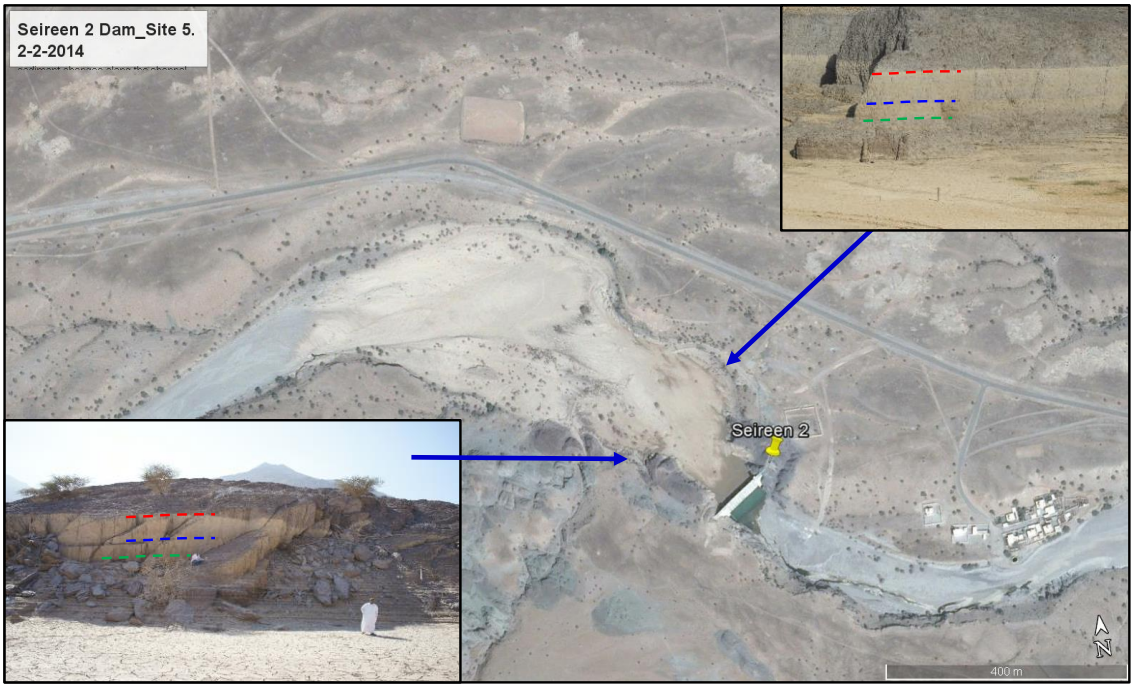

Fig. 6 Flood marks observed during the field survey at Asserin dam 2 (*Photos taken by Kyoto University Team, Field Survey on Nov. 29-Dec. 2, 2017*)

4.1 Flash floods marks

Flash floods marks are indicators for the maximum water level that the flood reach during the floods, or indicators for the sediment disposition or erosion. During the field survey, we have investigated the flood marks on banks of the wadi channel, especially at the reservoir at both dam (e.g. Assarin Up (Dam 2) (Fig. 6).

4.2 Pedon analysis

Several Pedon section were investigated along the reservoir to analysis the sediment and check the layers of sediments accumulated during the previous flash floods. Samples were collected for each layer for further Lab analysis. Soil analysis is

Fig. 7 Pedon cross section for sedimentation layers at the reservoir of Asserin dam 2 (*Photos taken by Kyoto University Team, Field Survey on Nov. 29-Dec. 2, 2017*)

still going on to know more about the sedimentation layers. For instance at Assarin Up dam, we found that the pedon consists of five sediment layers (Fig 7).

4.3 Wadi Channel Leveling

In order to assess morphometric changes along wadi channels, laser leveling was conducted along several longitudinal cross-section at both dams and also along wadi channels (Fig. 8)

4.4 Sedimentation measures

Several sedimentation bars were installed by the Ministry of Regional Municipalities and Water Resources in Oman. We measured the level of these bars and estimated how much sediments were deposited from 2011-2017 (Fig. 9). The sedimentation volume at the reservoir along Wadi Mijlas was estimated from the sedimentation measure bars installed in the reservoir before the dam constructions. It was found that the sedimentation volume due to four flash floods events over 7 years (From 2011-2017) was estimate about 8433 m3 at and Assarin Down (Dam 1) , and about 15041 m3 at and Assarin Up (Dam 2). Currently, InSAR data is being processing to assess the sedimentation yield and also numerical models to estimate the sediment transport, then all these outcomes will be compared and validated by the field investigation findings.

4.5 Morphometric changes

We have tried to assess and investigate the depositions and erosions along Wadi Channels. In addition to Wadi channel leveling conducted in the field, we also used google maps, to check some wadi channels morphometric changes due to the impacts of flash floods, such as the sedimentation changes at the dams before and the constructions showing the spatial topographic changes at the

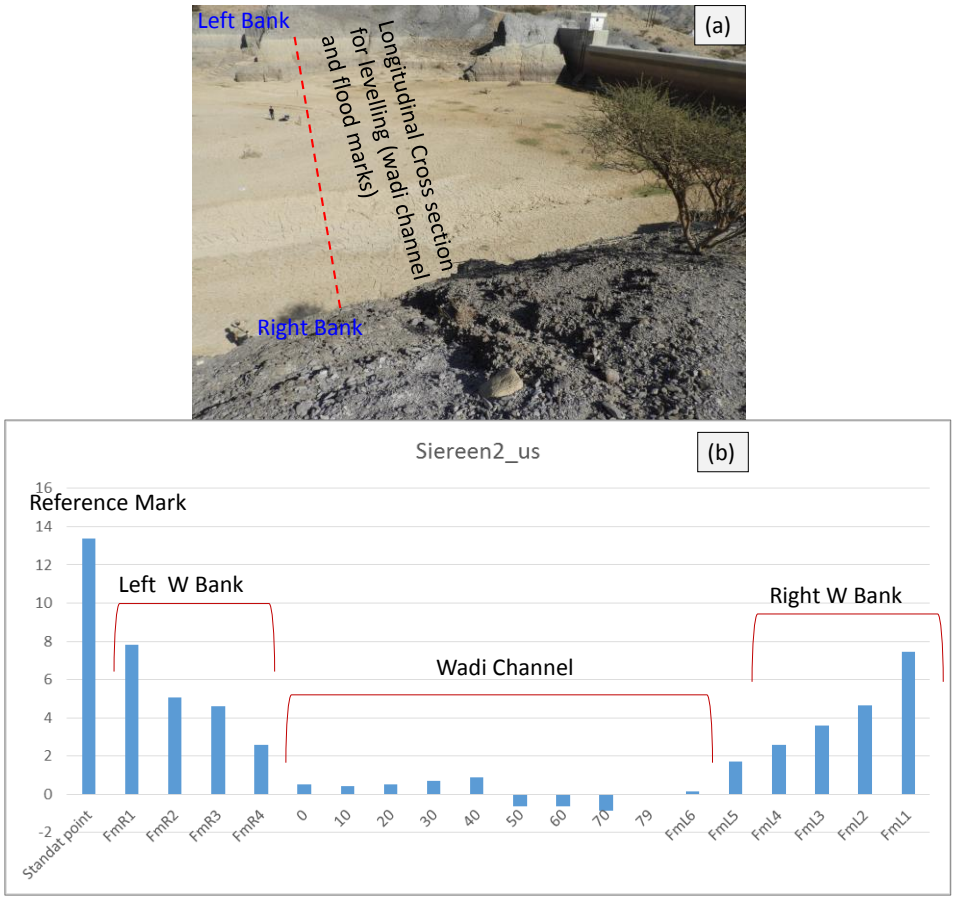

Fig. 8 Topographic leveling at (a) Assarin Dam Up (Dam 2) for wadi channel and flood marks (b) (*Photos taken by Kyoto University Team, Field Survey on Nov. 29-Dec. 2, 2017*)

reservoir at both dams along Wadi Mijlas (Fig. 10). Also, Along Wadi channels, it was observed the impacts of Gonu Cyclone on changing the channel morphology as shown on google maps before and after flash floods (Fig. 11). Currently, we are working on using InSAR data to assess the sediment yield at the target wadis.

Fig. 9 Sedimentation measures at the reservoir of Asserrin Dam at the upstream of Wadi Mijlas (*Photos taken by Kyoto University Team, Field Survey on Nov. 29-Dec. 2, 2017*)

4.6 Paleo-floods identification

Several sediment samples were collected from the deposited sediments along the wadi channels. Further analysis will be conducted to assess the age of the sediments in order to identify the pale-flash floods affected Wadi Mijlas (Fig. 12).

5. Discussion and future prospects

From this field investigation, we found that in order to understand the flash floods phenomena in arid regions in terms of water and sediment management, field survey is necessary. Therefore, from the wadi channel leveling and also investigation of flash floods marks, we found that there are four marks for the flash floods and from the historical events, there was about four flash floods events were recorded between the time period of 2011- 2017. It was found that they consisting with the recorded flash floods events. We are still working on analyzing the soil layers from the pedons, in order to link with the flash floods and also to compare with the flood marks. Then, we will compare the field survey estimates with both numerical modeling and satellite data such InSAR data for sediment yield assessment as proposed in Fig. 13.

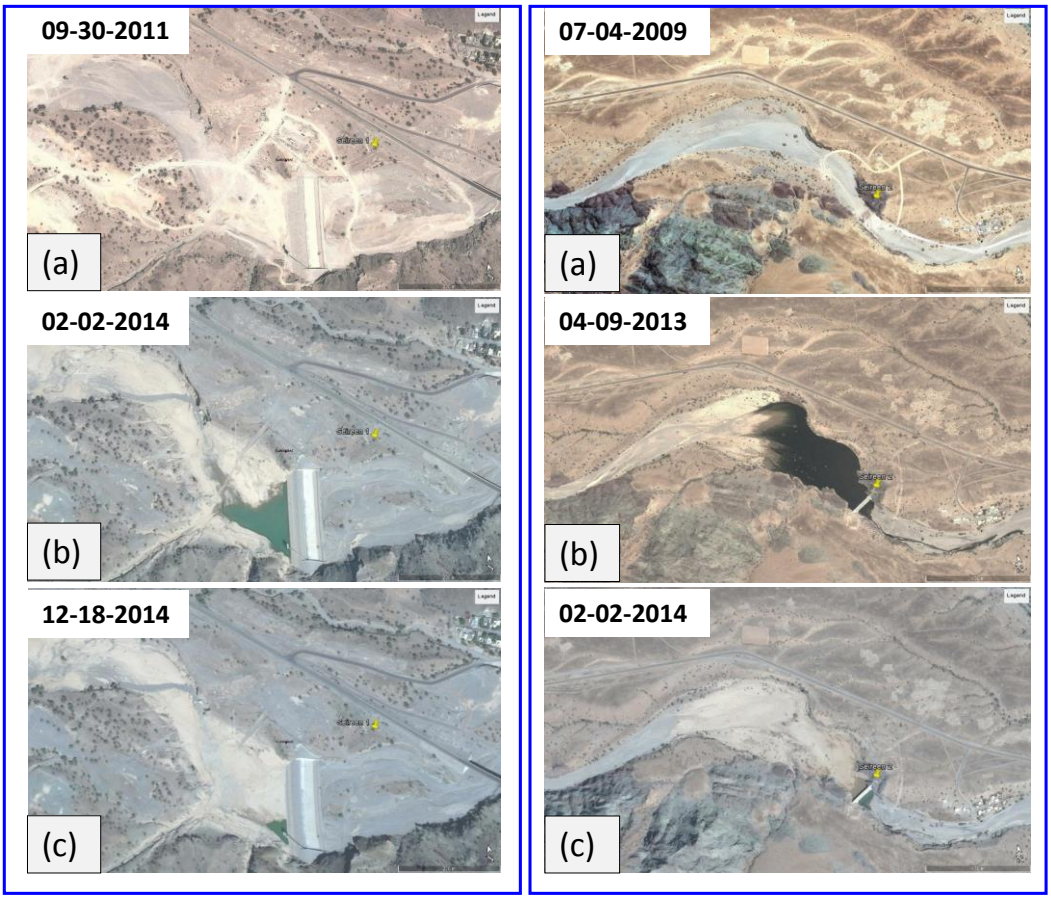

Fig. 10 Left Panel: Asserin dam 1 (downstream) construction and sedimentation impacts. Completion of dam construction in 2011(a), sedimentation impacts on the reservoir on Feb 2014 (b), and Dec. 2014 (c).
Right Panel: Asserin dam 2 (upstream) construction and sedimentation impacts. Before dam construction in 2009 (a), after flash floods and sediment deposition on the reservoir on April 2013 (b), dryness of the reservoir on Feb 2014 (c).

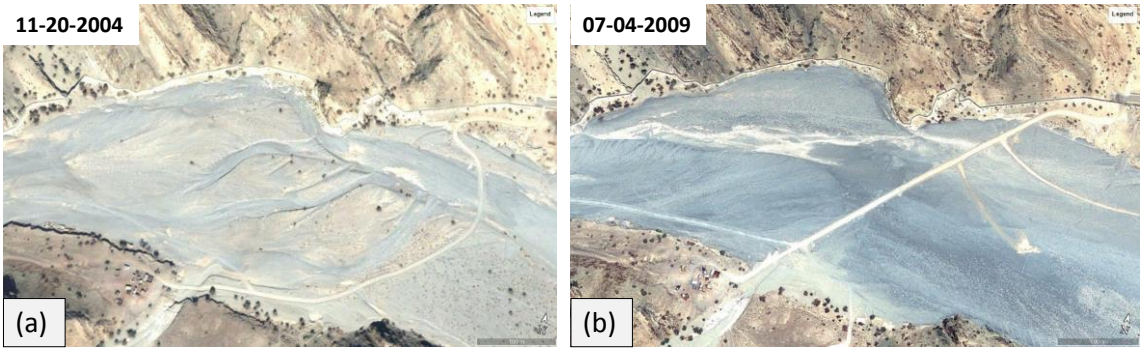

Fig. 11 Wadi channel morphology changes after Gonu cyclone in 2007. The sedimentation bars in Photo (a) were disappeared after the extreme floods (b) revealing to the huge transported sediment and the different in the soil colors is observed.

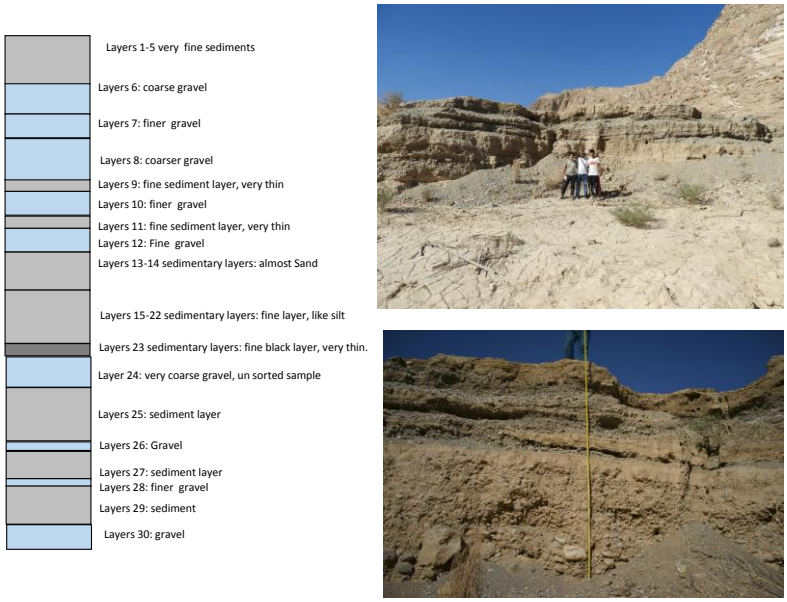

Fig. 12 Deposited sediments and layers were detected for analysis for paleo-flash floods (*Photos taken by Kyoto University Team, Field Survey on Nov. 29-Dec. 2, 2017*)

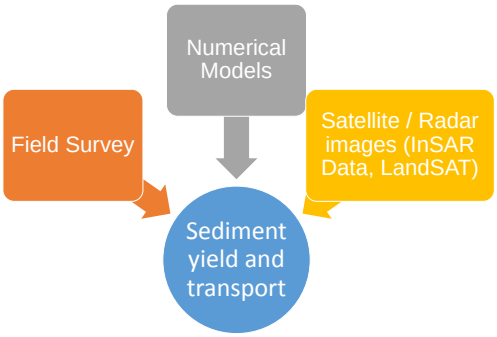

Fig. 13 Proposed integrated approach to assess sediment yield and sedimentation at wadi system reservoir.

6. Conclusions

In the present study, field investigation details were presented in order to understand the sedimentation impacts and also to validate the numerical models along with satellite data to assess the sediment yield in arid regions. It is well know that most of the arid regions are missing the sedimentation management and currently they have a real problem with the sedimentation issues. Thus, this study is quite crucial to assess the sedimentation throughout field survey, numerical modeling and satellite data, as well as to propose the best sediment management techniques in wadi basins. Further analysis is still going on and also further field survey will be conducted in the near future to complete the analysis, especially for paleo-floods and its implication for the climate changes.

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