

Integrated Multidisciplinary Approach for Flash Floods Modelling, Forecasting and Mitigation: The Way Forward to Sustainable Development of Wadi Basins

Sameh A. Kantoush*, Mohamed Saber, Tetsuya SUMI

Water Resources Research Center, Disaster Prevention Research Institute (DPRI), Kyoto University, Japan

*Corresponding author

Email: kantoush.samehahmed.2n@kyoto-u.ac.jp

Keywords: Wadi Flash Floods, Multidisciplinary Strategy, Society and Environment, Wadi Development

Wadi flash flooding in arid and semi-arid regions has recently become more frequent and devastating resulting in great property damage and extensive loss of life as well as environment degradation. Lack of data (availability, quality), disasters (flash floods and drought), water scarcity (quantity and quality), missing of management (water and sediment), and poor knowledge and approaches (models, strategies, and planning) are the main problems and struggles of wadi system in arid and semi-arid regions. Therefore, identifying main factors for increasing of wadi flash floods in terms of frequency and intensity are desperately needed to develop the powerful approaches for forecasting and to propose the proper mitigation strategies for risk reduction. Additionally, understanding the hydrological characteristics such as spatiotemporal variability of rainfall, infiltration process, runoff generation, and surface and subsurface water interaction along with investigation of wadi basin geomorphology, topography, and geology. This will be the optimal way to overcome such struggles.

Long-term rainfall data and their analysis are limited in most of arid regions. Although, many previous studies have been done to mitigate the flash floods in some arid regions, spatiotemporal variability in both flash floods magnitudes and frequencies are still not well understandable and not scientifically explained especially with their linkage with the climate change impacts. Therefore, there is an urgent necessity to develop a sustainable methodology to simulate and forecast of WFF based on monitoring networks of both rainfall and discharge in such arid regions.

In terms of WFF water management, arid and semi-arid regions are defined as areas where water is at its most scarce. The hydrological conditions in these areas are extreme and highly variable, where flash floods from a single large storm can exceed the total runoff from yearly hydrographs. These areas are facing the greatest pressures to manage the available water resources for their needs due to increasing population, water demand, agriculture area, pollution, and climate change impacts. Understanding the impacts of climate changes on increasing WFF frequency and magnitudes at wadi system in arid regions. Additionally, due to the gap of the absence of sustainable mitigation strategies and water management, linking with the effective developed hydrological models, proposing a sustainable mitigation measures with water managements approach throughout water harvesting and groundwater recharge are one of the main required objectives overcome wadi system problems.

Therefore, we have to think deeply and uniquely about wadi flash floods in arid regions to come up with the proper, applicable and innovative tools for forecasting, mitigation, and water management as well as wadi society development. In this work, we propose an integrated strategy based on multidisciplinary research including the following issues:

- **Innovative approaches:** What are the missing in the current developed models for wadi flash floods? How can we fill the occurred gaps in terms of modelling, forecasting, and mitigation? What are the requirements to come up with applicable techniques and tools to reduce the risk and manage the water to improve and develop the society and protect the environment?; How can we understand increasing the flash floods phenomena in frequency and magnitudes in terms of climate change?
- **Databased networks:** Do we have enough data for modelling and forecasting? What are the available meteorological data and other data? Do we have enough observation monitoring networks stations for meteorological and flow, and groundwater levels, etc?; If not, what we should do to overcome the problem and build the database for wadi system?.
- **Team works:** What are the available national and global networking for research collaboration? What do we need to initiate such important networks from different countries involving researchers, engineers, professionals, stakeholders, society, etc.?
- **Risk reduction and sediment management:** How can we manage and mitigate WFF water as well as reduce the risk disasters? How can we come up with WFF risk reduction using the effective hydrological models and mitigation measures?
- **Water harvesting and management:** How can we be able to combine the surface and subsurface approaches for the sustainable WFF water management in terms of water harvesting and groundwater recharge?; How can we manage and utilize such threaten WFF water to be suitable for agriculture activities and other domestic uses?; What are the expected enhancement on the available water resources and development the society in terms of agriculture and water demand?
- **Society and environment:** How can we contribute in wadi society and community development? How can we involve the society in the research and projects implementation?
- **Decision-making, planning, and governance:** What are the available development and planning in Wadi system society? Does the decision makers and governors are willing for projects implementations. Did the country initiated some planning in that regard? How can we help them to sustain their plan and policy?

The answers about these questions are the only and optimal way to overcome water related problems in wadi system for society development and environmental protection. Therefore, we propose such example of multidisciplinary approach based on the discussed factors (**Figure 1**). Such proposed multidisciplinary research strategy is being to focus on Wadi Flash Floods (WFF) modelling, mitigating, and harvesting and its related multidisciplinary socio-environment issues. The current and previous improvements, the gaps and missing in research and technologies, and our contributions and development will be achieved by this strategic way. The research group's contribution and developments will be achieved to answer the raised objective questions of water related problems in wadi system. Working together in groups under the same umbrella is the way forward to overcome such challenges and come up with building of database, new modelling approaches, water and sediment management, disaster risk reduction, wadi society development and environmental protect. Additionally, implementation the mitigation measures and harvesting structures, integration between this multidisciplinary themes, transferring knowledge and technologies, involving of wadi society in research (collecting data and implementation), developing public awareness and educational system are the main unique merits of such integrated strategy.

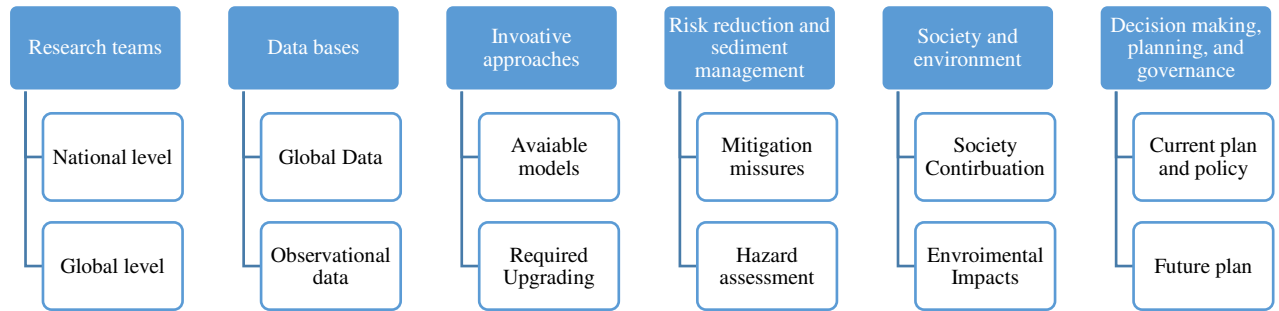


Figure. 1 A proposed concept for integrated multidisciplinary strategy for wadi system in arid regions.

The Second International Symposium on Flash Floods in Wadi Systems (2nd ISFF)



Integrated Multidisciplinary Approach for Flash Floods Modelling, Forecasting and Mitigation: the Way Forward to Sustainable Development of Wadi Basins

Sa me h Ka nto ush, Mo ha me d SA BER, Te tsuya Sumi

Wa te r Re so urc e s Re se a rch Ce nte r
Di sa ste r Pre ve nti on Re se a rch In sti tu te
Ky o to Un i ve rs i ty



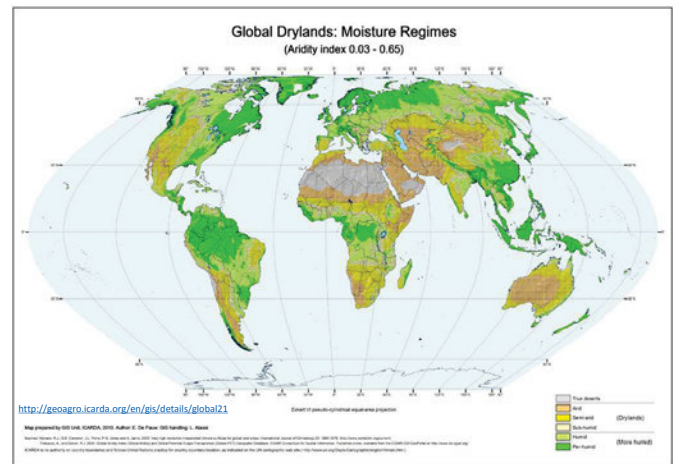
Wadi Background and Problematic

- Arid and Semi-arid regions are under pressure due to droughts.
- Rapid increase of population and urbanization has pushed people to high disaster risk zones such as Wadi flood plain.
- Reasons for increasing WFF disasters are 1) Lack of enough knowledge in local government and wadi communities on flooding risks and improper land use, Insufficient rainfall and flood runoff forecast and prediction measures,
- Public awareness and Socio - Eco educational regarding flash flood risk
- Not all flash floods are destructives and harvest by various technologies
- Until today, no comprehensive master planning to design mitigation measures by flood storage upstream, safety passage downstream and wisely use of floodwater (water harvesting) in Wadi systems..
- There is an urgent need to establish a guideline for assessment and mitigation and utilize floodwater as a new supply.
- The indigenous knowledge combined with the modelling and monitoring
- Important research challenges include, participation of Wadi local communities, data collection techniques, occurrences of WFF, forecasting and predications, warning systems and mitigation measures, sedimentation, Wadi ecosystem, and water harvesting techniques.

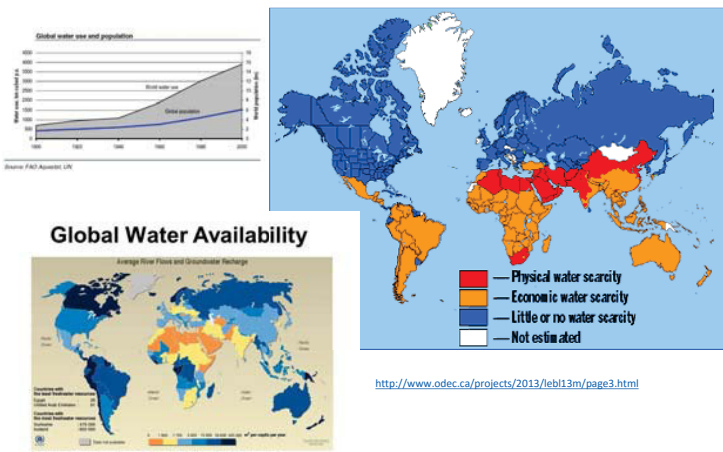
Introduction: Current challenges

| Water management and Scarcity | Disasters | Data deficiency | Approaches and techniques |
|---|--|--|--|
| <ul style="list-style-type: none"> • Water and Sediment • Paucity & Quality | <ul style="list-style-type: none"> • Flash floods • Droughts | <ul style="list-style-type: none"> • Availability • Quality • Missing | <ul style="list-style-type: none"> • Models • Strategies • Planning |

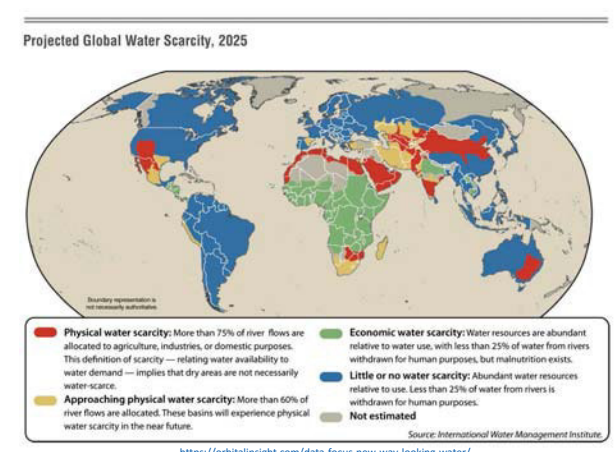
Current challenges: Water management and Scarcity



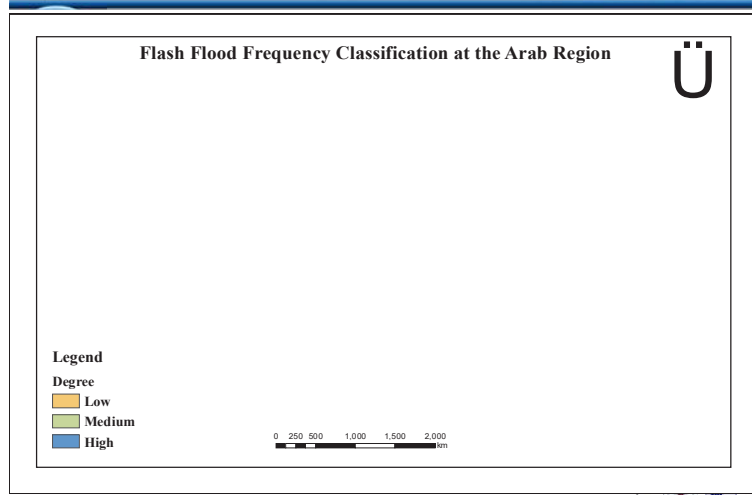
Current challenges: Water management and Scarcity



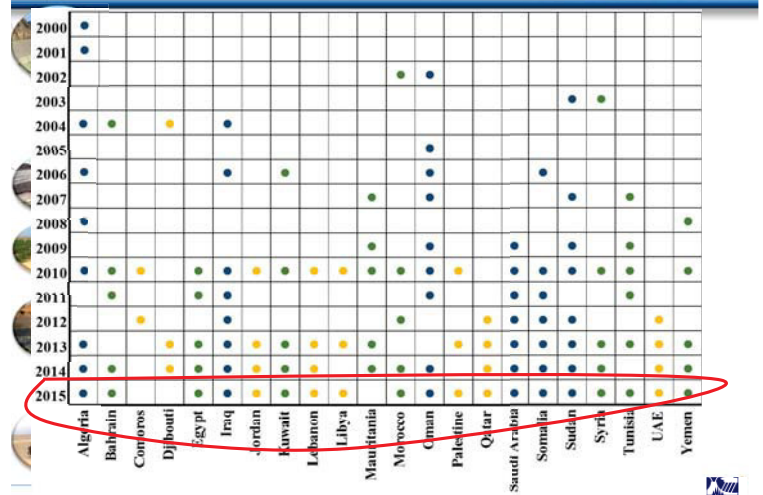
Current challenges: Water management and Scarcity



Wadi Arab Region Between Drought and Flash Floods



Wadi Arab Region Between Drought and Flash Floods



wadi Deadly Urban Floods and Storms Hit Arabian States Between Oct.-Nov. 2015

Severe storms trigger floods across Middle East

Thunder showers roll in from the Mediterranean as heavy downpours cause disruption in Syria, Iraq, Iran and Kuwait.

© Reuters/Corbis (3) (4) (5) (6) (7) (8) (9) (10) (11) (12) (13) (14) (15) (16) (17) (18) (19) (20) (21) (22) (23) (24) (25) (26) (27) (28) (29) (30) (31) (32) (33) (34) (35) (36) (37) (38) (39) (40) (41) (42) (43) (44) (45) (46) (47) (48) (49) (50) (51) (52) (53) (54) (55) (56) (57) (58) (59) (60) (61) (62) (63) (64) (65) (66) (67) (68) (69) (70) (71) (72) (73) (74) (75) (76) (77) (78) (79) (80) (81) (82) (83) (84) (85) (86) (87) (88) (89) (90) (91) (92) (93) (94) (95) (96) (97) (98) (99) (100)

Dailynewsegypt, 2015

Wadi Egypt (25th October- 4th November)

- Beheira: 25 people have been killed in wadi ALNatroun.
- Alexandria 52 mm in 24h
- Hurghada
- Ras Gharib
- Elsokhna and North Sinai

Wadi Yemen (1-3 & 8-10 Nov. Chapala Cyclone)

- Tropical Cyclone Chapala has been affecting southern Yemen with heavy rainfall, strong winds, storm surge and high waves.
- Heavy rains triggered severe floods in the provinces of Hadramawt and Shabwa.
- 49000 palm trees were destroyed, 301 House garden
- 37000 goats, 359 water ponds
- Total of 26 dead 18 of which are in Socotra

Wadi ▶ Oman

4 September 2015:

- 59.8 mm of rain fell in Amerat and 17.4 mm in Rustaq causing floods in Al Batinah Region and 4 deaths.

14-17 Oct. 2015

- Nizwa, Ras Al Hadd and Bahla
- city of Ibra saw 104 mm of rain on 16 October 2015, with at least 3 other locations seeing 40 mm of rain in one day



Wadi ▶ Iraq



- 28,29-October
- 5 Children's during the flood lost of life in Baghdad
- 58 total death all over Iraq
- 60,000 displaced



Wadi ▶



Kuwait

- Salmia
- 27 Oct.



Jordan

- 25-Oct. El Shouna and El Ahoar El Shamalia, Toufila
- 200 houses damage
- Many cars drifted



Lebanon



Libya



Wadi ▶ Saudi Arabia



- 29 Oct.
- 2 Death in Tarief Governorate

18 Nov. Flash Food



- Jeddah (22mm in 15 minutes) (3 Death), Madinah (7 death), Hail (2 Death) and Mekkah



Wadi ▶ Qatar



- 25 Nov.
- Doha, Qatar, recorded more than a year's worth of rain in one day



| QATAR METEOROLOGIST الهيئة العامة للأرصاد الجوية QATAR METEOROLOGICAL AUTHORITY | | | |
|---|-------------|------------------|---------------|
| Total rainfall Accumulation since Tuesday (Yesterday) 24/11/2015 until Wednesday 25/11/2015 (Today) 12:00 pm. | | | |
| Ras Lafan | Al Khor | Doha Airport | Hamad Airport |
| 8.5 mm | 2.4 mm | 16.9 mm | 80.8 mm |
| Abu Samra | Al Karanaah | Qatar University | Abu Hamour |
| 26.5 mm | 1.6 mm | 17.5 mm | 31.8 mm |
| Dukhan | Al Wakrah | Al Jamailiya | Al Batnah |
| 6.8 mm | 6.6 mm | 3.2 mm | 3.2 mm |
| Ummbab | Turaynah | Al Shahalmiya | Al Shahalmiya |
| 6.1 mm | 1.8 mm | 3.1 mm | 5.1 mm |
| | Al Ruwais | Ghuwayriya | Masaheed |
| | 1 mm | 0.3 mm | 17.8 mm |



Wadi ▶ Sudan



- 25 Oct. 2015
- Red Sea Sudan 443 house



Wadi ▶ Palestine

10 Nov.

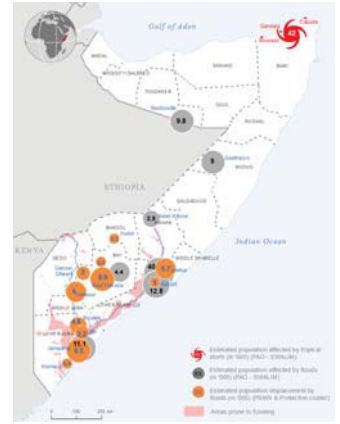
- Floods in Ghaza Khan Younis and Beit Degan
- Ashkelon also had flash floods after 30mm of rain fell in less than an hour.



Wadi ▶ Somalia

Oct. Nov. 2015

- 60,000 people have been displaced
- The tropical cyclones Chapala and Megh which made a landfall in Yemen caused some damages in parts of coastal areas of Puntland and Somaliland.



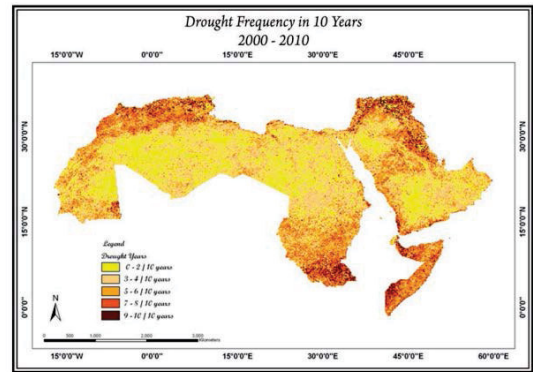
Wadi ▶ Algeria

- 17,000 homes are directly impacted in Tindouf in south-western Algeria and five Sahrawi refugee camps



Current challenges: Disasters (Droughts)

Drought Vulnerability in the Arab Region (2000 – 2010)



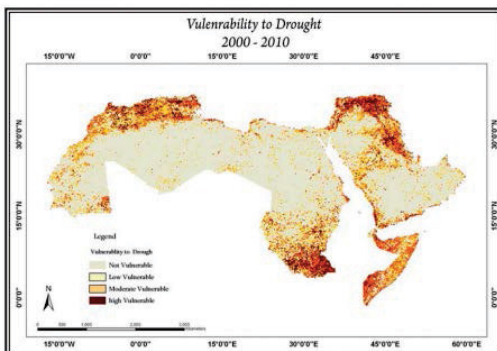
http://www.unisdr.org/files/23905_droughtsyriasmall.pdf

2nd ISFF, Oct., 2016

22

Current challenges: Disasters (Droughts)

Drought Vulnerability in the Arab Region (2000 – 2010)



http://www.unisdr.org/files/23905_droughtsyriasmall.pdf

23

Current challenges: Data deficiency

1. Lack of monitoring Network stations in arid and semi-arid regions
2. Missing of historical data
3. Data quality, Incomplete time series data
4. Data accuracy, errors

24

Current challenges: Approaches and techniques

1. A few developed approaches to solve the aforementioned problems
2. Lack of integrated approaches
3. Missing of global collaborations to develop physical based models

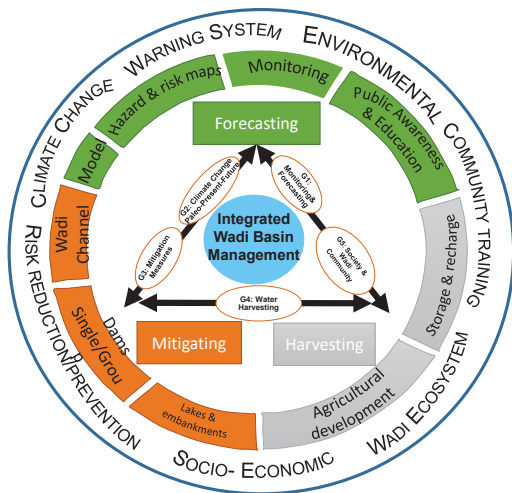
How can we overcome such problems throughout developed an integrated Approaches for Wadi Sustainable development

Objectives:

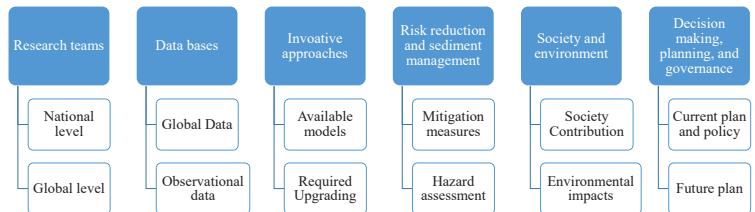
The goal of this integrated approach is to come up with the proper, applicable and innovative tools for forecasting, mitigation, and water management as well as wadi society development.

25

26



Proposed concept for integrated multidisciplinary strategy for wadi system in arid regions



28

Team works

Research teams

- National level
- Global level

- What are the available national and global networking for research collaboration?
- What do we need to initiate such important networks from different countries involving researchers, engineers, professionals, stakeholders, society, etc.?
- How can we start from now?

Building Database

Database

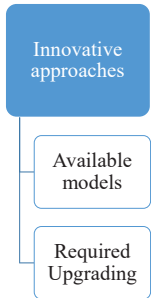
- Global Data
- Observational data

- Do we have enough data for modelling and forecasting?
- What are the available meteorological data and other data?
- Do we have enough observation monitoring networks stations for meteorological and flow, and groundwater levels,...etc.?
- If not, what we should do to overcome the problem and build the database for wadi system?

29

30

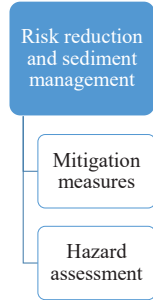
Innovative approaches



- What are the missing in **the current developed models** for Wadi flash floods?
- How can we fill the **occurred gaps** in terms of *modelling, forecasting and mitigation*?
- What are the requirement to come up with **applicable techniques and tools** to reduce the risk and manage the water to improve and develop the society and protect the environment?
- How can we understand increasing the flash floods phenomena in *frequency and magnitudes* in terms of climate change?

31

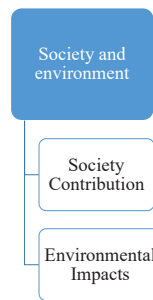
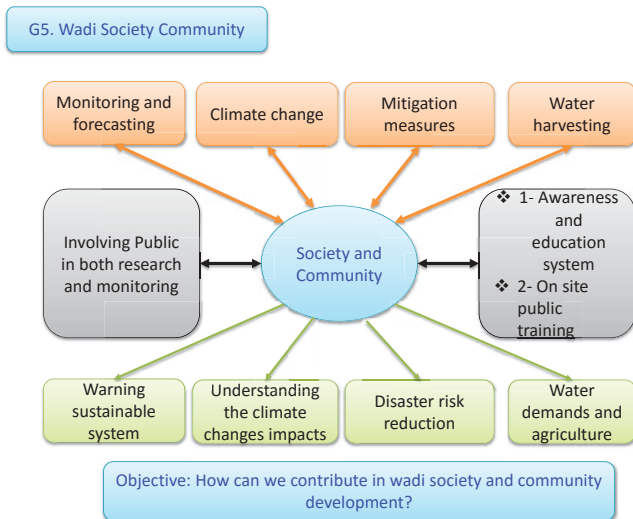
Risk reduction and sediment management



- How can we manage and mitigate WFF water as well as reduce the risk disasters?
- How can we come up with WFF risk reduction using **the effective hydrological models and mitigation measures**?
- How can we manage *the associated sediments* with flash floods

32

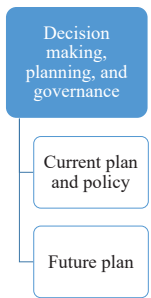
Society and environment



- How can we contribute in wadi society and community development?;
- How can we involve the society in the research and projects implementation?
- What are we need to reduce the *enviromental degredation* due to wadi disasters

34

Society and environment



- What are the available development and planning in wadi system society?;
- Does the decision makers and governors are willing for projects implementations?
- Did the country initiated some planning in that regard?
- How can we help them to sustain their plan and policy?

Conclusion

- The answers about these questions are the only and optimal way to overcome water related problems in wadi system for society development and environmental protection.
- The current and previous improvements, the gaps and missing in research and technologies, and our contributions and development **could be achieved by the proposed integrated approach.**
- Working together in groups under the same umbrella **is the way forward to overcome such challenges** and come up with building of database, new modelling approaches, water and sediment management, disaster risk reduction, wadi society development and environmental protect.

Conclusion

- implementation the mitigation measures and harvesting structures, integration between this multidisciplinary themes, transferring knowledge and technologies, involving of wadi society in research (collecting data and implementation), developing public awareness and educational system *are the main unique merits of such integrated strategy*

37