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Impacting Policy: Harnessing Science on Climate Change and Water through Partnerships with Decision-Makers in the Middle East and North Africa – Reflections

R. A McDonnell[a], K. Bergaoui[b], A. Khalaf[b], R. Zaaboul[b] and M. Belhaj Fraj[b]

[a] *International Center for Biosaline Agriculture, Dubai, UAE and Oxford Water Futures Group, University of Oxford, Oxford, UK**
[b] *International Center for Biosaline Agriculture, Dubai, UAE.*

Abstract

Bringing science and technology from the United States National Aeronautics and Space Administration (NASA) to the Middle East and North Africa (MENA) region provides an opportunity for enhanced understanding of natural resources and improved decision-making. The programme Modelling and Monitoring Agriculture and Water Resources Development (MAWRED), which develops advanced data generation as well as mapping and modelling skills in local MENA researchers, bridges the gap between policymaking and the complex science behind many applications. One of the project's foundation stones has been the building of partnerships between international donors, researchers and local government ministries/agencies in the programme's key countries of Tunisia, Iraq, the West Bank/Gaza and Yemen. Given the region's political turbulence, this process can be complex and dynamic. However, it brings huge rewards through understanding in greater detail the region's water balance, especially with regard to agricultural use and the potential impacts of climate change on food and water security.

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Keywords: climate change; agriculture; water resources; modelling; remote sensing; partnerships

1. The need to bring new science insights into the policy development process

For people with access to leading scientific journals describing the latest modelling and data analysis, the possibilities for deriving solutions to difficult water challenges seem closer today than ever. Scientific insights gained through new satellite sensors linked to ever more sophisticated models are able to provide warnings and advice on water dynamics above and below ground, both for today and under future conditions. Providing this scientific evidence to different stakeholders helps support both increased understanding of the nature of the resource situation, and partnerships across the science-policy divide in the development of enhanced management strategies. However, in many countries without access to this kind of knowledge and skills, the reality is quite different. In these countries, scientific advisors, ministers and other decision-makers involved with managing, and planning the management of, national water resources receive only limited flows of water data and new scientific knowledge, ensuring that evidence and insight is partial and often inadequate.

* *Corresponding author.*
Email address: r.mcdonnell@biosaline.org.ae

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In these ever more challenging times for water management, partnerships between scientists, applied research centres/knowledge brokers and users are needed to ensure in-depth support and the provision of quality evidence, whatever the political framework in place. In the Middle East and North Africa (MENA) region, economic, social, and arguably political, developments are all limited by water. The natural aridity of the region ensures that allocation is a foremost challenge to strategic planning. Whilst engineering technology centred on treated wastewater and desalination bring new inputs to the resource balance equation, the ability to manage water and linked food security is still difficult, complex and politically charged. Careful analysis is required to understanding the extent and nature of available resources and uses, and the financial and energy costs involved in providing supplies. Yet few ministries responsible for water have available data that is current and covers the main areas of their country.

To help address this issue, the International Center for Biosaline Agriculture (ICBA), is acting as both data generator and knowledge broker through its regional programme named MAWRED (Modeling and Monitoring Agriculture and Water Resources Development, and meaning the source in Arabic). Through this initiative, key water, crop and climate data outputs are developed supporting decision-making and policy development across a variety of knowledge users.

2. New insights from the MAWRED programme

With agriculture using by far the lion's share of water in the MENA region, any studies to support improved resource planning and management need to include details of crop production systems. Yet for many countries, supporting data are scarce, poor in space and time coverage or not shared. To fill these data gaps, it is possible to harness the insights available from scientific research in space-based observations and modelling. This data source cannot replace the valuable collection of local field data, but it goes some way to bring evidence to the policy process. To understand current production systems and their impacts on ground water, modelling and mapping developments have focused on generating new data on where crops are grown, irrigated areas, crop yields and changes in water dynamics. And with the generation of downscaled data on climate change, potential threats under future conditions are also modelled and explored (as illustrated in Figure 1) at the regional and country scale (for Tunisia, Yemen, Iraq and the West Bank/Gaza).

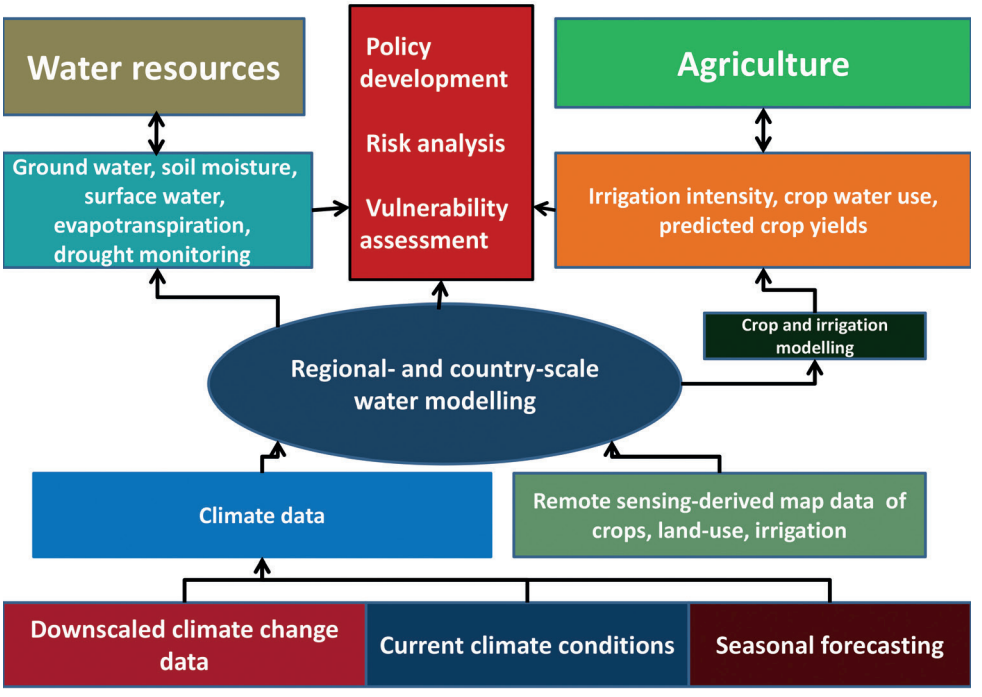

Figure 1. The water, agriculture and climate modelling and mapping elements of the MAWRED programme

2.1. Climate change downscaling and analysis

In the main international climate change reports, analysis of predicted impacts and vulnerabilities in the Middle East is limited, reflecting the state of research in this field for the region (IPCC, 2013; IPCC, 2007; Tolba and Saab, 2009). In recent years, there have been increased activities (Evans, 2009; 2010), but much of this has focused on climatology rather than the impacts of climate change on water and agriculture. To address this gap in knowledge, work undertaken in the MAWRED programme has centred on the computationally and analytically complex area of identifying the general circulation models (GCMs) that most accurately represent the region's climate, and downscaling these to a 45 km pixel resolution for the region, and a 15 km pixel resolution for Tunisia and Yemen.

In comparing MENA region outputs for the historical period (1979-2005) from the various GCM's relative to observed values, has highlighted both an overestimate of precipitation in some parts of the region, and a dry bias on others. Going forward, GCMs predict that the complex interactions of changes in oceanic and atmospheric systems, such as the monsoon, are likely to bring a substantially drier and warmer environment for countries in North Africa and the Levant region (Evans, 2009; 2010). Increased precipitation is predicted for the southern parts of the Arab Gulf region (Verner, 2012). Using these findings in subsequent water and crop modelling gives new insight on likely future impacts.

2.2. Water modelling

The second component of the MAWRED programme focused on establishing water models for both the national and regional scales. Using models from NASA and other US government agencies (Kumar *et al.*, 2006; Peters-Lidard *et al.*, 2007), ICBA researchers made further calibrations and validations in order to represent the hydrological processes of the arid MENA region. This modelling process uses advanced data assimilation techniques to bring field observations into the calculation process, thereby ensuring greater accuracy in data outputs. One of the challenges in the models is that the flows of water in the region are as much determined by human activities, especially pumping water for irrigation, as they are by natural processes. Representing these human abstractions of water is difficult as few records are collected or shared. To bring in more accurate representations of water losses, the ICBA team used new irrigation maps derived from remotely-sensed data. Following calibration, the resulting water models have been used as a basis for regional and national explorations of the impacts of climate change. Through combined climate and water modelling, the researchers are able to predict variations in temperature, precipitation and evapotranspiration, indicating areas where water stress is likely to increase in the future.

2.3. Crop mapping and modelling

Agricultural production is important for both food security and rural livelihoods in the MENA region, yet few countries have up-to-date maps or values for areas where key crops are grown. There is also little detailed information on how much water is used by the different crop systems, except for general percentage estimates, often around 70 per cent, for the total used by the agricultural sector. Thus, the third important component of the MAWRED programme, mapping and modelling crop production systems, not only brings current insight into what is being grown where, and the amount of water used, but also provides values for yield. Using the Decision Support System for Agrotechnology Transfer (DSSAT) crop yield model (Jones *et al.*, 2003; Hoogenboom *et al.*, 2010), the influences of weather, management and local crop varieties are explored for wheat, barley and, in the future, sorghum, maize and pearl millet. With the calibration and validation of the model for wheat in Tunisia, the likely impacts of climate change on yields have further been explored, and possible variations in management practice examined to combat the predicted decreases in outputs.

3. Analysis

The scientific research being undertaken brings together complex modelling and mapping processes to yield insights for decision-makers in the key areas of current and future water and food security. Yet the real success of the project, bringing science to the policy process, arguably centres on building strong partnerships between technical experts and donors, as well as the stakeholders who will use and continue to generate new data. The different interacting partnerships are illustrated in Figure 2 and involve flows of knowledge, skills, models and data between the various enabling and stakeholder organisations. The new insight gained from developing models for the region will add to the scientific literature, but arguably more important, and with a lasting impact, is the active engagement between the various users of the data – ministries, the private sector, national research centres, NGO's and international organisations.

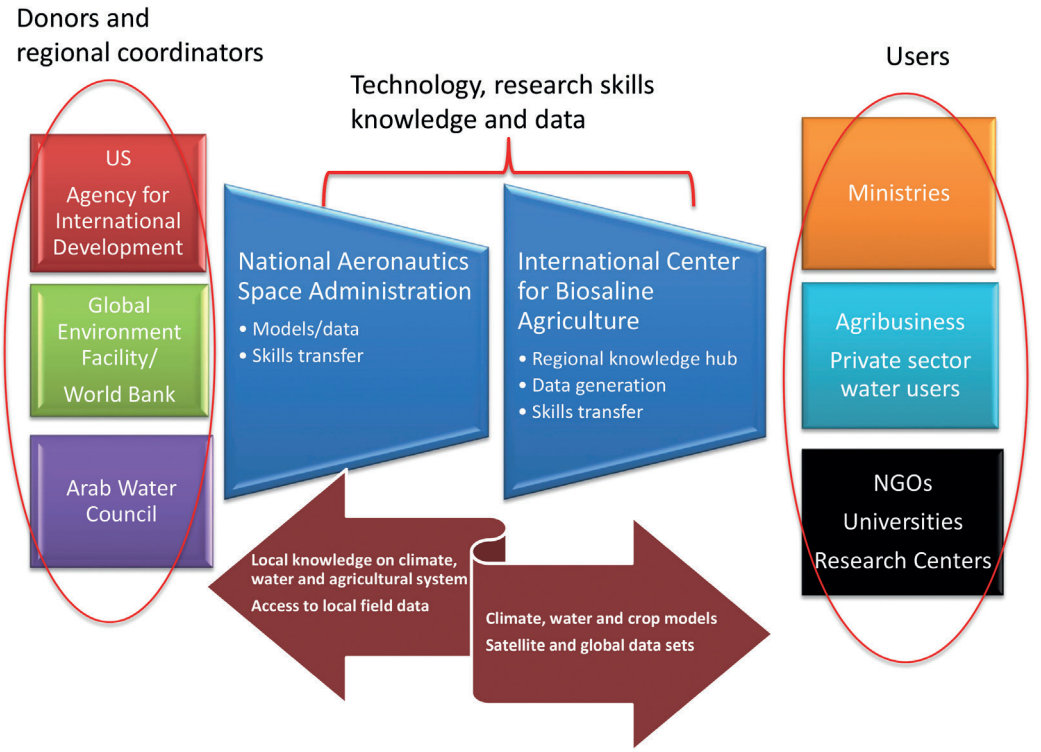

Figure 2. Interacting partnerships between enabling and stakeholder organisations involved in the Modeling and Monitoring Agriculture and Water Resources Development programme.

Maintaining and building local partnerships during the turbulent times of the Arab Spring has been complicated, with arguably more variables and unknowns than scientific work. The need to continue protecting and using wisely the scarce water and agricultural land resources, however, remains the same whoever is in government. The changing political landscape has brought new actors with different agendas and priorities, and it has been important to maintain dialogues across the partnerships on any changing priorities and needs. These dialogues have been helped by the many local scientists and public servants involved who have remained in their positions and so have allowed established partnerships to continue.

A range of efforts have maintained the partnerships in the MAWRED project. These include regular conference calls, visits, joint training of staff and contact through personal connections, for both local user groups and international organisations. ICBA has acted as both a regional research/training centre and a hub through which knowledge, data and partners pass. For example, it established a high-performance computing cluster for undertaking the heavy computer processing involved in downscaling climate change data; this was important on a number of levels. Training by international researchers of the MAWRED team on the methods and models used for downscaling was vital. To further develop capabilities in-country, local climate specialists passed this knowledge on through many different training activities, in Arabic, French and English. The data generated by the downscaling operations at ICBA was also shared directly with local agencies, through physical hardware such as external hard drives where fast reliable internet was not always available. This ensured that the climate change data could be used in projects and areas of analysis beyond those of the MAWRED project, bringing insight across an increasing variety of sectors.

There have been various political consequences resulting from the unrest in the MENA region, with changing strategic goals and areas of policy focus providing a challenge for the MAWRED programme. However, a welcome change has been an increased emphasis on the technical training of young people. Whilst international organisations such as ICBA continue in the role of regional knowledge developers and brokers, the practice of bringing modelling

and data analysis skills to various agencies within countries in the region has become even more important. Enhancing the skills sets of young engineers, an increasing political priority in many countries in the region, is crucial for ensuring sustainability in efforts to generate data, once the MAWRED programme has ended. Training both within the region and outside, with United States universities and agencies, is bringing these new scientific methods to local organisations. The challenge will be ensuring that the dissemination of these skills is supported through developments in IT infrastructure providing adequate processing power and reliable and speedy internet connections.

4. Lessons to take forward

The 2013 World Water Week in Stockholm centred on cooperation through building partnerships; the work of the MAWRED programme illustrates both the enormous benefits and the challenges in these ideas. Scientific developments generated by world leading agencies such as NASA can bring new insights on dynamics in key water variables such as ground water, evapotranspiration and soil moisture. They also allow us to better understand crop production systems and their water use. Transferring these developments to new regions is challenging and involves strong partnerships between international and local scientists as well as decision-makers. Models need to be calibrated and verified for a region, and working through scientific centres and national agencies is required for the exchange of local knowledge and data. This helps ensure that modelling is representative and as accurate as possible; it is only when decision-makers trust scientific information that it is used and believed.

Maintaining effective working partnerships across time zones, cultures, languages and levels of understanding requires continuous engagement and communication. Given the political turbulence in the MENA region, this can be challenging as well as rewarding for all parties. Compromise solutions may be required to reflect the developing needs of the various parties involved, where political changes bring changing emphasis in strategy and water policy priorities. For some countries, insights on climate change are vital in planning water management strategies today, especially where recent droughts or floods have adversely affected the population. In others, the priority is understanding the implications of crop yields and food security for water resources, as the demands of feeding an increasing population are felt. The knowledge needed, and the tool box of models and techniques used, thus will vary between the countries involved. However, through knowledge brokering, active engagement, training and skills transfers, the benefits of advances in water science can reach ever more people.

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References

Evans, J.P. (2009) 21st Century climate change in the Middle East. Climatic Change 92: 417-432. (http://link.springer.com/article/10.1007%2Fs10584-008-9438-5).

Evans, J.P. (2010) Global warming impact on the dominant rainfall processes in the Middle East. Theoretical and Applied Climatology 99(3-4): 389-402. (http://link.springer.com/article/10.1007%2Fs00704-009-0151-8).

Hoogenboom, G., Jones, J.W., Wilkens, P.W., Porter, C.H., Boote, K.J., Hunt, L.A., Singh, U., Lizaso, J.L., White, J.W., Uryasev, O., Royce, F.S., Ogoshi, R., Gijsman, A.J., Tsuji, G.Y. and Koo, J. (2010) Decision Support System for Agrotechnology Transfer (DSSAT) Version 4.5 [CD-ROM]. Honolulu, Hawaii: University of Hawaii.

IPCC (2007) Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Eds. Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M. and Miller, H.L.). Cambridge, UK and New York, USA: Cambridge University Press.

IPCC (2013) Climate change 2013: The physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Eds. Stocker, T.F., Qin, D., Plattner, G. K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V. and Midgley, P.M.). Cambridge, UK and New York, USA: Cambridge University Press.

Jones, J.W., Hoogenboom, G., Porter, C.H., Boote, K.J., Batchelor, W.D., Hunt, L.A., Wilkens, P.W., Singh, U., Gijsman, A.J. and Ritchie, J.T. (2003) DSSAT Cropping System Model. European Journal of Agronomy 18:235-265.

Kumar , S.V., Peters-Lidard, C.D., Tian, Y., Houser, P.R., Geiger, J., Olden, S., Lighty, L., Eastman, J.L., Doty, B., Dirmeyer, P., Adams, J., Mitchell, K., Wood, E.F. and Sheffield, J. (2006). Land Information System – An interoperable framework for high resolution land surface modeling. Environmental Modelling & Software 21:1402-1415.

Peters-Lidard , C.D., Houser, P.R., Tian, Y., Kumar, S.V., Geiger, J., Olden, S., Lighty, L., Doty, B., Dirmeyer, P., Adams, J., Mitchell, K., Wood, E.F. and Sheffield, J. (2007) High-performance Earth system modeling with NASA/GSFC's Land Information System. Innovations in Systems and Software Engineering 3(3): 157-165 (http://link.springer.com/article/10.1007/s11334-007-0028-x).

Tolba, M.K. and Saab, N.W. (2009) Arab environment climate change: Impacts of climate change on Arab countries. Beirut, Lebanon: Arab Forum for Environment and Development (http://www.afedonline.org/en/inner.aspx?contentID=433).

Verner, D. (2012) Adaptation to a changing climate in the Arab countries. Washington DC, USA: World Bank (http://elibrary.worldbank.org/doi/book/10.1596/978-0-8213-9459-5).