

Harsh Summer, Wet Winter?

A Long Term View of Iraq's Water Resources

15 May 2019







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The initial research for this report was a cooperative endeavour between Robert Tollast, Nick Waters and Lutz Krebs, during a Bellingcat workshop in 2018.

The use of satellite imagery to observe changes in river discharge is a complex undertaking, particularly for changes quantifiable enough for detailed analysis. This research is not intended to perform such a task. Instead, the intention is to show what is possible to observe with open source imagery which can detect relatively small changes in dam reservoirs, and also to assess what might be perceived as unusually low river levels, comparing observations with historic imagery from periods of drought across the river basin.

In the long term, these changes have to be seen in context. Recently, there has been optimism in Iraq following a particularly wet rainy season (although farmland is now flooded) while last summer there was panic across central and northern Iraq as Tigris water levels were particularly low. In Basra high temperatures and saltwater encroachment in the Shatt al Arab contributed to a major public health crisis. Taking a longer view, this does not change the bigger picture: Iraq's water supply fluctuates significantly, as the images of the Tigris river here show. But the overall trend points towards crisis, regardless of the current wet conditions.

During the workshop, we monitored activity at the Ilisu dam in Turkey, the Mosul dam and several sites over the summer of 2018, using low resolution Planet Labs and high resolution Terraserver imagery. The context of this was the water crisis in Iraq of June 2018, when Turkey commenced filling the Ilisu dam only to halt filling after a diplomatic request by Iraq. We were able to verify statements made at this time by both the Iraqi and Turkish governments as factually correct.

Iraq was particularly concerned because, since the start of major dam construction on the Euphrates in the 1970s, the river flow has fallen by up to 45%, while a great deal of water losses have come from rapid population growth and climate change, inefficient irrigation, higher evaporation rates and lower precipitation.¹

¹ M. Nouar Shamout, Glada Lahn. The Euphrates in Crisis Channels of Cooperation for a Threatened River. Chatham House. Chatham House. April 2015.

https://www.chathamhouse.org/sites/default/files/field/field_document/20150413Euphrates_0.pdf

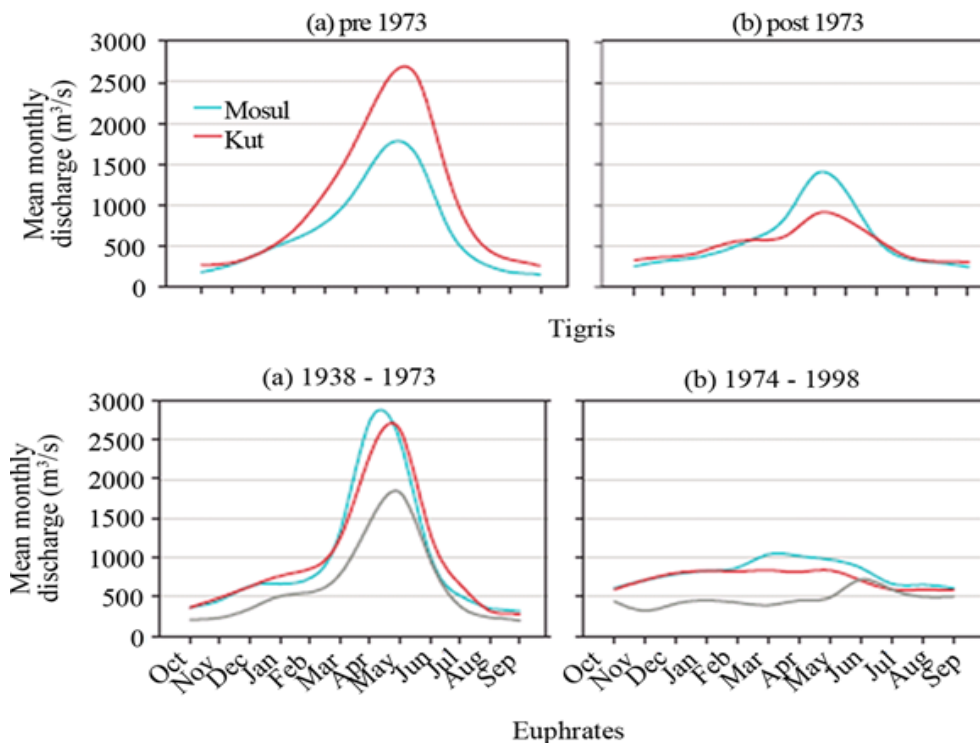


Figure 1: Historic Monthly Discharge from Mosul and Kut Dams (Source: Iraq Energy Institute Task Force for the Future of Iraq's Water Resources)

With this in mind, there was great concern in Iraq on June 1st, when Turkey began filling the Ilisu dam (10.4 billion cubic metre capacity).² For context, the Tigris river discharged 42.9 billion cubic metres into Iraq during a period of drought in 2009,³ with an average flow rate up to 52 bcm.⁴ Mosul dam capacity is 11 billion cubic meters, although is generally kept at 9 billion or lower due to dangerous problems with the dam's structure.⁵ This became terribly clear in March, when the dam's gates were opened due to heavy rain, unleashing a deadly current which was a contributing factor to the Mosul ferry disaster.⁶

Iraq also faces many other dams across its borders, including the Ataturk dam on the Euphrates, which has a maximum capacity of 27 billion cubic meters.⁷ Combined with Iranian dams such as the Sardasht dam, completed in 2017, Iraq has felt that its water resources are being held back. Critics among Iraq's neighbours contend that Iraq has enough water, but manages its resources poorly, while defenders of Iraq say its progress developing water infrastructure has been hindered by sanctions and wars that are not the fault of Iraqi farmers or post 2003 governments.

² Republic of Turkey Ministry of Foreign Affairs. Information on Ilisu dam. <http://www.mfa.gov.tr/ilisu-dam.en.mfa>

³ United Nations Inter Agency and Analysis Unit. Water in Iraq Factsheet.

https://reliefweb.int/sites/reliefweb.int/files/resources/A1F9733337B9CE83C12577C90032CCED-Full_Report.pdf

⁴ Stratfor Assessments. Mesopotamian vitality falls to Turkey. 05.01.15

⁵ AFP. Iraq seeks to reassure over reservoirs and dam pressures. 09.04.19 <https://www.dailymail.co.uk/wires/afp/article-6903993/Iraq-seeks-reassure-reservoirs-dam-pressures.html>

⁶ AP. Iraq ferry sinking: More than 90 people drown in Mosul. 21.03.19 <https://www.theguardian.com/world/2019/mar/21/iraq-ferry-sinking-people-killed-mosul-tigris-river>

⁷ Julia Harte. New dam in Turkey threatens to flood ancient archaeological sites. The National Geographic. 21.02.14 <https://news.nationalgeographic.com/news/2014/02/140221-tigris-river-dam-hasankef-turkey-iraq-water/>

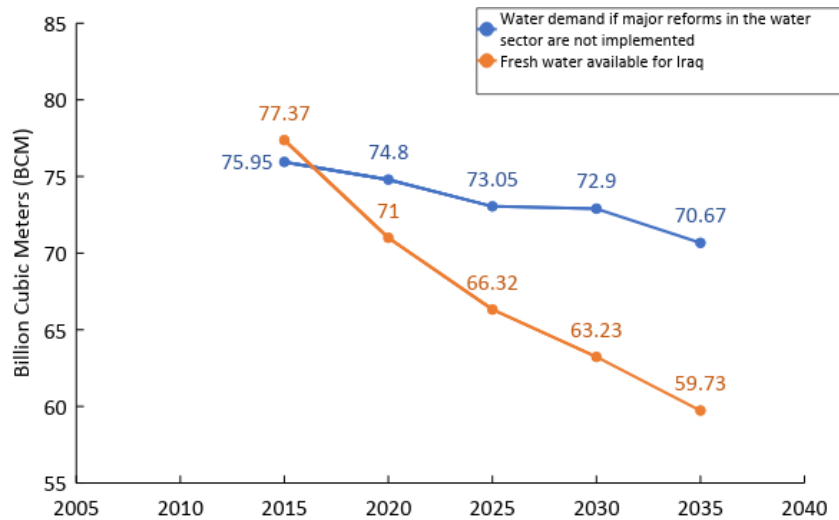


Figure 2: Historic and projected water supply and demand in the Tigris-Euphrates river basin. (Source: Iraq Energy Institute Task force for the Future of Iraq’s Water Resources)

Aside from observing water levels in the river Tigris at the newly completed Ilisu dam over the summer of 2018, we were also interested in a much longer timeline to see the wider picture of the water crisis in Iraq, and have included images here that give important context to the task of looking at short term changes due to dam filling, with other important factors to consider including water management and internal water sharing within Iraq.

We concluded that as satellite imagery becomes increasingly available to the general public, this has the potential to dispel rumours and verify statements about dam construction and filling, with possible applications for monitoring other trans-boundary water basin disputes. As noted, there is important limitation here: Depending on the shape of the river channel, some rivers will not always reflect a change in discharge in the change of their width. However, Ling (2012) observes,

“Most rivers possess various features sensitive to relatively small discharge changes, such as sidebars and islands. In general, a river island area often shows significant changes as the river rises, even if the river width does not change due to the presence of vertical embankment.”⁸

With this in mind, we were interested in changes in the appearance of river islands and or sand bars over short time durations which could verify, or debunk, both government claims about the filling of dams and releases of water, and claims on social media showing scenes of the Tigris almost empty of water. See the work of Wim Zwijnenberg for other work using satellite imagery related to the environment in Iraq.

⁸ Feng Ling, Xiaobin Cai, Wenbo Li and Fei Xiao. Monitoring river discharge with remotely sensed imagery using river island area as an indicator. Journal of Applied Remote Sensing. September 2012. https://www.researchgate.net/publication/236232669_Monitoring_river_discharge_with_remotely_sensed_imagery_using_river_island_area_as_an_indicator

STORY



1. On June 2nd, pictures emerged on Iraqi social media showing dramatically low river levels in central Mosul and Baghdad. These two images of Mosul were posted by Iraqi journalist Mustafa Habib on his twitter account. Note in these pictures, wire framed ruined structures, circled in red. Aquatic vegetation is visible on the river bed; in satellite pictures this appears as a large area of dark green.



We were able to geolocate this area, narrowing it down to two viewpoints, one from the middle of the river, the second from the "5th bridge" in Mosul, which crosses over from the so called "Left bank" (East Mosul) near the funfair on the eastern side, which looks directly onto the devastated western part of the Old City. Amid the devastation, wire framed ruined structures are visible (circled red), possibly some of the 115 greenhouses in

Mosul that have had covering blown off by explosives.



2. The image on the left from TerraServer shows the structures outlined in red. In most satellite imagery, the frames are barely visible. Image: TerraServer/[Licensor]



Mosul June 2018

3. The image on the left from Planet Labs is a wider shot of the same area at the time. Almost all of the river bed, with the exception of a narrow channel on the west side, is completely or partially exposed.



Mosul June 2017

4. While concerning, was this water level unusually low for the time of year? We observe the same spot by the 5th bridge the previous summer, as the battle was drawing to a close, to see if June 2018 was particularly worse than June 2017, ruling out whether,

amid the conflict, little attention had been paid to river levels. The river level is clearly higher, although the river bed is just becoming visible in dark green. The river bed here comprises deposited material on the eastern bank of the river, where the flow is slower.



between the river and the park on the east bank.

Mosul June 2016

5. On the left is the same area in June 2016. Again, the river levels here are high, but perhaps not as high as June 2017 (notice the lighter colouration, possibly lighter coloured deposited material). The water is approaching the hard surface road that runs



Mosul February 2018

6. February 2018: the river will soon approach its peak discharge of the summer, which is influenced by snowmelt in the mountains of southern Turkey.



Mosul May 2018

7. In May however, there is a significant drop in water levels. This image, with most of the river bed visible, closely matches images of the river at the start of June 2018. It is unclear how much of this is due to the filling of Ilisu, once we examine what is

happening at the Mosul dam (see above.) At the Mosul dam, we see the Iraqi government has been filling the reservoir, most likely in preparation for the filling of Ilisu, building as much summer storage as possible (limited by the structural problems with the dam.)



Mosul June 2018

8. In June, the water level initially looks higher, because the river bed appears greener. On closer inspection, the shape of the exposed river bed appears almost indistinguishable from May. The greener appearance is likely explained by invasive,

fast growing algae or other hydrophytes, which grow on the fertile sediment.⁹ Some species of these plants can reach exponential growth, capable of rapidly covering this area.



9. By July, it has become apparent that Turkey has agreed to Iraqi government calls to halt filling of the dam. The water level appears to have returned to a level similar to the spring, albeit somewhat lower with more of the river bed visible than in February.



10. Images over summer 2018 confirm statements by the Turkish government that the filling of the dam had begun, and was halted in early June following an Iraqi government request.¹⁰ In this image from May 2018, the Tigris at Ilisu, Turkey, reveals a sand bar in the middle of the channel.

⁹ Mazin Fadhel. Water sharing of river Tigris between Iraq and Turkey, historical economic study. University of Mosul.

Researchgate. Jan 2009.

https://www.researchgate.net/publication/317492545_Water_sharing_of_river_Tigris_between_Iraq_and_Turkey_historical_economic_study

¹⁰Tulay Karadeniz, Ahmed Aboulenein. Turkey Halts Filling Tigris Dam After Iraq Complains of Water Shortages. Reuters.

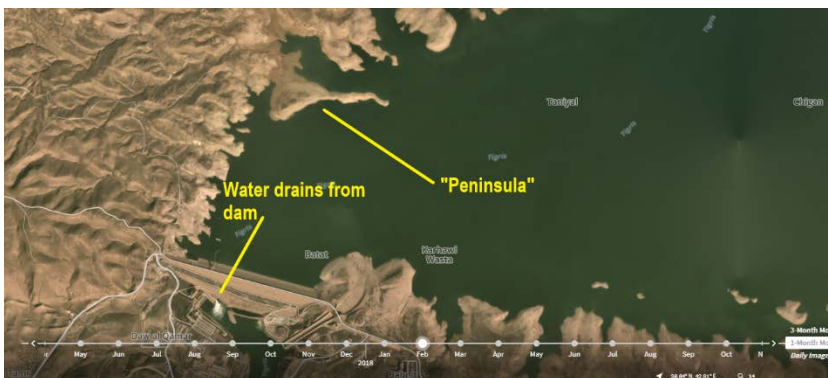
07.06.18. <https://www.reuters.com/article/us-iraq-turkey/turkey-halts-filling-tigris-dam-after-iraq-complains-of-water-shortages-idUSKCN1J320X>



11. By June, the sand bar has been submerged as the dam begins filling.



12. By July however, it is evident that more of the sand bar than was previously visible has re-emerged as water levels fall.



13. However, this story is multi-dimensional. When we look at activity at the Mosul dam, we see two things. Firstly, the reservoir level falls over the spring of 2018, before rising again as summer approaches, possibly in anticipation of Ilisu filling. Here is the Mosul

dam in February 2018. Water is draining from the dam (white water is visible at the dam gates) revealing a “peninsula”, lowering levels from the winter rains.



14. On the left is a picture taken in June 2018, it is clear that the Mosul dam has filled, turning the peninsula into an island. This draws attention to the importance of communication to the Iraqi public by the Iraqi Ministry of Water Resources, something they are now more pro-

actively engaged in regarding water levels and water releases. Going forward, there will be difficult discussions ahead, but it is evident that satellite monitoring is a useful tool-- perhaps in the event of a diplomatic crisis. We can see that "low water levels," while concerning, are not always what they seem.



Mosul June 2010

15. While images of the brief but dramatic fall in Tigris levels at Mosul illustrate some of the stakes in water sharing, recent historical imagery is equally concerning. On the left we see the same stretch of river in June 2010, following the drought which ravaged much of the region between 2007-09,¹¹ from TerraServer imagery. Water levels are dramatically low,

while Iraq's options for reserve storage at the Mosul dam are limited due to the soluble gypsum foundations of the structure, which has often forced the dam operators to keep water levels lower than total reservoir capacity. Note the artificial lake in the top right of the picture. This was originally a branch of the Khosr river joining the Tigris. Looking closely, the Khosr appears to be channelled into the Tigris through a tunnel opening in the lake. In a map from 1944 (below) we see how different this area used to look. *Image: TerraServer/[Licensor]*

¹¹ David Kaniewski, Elise Van Campo, Harvey Weiss. Drought is a recurring challenge in the Middle East. Proceedings of the National Academy of Sciences of the United States of America.06.03.12. <https://www.pnas.org/content/109/10/3862>



16. None of these images compare to June 2002, where we see very high water levels in the river. Water appears to be thundering down the channel and levels are approaching the road and flooding a small jetty next to the park. The danger this would present to boats and ferries is very evident.



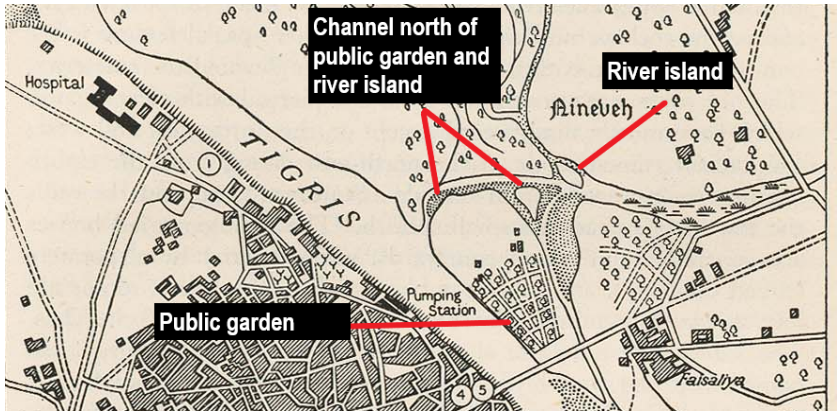
Mosul August 1968

17. The image on the left is from the declassified U.S. CORONA spy satellite program. It illustrates the impact of urbanisation and dam construction within Iraq, prior to the construction of the GAP dams in Turkey. Iraq's population has exploded

from over 9 million in 1968 to nearly 40 million today.¹² The sand bar here has a secondary river channel and appears more "solid" in form, although probably prone to inundation. Following the completion of the Mosul dam in the late 80s, at least 1 cubic kilometre of sediment had built up within its reservoir by 2016.¹³ This could explain the larger sand bar which is visible in this photo. With the completed dam trapping sediment by 1989, more sediment is taken away south of the dam by "scouring" (river erosion by hydraulic action) than deposited on the sand bar, gradually reducing its size. Note that the tributary to the Tigris, the Khosr river, is joining the Tigris just south of the park and also north of the park where it joins the secondary channel cutting through the sand bar. This situation has changed by the 2000s.

¹² For historic population data on Iraq, see World Population Review: <http://worldpopulationreview.com/countries/iraq-population/>

¹³ Mohammed E. Mohammed, Nadhir al Ansari, Issa E. Issa, Sven Knutsson. Sediment in Mosul Dam reservoir using the HEC - RAS model. Lakes and Reservoirs.14.10.16 <https://onlinelibrary.wiley.com/doi/full/10.1111/lre.12142>



18. A British army map from 1944 shows that the area around the public garden where the Khosr joins the Tigris. This area saw a lot more hydrological activity, with river islands north east of the “park” area, which no longer exist. This is illustrative of the dramatic fall in river discharge levels in the river basin during the 20th century.

basin during the 20th century.



Mosul February 2019

19. As reported in recent months, the river at Mosul currently has high water levels from heavy rain over the winter.

Conclusion

Satellite imagery, even at low resolution, can be useful to verify government statements on trans-boundary water basin management. This could be particularly useful in a short time-frame, such as the filling period for a dam, but caution must be exercised as we saw here, the impact of short-term dam filling appeared similar to the severe drought of 2007-2010, while dam reservoir management through the length of the river channel can present a misleading picture when looking at small sections of a river course.

However, satellite monitoring can still assist governments, civil society organizations, expert observers and NGOs to increase transparency in instances of contested water resources, particularly if water metering becomes contested. In Iraq, it can be applied to multiple waterways outside the country's borders, where dams are being constructed, while Syria manages the 14 billion cubic meter Taqba dam.¹⁴ It is also highly applicable to equitable water resource management within Iraq.

The approach can also help with expectation management and crisis management, helping to verify, by geolocation, photographs of water levels, assisting governments to clarify water policy and prevent panic among the general public. Looking ahead, advanced use of satellite imagery to measure river discharge will not be possible until 2021 when the SWOT (Surface Water and Ocean Topography) satellites are expected to launch.¹⁵

¹⁴ Abdel Jawad Sakran. The Euphrates Dam Is at Risk in the SDF Operation to Capture It from ISIS. Atlantic Council. 27.01.17. <https://www.atlanticcouncil.org/blogs/syriasource/the-euphrates-dam-is-at-risk-in-the-sdf-operation-to-capture-it-from-isis>

¹⁵ Colin J. Gleason, Pierre Andre Garambois and Michael T. Durand. Tracking river flows from space. Earth and Space Science News. 26.07.17. <https://eos.org/project-updates/tracking-river-flows-from-space>




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