

## Temporal Analysis of Shabelle River Water-levels as Seen from Very High-resolution Satellite Images

The Shabelle River which is one of the two perennial rivers in Somalia has had some sections of the channel getting dry for the third time in three years. The first being February and March 2016, then February and March 2017 and finally some sections dried early December 2017 to Mid-March 2018. The Gu rains are expected to kick off in late March and early April within the basin and this will see a rise in river levels. While there are many reasons behind the drying river bed, the main driver to this could be attributed to consecutive failed rainy seasons both in the Ethiopian Highlands and inside Somalia.

Rainfall analysis indicates depressed rains during the Deyr seasons of 2015, 2016 and 2017. The poor rains, and increased agricultural water use led to significant reduction of river flow. Massive sedimentation on the river bed has also resulted in decreased water quantity and quality along Shabelle River. Some reports attribute the flow reduction to riverine activities in Ethiopia where the river originates.

SWALIM has analysed the temporal river level status using observed river level data and very high-resolution satellite images taken on different dates in selected towns

along the Shabelle River. The analysis of multi-temporal images performed by visual estimation of the water levels covers the period from January 2017 to January 2018.

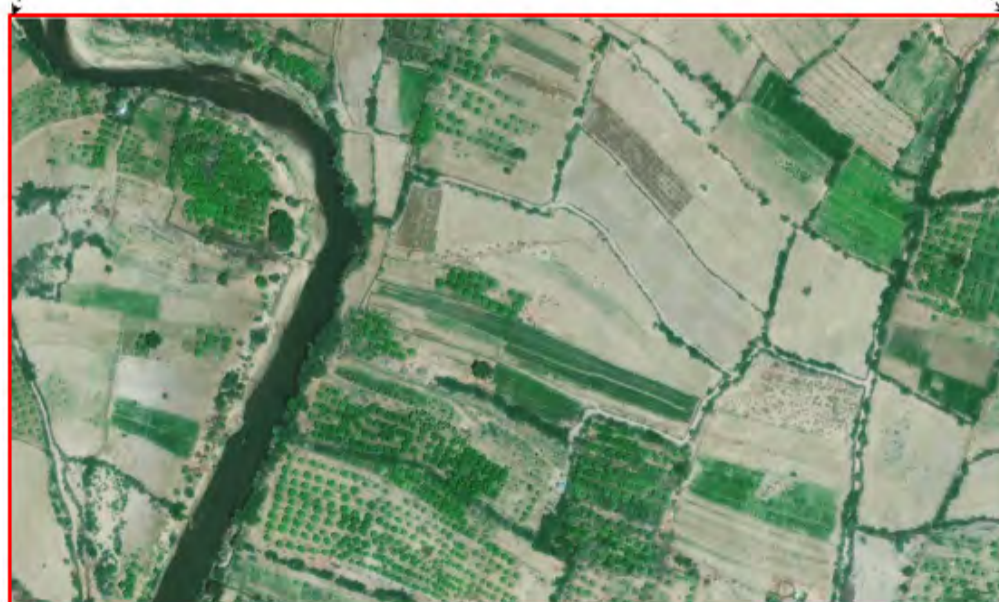
The most suitable cloud free images used are panchromatic black and white acquired by the World View 1 satellite. The readability of panchromatic images is more difficult, but generally water is displayed in a dark grey colour, while bare soil is represented by a light grey colour.

In addition SWALIM analyzed the vegetation conditions using the Enhanced Vegetation Index (EVI) for December 2001 and December 2017. The selection of these two periods was informed by observation of similar rainfall/vegetation trends in the previous months. This analysis shows a great increase of active irrigated crops upstream (Belet Weyne) in 2017, a slight increase in Bulo Burti and clear decrease in Jowhar (downstream), which could be explained with a progressive increase of water abstraction upstream, affecting the Shabelle river level downstream.

### Shabelle River at Belet Weyne, Hiraaan Region

Belet Weyne is a city in central Somalia. It is the capital of the Hiraaan Region, located in the central valley of the Shabelle River near the Ogaden inhabited by Somali Ethiopians, some 332 km north of Mogadishu. The Shabelle River divides the town into east and west. By area, Belet Weyne is one of the six largest and most populous cities in Somalia.

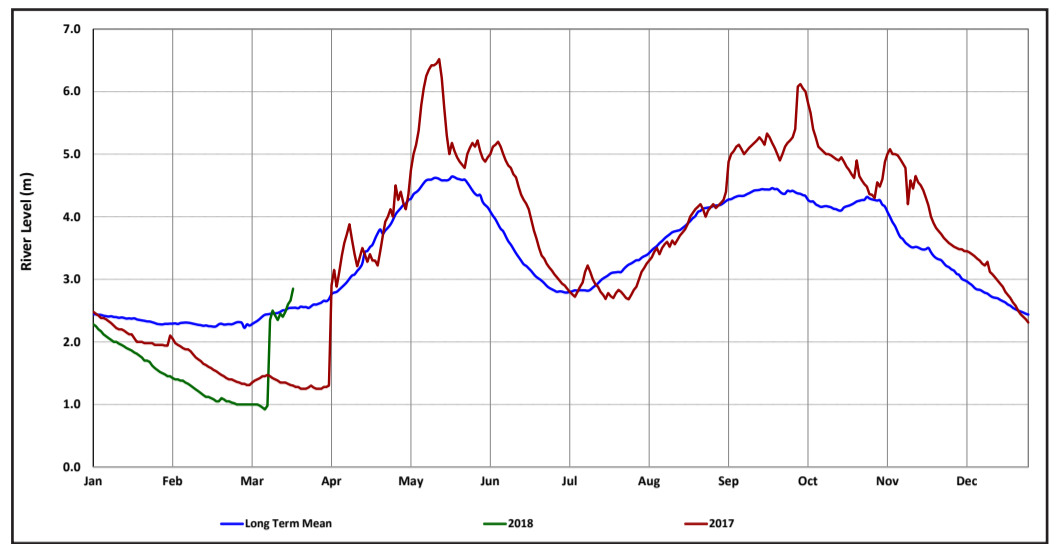
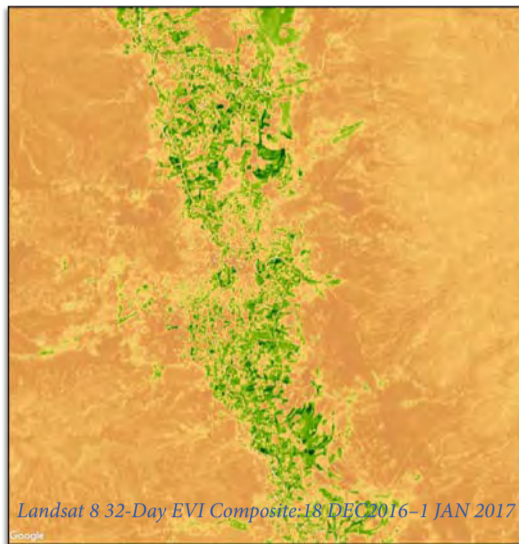
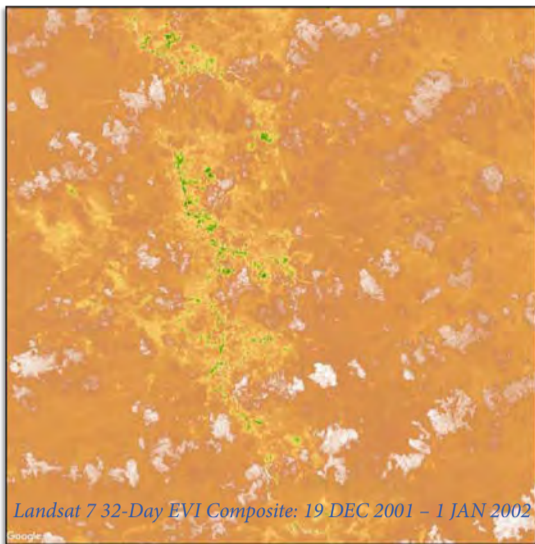
The town has been affected by the major historical river flood events which occurred in 1961, 1977, 1981, 1997, 2005, 2006, 2013 and most recently in 2015. It will continue to be vulnerable to any future floods due to its location in the river plain.



The figures above show the comparison of a GeoEye image of February 2018 (right) and a World View 2 image of February 2012 (left), depicting an area located about 2.5 km South of Belet Weyne. It is interesting to notice that the active cropped area (green) is much more extended in 2018 as compared to 2012, mainly due to a change of the agricultural practise. In 2012 the area is mainly covered by seasonal herbaceous crops (not active in February), while in 2018 the area appears to be covered by permanent tree crops (active in February), which need to be irrigated throughout the year. The red outlined inset shows a portion of the tree crops present in the area.



### Shabelle River at Belet Weyne, Hiraan Region



The overview of the agricultural area in Belet Weyne shows that in Dec 2016 the active irrigated crops (green) covers a bigger area as compared to 2001. With population growth and resettlements in riverine areas it is expected there will be more agricultural activities along the river with time. With no sufficient rains to irrigate the crops, more water is drawn from the river leading to reduced flow. The graph on the right shows the Shabelle river levels at Belet Weyne in 2018 compared to the 2017 levels and the long term mean.



The image shows that river level is very low, as evidenced by the presence of sand deposits/river bed (yellow outlined) occurring along the river.



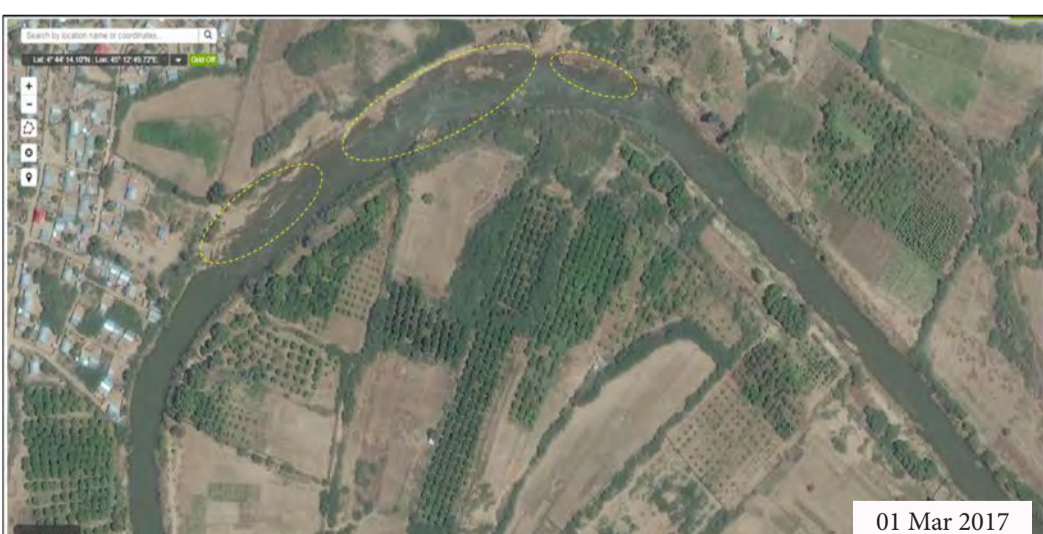
The image shows a low river level as evidenced by the presence of sand deposits/river bed (yellow outlined) occurring along the river. However, on this date the river level is higher as compared to the previous image (12 Jan 18). In fact, in some portions sand deposits either are submerged or with reduced extent.



The image shows that river level is normal. The high sediment load indicated by the light brown colour of the water demonstrates the high-energy of the river flow following the Deyr rains in October and November 2017.



In this image, the sediment load indicated by the brown colour of the water demonstrates the high-energy of the river flow. Sand deposits visible in the previous images are not visible as they are completely submerged. April also marks the beginning of Gu rains that lead to increased river flows.



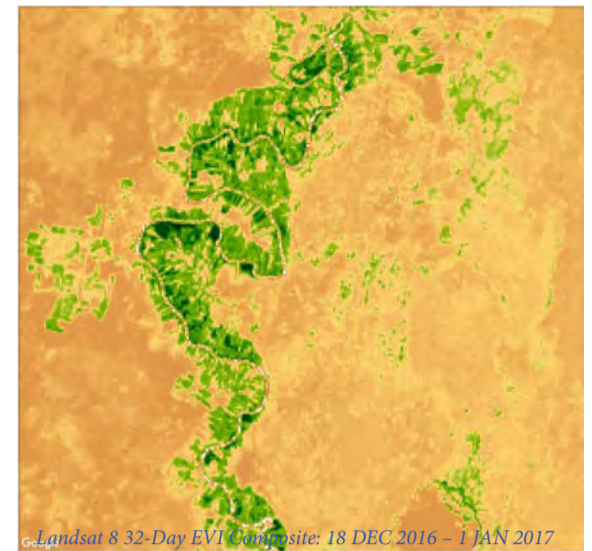
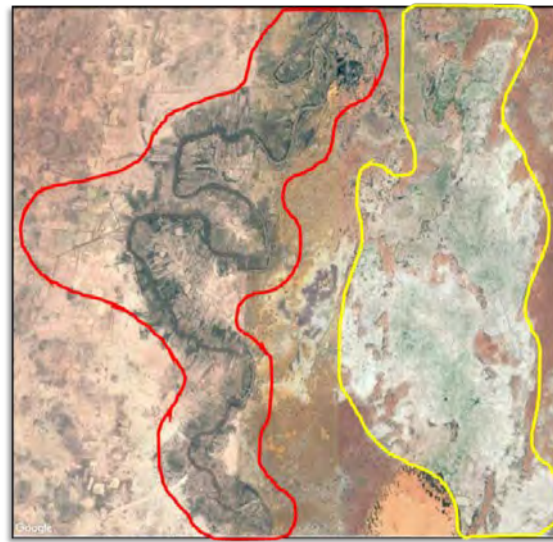
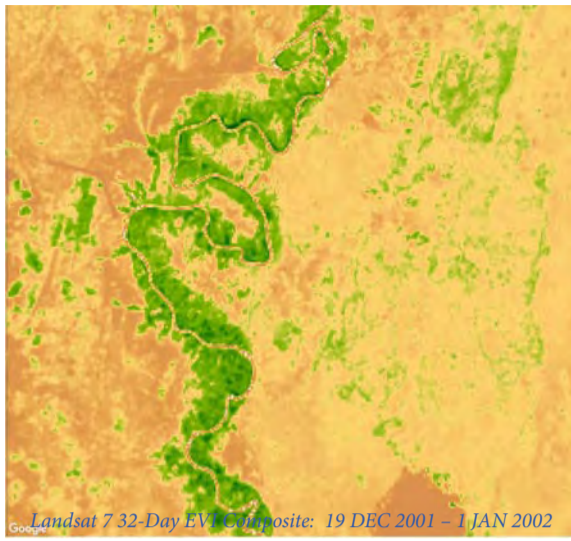
The image shows that river level is low, as evidenced by the presence of sand deposits/river bed (yellow outlined) occurring along the river. The dark green colour of the river indicates sediment load hence the low-energy of the river flow.



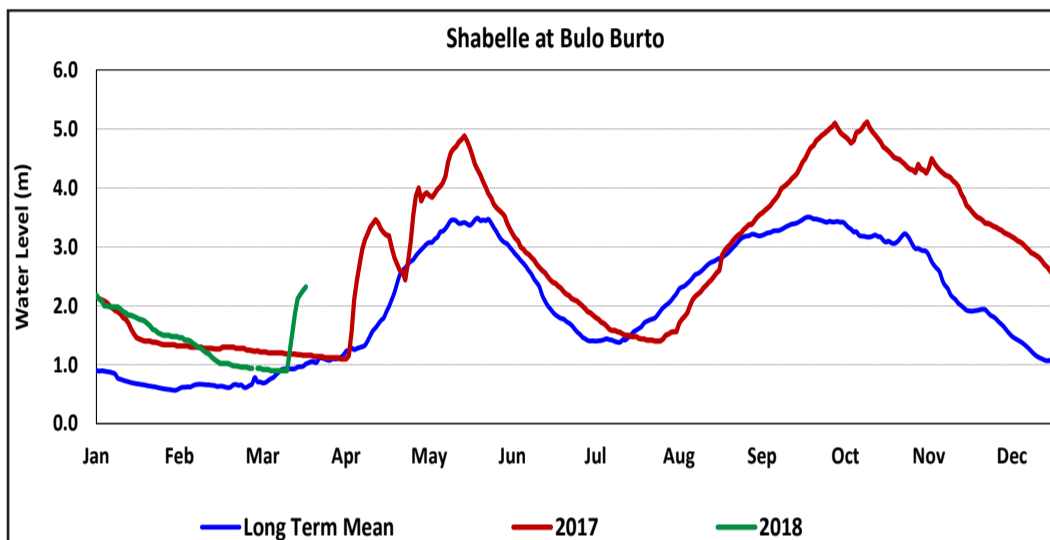
The image shows that river level is low, as evidenced by the presence of sand deposits/river bed (yellow outlined) occurring along the river. However, the river level on this date seems to be slightly higher as compared to the previous image.



### Shabelle River at Bulu Burti, Hiraan Region



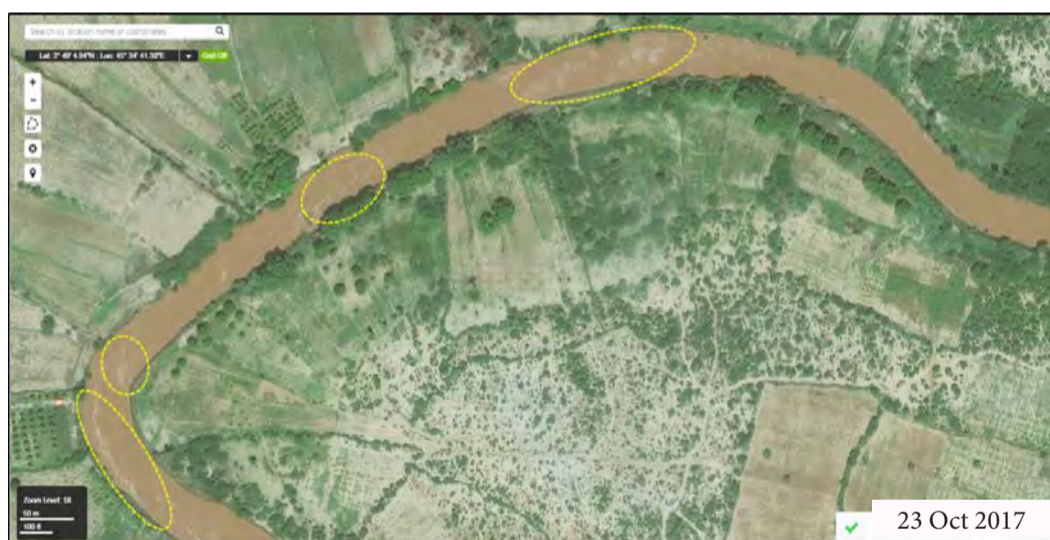
The overview of the agricultural area in Bulu Burti shows that in Dec 2016 the active irrigated crops (green) cover a bigger area as compared to 2002. We can assume that more water from the Shabelle River was diverted to the agricultural areas in Dec16 - Jan2017, affecting the river level. In the middle image outlined in red is the agricultural area under irrigation and outlined in yellow is the rain fed agricultural area. A decrease of active rain fed agriculture as of Dec 2016 when compared to Dec 2001, indicates a shift to irrigated agriculture when rainfall does not allow to grow crops.



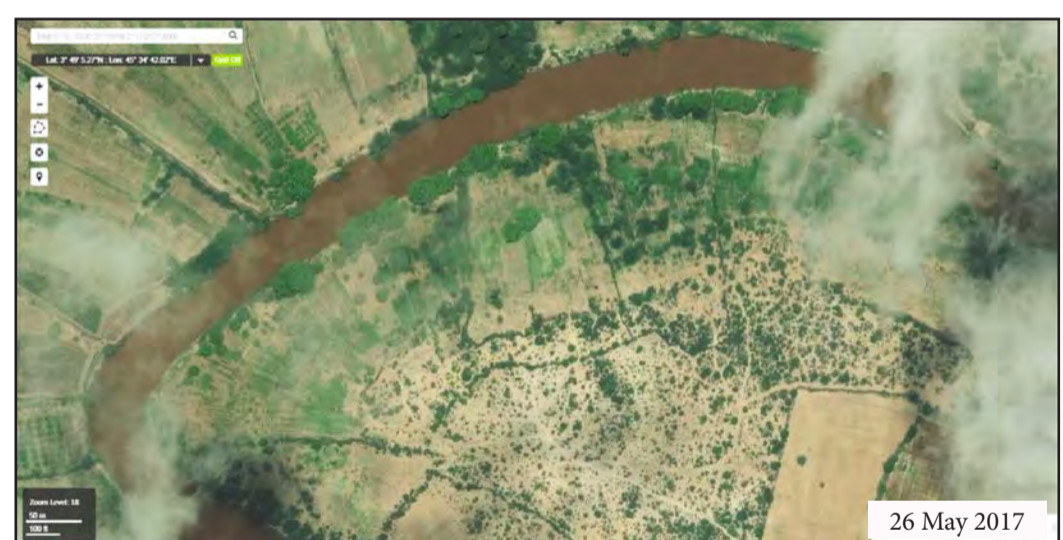
The graph shows the current river level compared to the 2017 level and the long term mean.



The image shows that river level is very low, as evidenced by the outcropping of sand bars along the embankment (yellow outlined).



The image shows that river level is high. In fact sand bars along the embankment are submerged. The sediment load is high meaning that the energy of the water increased, as indicated by the ripples on the water surface (yellow outlined).



The image, though a bit hindered by clouds, shows that river level is high. Sand bars along the embankment are completely submerged. The energy of the water stream is normal as no ripples on the water surface are noted.



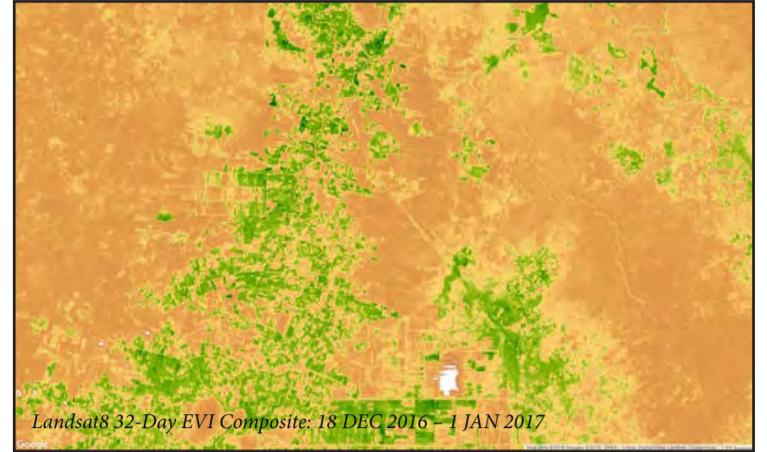
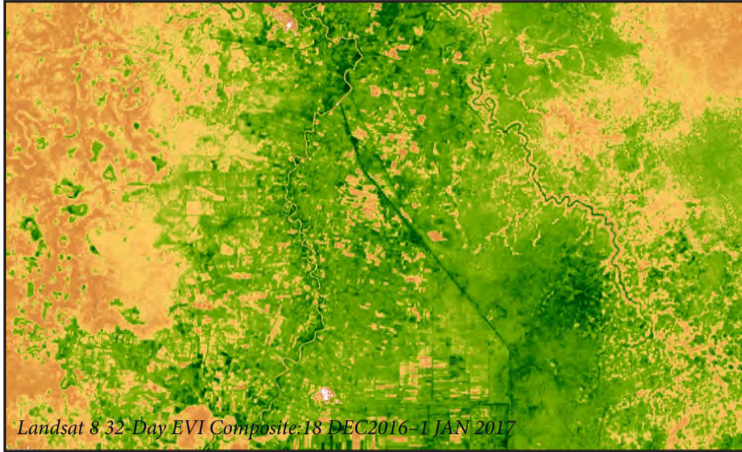
The image shows that river level is lower as compared to May 2017. Portions of sand bars along the embankment (yellow outlined) are visible. The energy of the water stream is high as indicated by the ripples on the water surface.



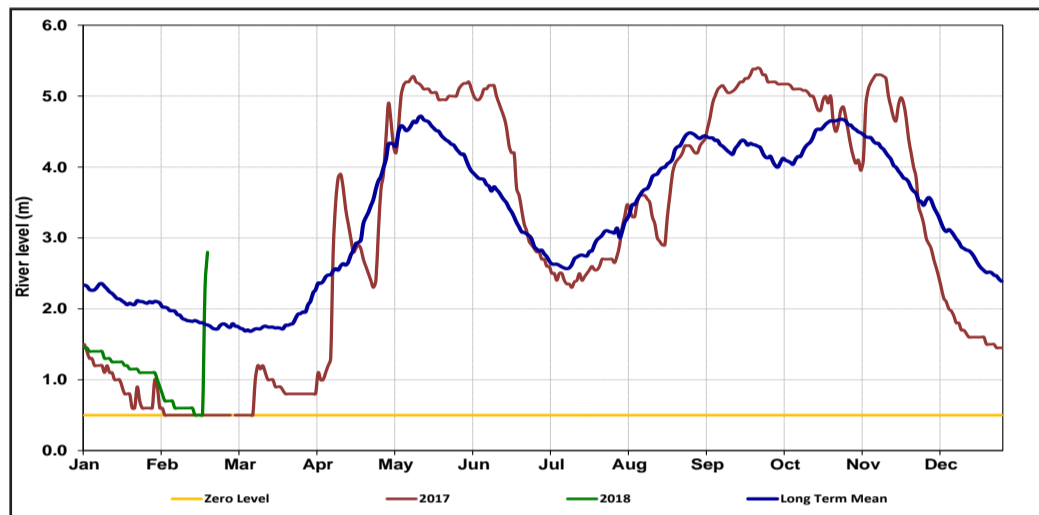
The image shows that river level is very low, as evidenced by the outcropping of sand bars along the embankment (yellow outlined). The width of the river has decreases as compared to the previous images.



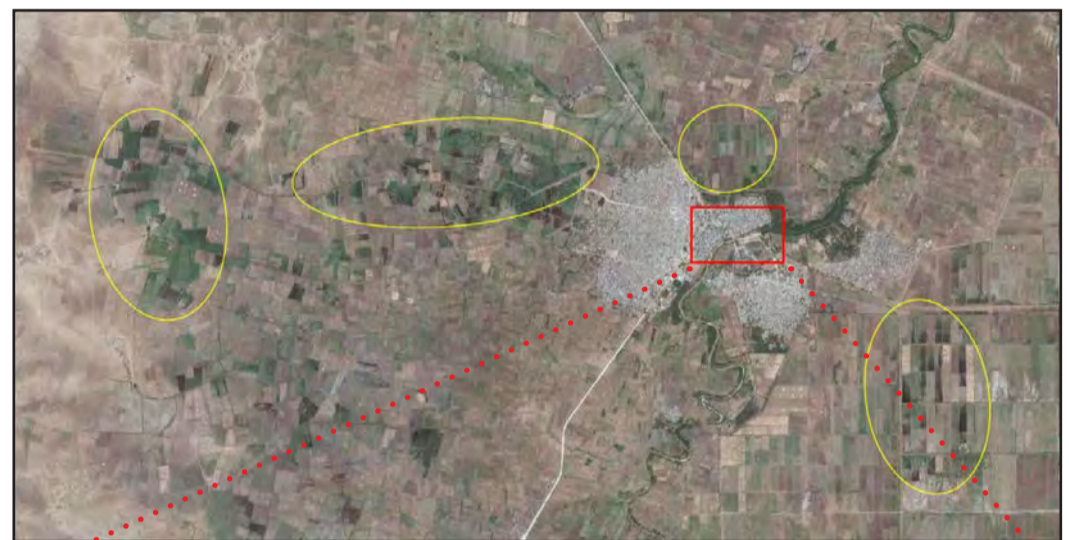
## Shabelle River at Jowhar, Middle Shabelle Region



The overview of the agricultural area in Jowhar shows that in 2001 the active crops (green) cover a much bigger area as compared to Dec 2016. We can assume that this is the effect of an increased use of water upstream, which has affected water availability in Jowhar and downstream. In the middle image, outlined in red is the agricultural area under irrigation, in yellow an area made of a mixture of agriculture and natural vegetation. Most of the agricultural land is rain fed and outlined in blue is natural vegetation. There is a dramatic decrease of active rain fed agriculture as of Dec 2016 indicating a failure of seasonal rain fed crops, in Jowhar.



The graph shows the current river level compared to the 2017 level and the long term mean.



The image shows that river level is normal to high, the weir is completely submerged and portion of sand banks, which are generally outcropping, are submerged (yellow outlined).



The image shows the weir in Jowhar. Downstream of the weir the river is dry as evidenced by the outcropping of the river bed. The two canals upstream the weir are active as they are providing water to the surrounding irrigated area. However, the amount of irrigated land is confined just along the primary canal, as shown with yellow outlined circles in the image showing the overview of the area. It is also noted that the majority of fields irrigated by the canals downstream the weir are not cropped.



Similarly to December 2017, the image shows that river level is very low, as evidenced by the outcropping of a portion of the river bed downstream the weir and sand banks (yellow outlined). The two canals are active.



Similarly to April 2017, the image shows that river level is very low, as evidenced by the outcropping of a portion of the river bed downstream the weir (yellow outlined).

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