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Commentary

Aral Sea syndrome desiccates Lake Urmia: Call for action

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ABSTRACT

Lake Urmia, one of the largest saltwater lakes on earth and a highly endangered ecosystem, is on the brink of a major environmental disaster similar to the catastrophic death of the Aral Sea. With a new composite of multi-spectral high resolution satellite observations, we show that the area of this Iranian lake has decreased by around 88% in the past decades, far more than previously reported (~25% to 50%). The lake's shoreline has been receding severely with no sign of recovery, which has been partly blamed on prolonged droughts. We use the lake basin's satellite-based gauge-adjusted climate record of the Standardized Precipitation Index data to demonstrate that the on-going shoreline retreat is not solely an artifact of prolonged droughts alone. Drastic changes to lake health are primarily consequences of aggressive regional water resources development plans, intensive agricultural activities, anthropogenic changes to the system, and upstream competition over water. This commentary is a call for action to both develop sustainable restoration ideas and to put new visions and strategies into practice before Lake Urmia falls victim to the Aral Sea syndrome.

Introduction

Lake Urmia, one of the largest saltwater lakes on earth and a highly endangered ecosystem, is on the brink of a major environmental disaster similar to the catastrophic death of the Aral Sea. Once with a surface area of approximately half a million hectares, Lake Urmia's shoreline has been receding severely with no sign of recovery, leading to a significant shrinkage in the lake's surface area. Situated ≈1273 m above the sea level, this shallow terminal lake is surrounded by a range of high mountains (UNEP, 2012; Ghaheri et al., 1999). A unique feature of this UNESCO designated Biosphere Reserve and National Park is its hypersaline environment, with salinity ranging from 217 to more than 300 g/l, approximately eight times higher than sea water (UNEP, 2012; Ghaheri et al., 1999; Ahmadzadeh Kokya et al., 2011). Unique and rare types of diatoms, phytoplankton and bacteria can survive in such a hypersaline environment. The lake is the world's largest habitat of brine shrimp Artemia (*Artemia urmiana*), which is a major food source for migratory birds such as flamingos, pelicans, ducks and egrets (Barigozzi et al., 1987; Vahed et al., 2011; Ahmadi et al., 2011). The intensity of bird migration to the area largely depends on the primary production of Lake Urmia, and particularly on availability of salt-adjusted brine shrimp (Karbassi et al., 2010; Eimanifar and Mohebbi, 2007).

In the past decade, the lake's average water level has decreased significantly, endangering this unique ecosystem (Hassanzadeh et al., 2012; WRI, 2006; Tisseuil et al., 2013; Abbaspour and Nazaridoust, 2007; Farzin et al., 2012; Sima and Tajrishy, 2013; Jaafari et al., 2013; Tourian et al., 2014). While the current status of Lake Urmia is catastrophic, the continuation of the lake's retreat could lead to yet another major environmental tragedy similar to the fate of the nearby Aral Sea in Eurasia (UNEP, 2012; Micklin, 2007; Small et al., 2001). Once one of the largest lakes on earth, the Aral Sea gradually declined to less than 10% of its original size after diversion of the lake's inflow from Amu Darya and Syr Darya rivers for ill-conceived irrigation development in the Soviet era (Micklin, 2007; Gaybullaev et al., 2012; Micklin, 1988), causing severe economic, environmental, and health consequences (Whish-Wilson et al., 2002).

Drastic changes in Lake Urmia: causes and consequences

Composite multi-spectral high resolution (30 m) satellite observations show drastic changes in lake area since 1972 (Fig. 1). The area of

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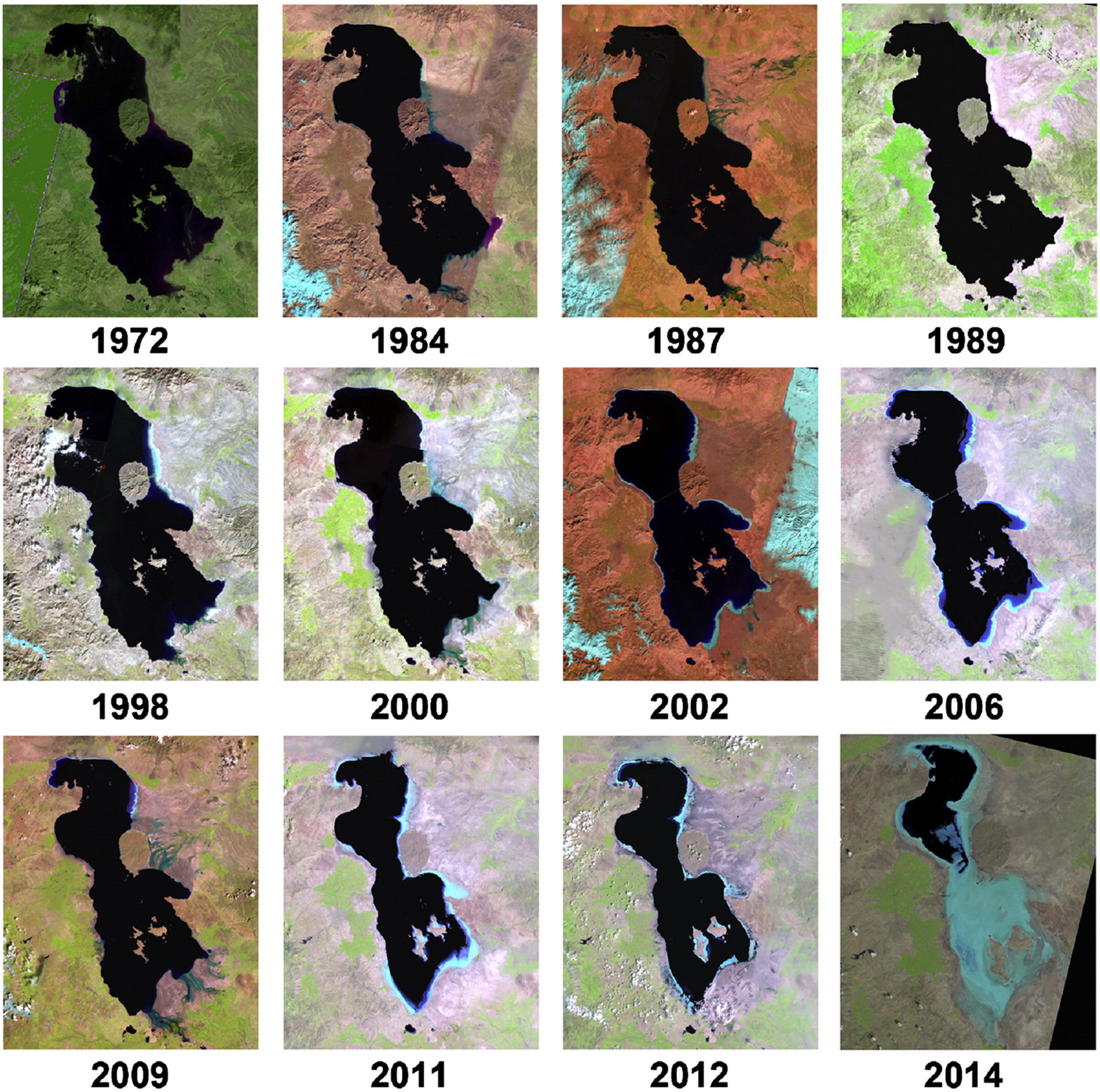

Fig. 1. Changes in area of Lake Urmia from October 1972 to August 2014, derived from LandSat imagery.

Lake Urmia , with detectable water from space, has decreased by around 88% (Fig. 2a), far more than previously reported (≈25% to 50%; (Hassanzadeh et al., 2012; WRI, 2006)). Consequently, the volume of Lake Urmia is at a record low in August 2014, approximately 80% less than in 1972 (Fig. 2b). A time series of the volume of the lake was derived using the lake's Area–Volume–Height curve available from WRI (2006). It should be noted that in determining the area of the lake in different years, we relied on detectable remotely sensed water. Therefore, our estimates are subject to some uncertainties as areas with negligible water or mud may have not been accurately detected given the resolution and accuracy of satellite images.

The lake's shoreline retreat has exposed the former lake-bed (Fig. 1), which consists of salt crusts (≈400 km^2 of sodium chloride-covered salt flats), to wind forces (Golabian, 2010). The resulting salt storms increase the risk of irreversible ecosystem regime shifts, diminish fertility of nearby agricultural lands, and cause biotoxicity and chronic human health consequences (Cook et al., 2005; Yamaguchi et al., 2012). To the best of our knowledge, risks of potential diseases from Lake Urmia salt storms have not been explored at local or regional scales.

During the unfolding of this environmental catastrophe which has heightened public and political sensitivity (Madani, 2014), extended drought periods and climatic changes have been blamed by local authorities as one of the causes of the lake's shrinkage. Indeed, changing hydrologic patterns due to climatic changes and increase in the frequency and intensity of droughts are important factors that can affect the variability of the lake's surface (Tabari et al., 2012; Abbaspour et al., 2012; Nikbakht et al., 2013; Damberg and AghaKouchak, 2014; Delju et al., 2013; Golian et al., 2014; Tabari et al., 2014). Nonetheless, a

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