

Significance of Satellite Remote Sensing Data for Wetland Inventory, Monitoring and Management

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Received: November 17 2018/Accepted: 25 December 2018/Published: 07 January 2019

Abstract

Wetlands are the most important ecosystem of the earth which is providing many ecosystem services, functions, and values and considering as the kidney of the environment and it controls everything like the water cycle, carbon cycle, sediment and nutrient cycles in the system. Wetlands, the cradles of biodiversity and key constituent of our environment, are among the most productive ecosystems housing more or less all floral and faunal taxonomic units. However, wetlands continue to decline and permanently lost globally, both in area and in quality. Wetlands histories show us, wetlands have been degraded, altered, and altogether removed from the landscape as a result of direct and indirect human influences in all corner of the world. Therefore, wetland ecosystem needs to make frequent monitoring, inventory and designing feasible management system. This requires some special tools which able to access large cover, fragmented and complex wetland ecosystem like remote sensing technologies. Satellite remote sensing techniques play a great role in this regard. Wetlands environment is relatively horrible and complex ecosystem due to its unknown and elusive depth, composition and structure. Moreover, aquatic and wetland ecosystems are cover large area of earth's surface. Wetland environment is extended coverage of the land surface and complex system as compared to other ecosystem such as forest and water. Collecting data in this area using in situ measurement or ground based approach is hard and difficult. For this, satellite remote sensing application has indispensable advantage for monitoring and managing wetland ecosystem. However, the application of satellite remote sensing on wetland monitoring and inventory has facing a challenge in developing country's researcher who couldn't get enough research budgets that directly affect satellite data quality. To get high quality data like QUICK BIRD, SPOT and IKOKNS by ordering from the producers, it is time taking and the price of this data extremely expensive unless some sponsor organization is found. Therefore, it is challenging for young and developing Country's researcher and they are forced to use open source satellite remote sensing data which are low in resolution. Except Landsat, sentinel and some other satellite data which are low in spatial, temporal and spectral resolution, Satellite data like IKONS, QUICK BIRD, and SPOT are providing high quality data but commercial (not accessible freely for research).

Keywords: Remote sensing, satellite data, wetland, remote sensing, inventory, monitoring.

Introduction

Wetlands are defined as lands transitional between terrestrial and aquatic eco-systems where the water table is usually at or near the surface or the land is covered by shallow water (Bloomfield, 1994). According to the Ramsar convention, wetlands can be defined as areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed 6 m (Mucheye *et al.*, 2018). It is also defined as wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water (Dasilveira, 2002; AISghair, 2013).

Wetlands are the most important ecosystem of the earth which is providing many ecosystem services, functions, values and considering as the kidney of the environment and it controls everything like the water cycle, carbon cycle, sediment and nutrient cycles in the system (Hearn, 1991; Wetland Ecosystem Services, 1997; Wetlands for our Future Wetlands, 2015; Mucheye *et al.*, 2018). Wetlands, the cradles of biodiversity and key constituent of our environment, are among the most productive ecosystems housing more or less all floral and faunal taxonomic units. They are not only important for the survival of fishes, birds, turtles and crocodiles and other aquatic life but also are habitats of many rare and endangered species (Dawson *et al.*, 2003; Garg, 2015).

However, wetlands continue to decline and permanently lost globally, both in area and in quality (Scholar and Shi, 2013; Wulder *et al.*, 2018). As a result, the ecosystem services that wetlands provide to society are diminished. Contracting Parties and their policymakers are urged to take immediate action to meet the Ramsar Convention's objective to stop and reverse the loss and degradation of wetlands and services to people (Ramsar Briefing Note, 2015). The last decade's wetlands histories show us, wetlands have been degraded, altered, and altogether removed from the landscape as a result of direct and indirect human influences in all corner of the world (Dasilveira, 2003; Wetlands for our Future Wetlands, 2015). The direct and indirect intervention of human is doing due to giving less attention to wetland conservation and management of both policy makers and communities (Dawson *et al.*, 2003). To overcome the problems related to wetland inventory, monitoring, management and restore, having historic, actual and potential information is very critical to influence the concerning bodies and an effective and efficient management of wetlands requires an exhaustive survey of their distribution and determination of whether or not they have changed over time and to what extent (Jensen *et al.*, 1993; Baker *et al.*, 2006). GIS database with satellite remote sensing is an efficient tool to do such types of activities with regard to wetlands environment (Krishnakumar and Venkatakrishnan, 1998). The aim of this review paper is to synthesize the importance of satellite remote sensing technology for wetland inventory, monitoring and management.

Remote sensing (RS)

Remote sensing is defined as a science/art of obtaining information about an area, an object and a phenomenon through the analysis of data that acquired by a device which is not physical contact with the object/phenomenon (Kumar *et al.*, 2003). It is a recent and rapidly valued as useful tools for providing spatio-temporal dynamics of the surface of the land and is an effective tool to monitor changes to wetland ecosystem attributes, and to provide information needed to model ecosystem structural and functional parameters (USIAD report, 2017; Yan *et al.*, 2017).

Importance of RS in terms of accessibility wetland environment

Wetland environments are the sum of water, soil, and biota that occur in areas that are saturated with water for sufficient periods to promote aquatic processes as indicated by hydric soils, hydrophytic vegetation, and biological activities adapted to the wet environment (EJAR, 2013). It is relatively horrible and complex ecosystem due to its unknown and elusive depth, composition and structure. Aquatic and wetland ecosystems are cover large area of earth's surface (Wulder *et al.*, 2018).

Therefore, data gathering can represent a significant challenge for researchers and planner in wetland ecosystem thereby has been hampered by difficult access and their episodic nature (Dean and Populus, 2007; Dasilveira, 2002; Krishnakumar and Venkatakrishnan, 1998). This situation makes the wetland environment difficult to collect data for inventory and monitoring by in-suit measurement (Johnson *et al.*, 2010). Information about wetland dynamics remains a major missing gap in characterizing, understanding, and projecting changes (Nghiem *et al.*, 2017). Remote sensing technology is crucial to fill the gap and challenges due to large area coverage and complex wetland system which is hard to collect data for further inventory and monitoring (Kavyashree and Ramesh, 2016; Teodoro, 2016; Yan *et al.*, 2017).

Importance of RS in terms of cost and time

As explained above, wetland environment is extended coverage of the land surface and complex system as compared to other ecosystem such as forest and water. Collecting data in this area using in situ measurement or ground based approach is hard and difficult (Chapman *et al.*, 2006; Kavyashree and Ramesh, 2016). On top of this, dynamics of wetland's environment is high and frequently occurred (Kasischke, 2003) because of its sensitivity for specific event like drought, flood, human and animal disturbance (Chapman *et al.*, 2006). Therefore, it needs time series data to have complete database for wetland inventory and management system that also requires large investment and finance. Wetlands distribution on the land surface is dispersed and monitoring, management and inventorying of such ecosystem in situ is more expensive, time taking and logistically challenging or have restricted access (Gallant *et al.*, 2015). However, remote sensing techniques have proven to be a successful tool for mapping and monitoring wetlands (Garg, 2015; Yan *et al.*, 2017). It is often less costly and time-consuming for large geographic areas compared to conventional field mapping (Ozesmi and Bauer, 2002; Dasilveira, 2002; Teferi *et al.*, 2010 as cited in Kaplan and Avdan, 2018; Klemas, 2013).

Challenges of satellite remote sensing on wetlands

Wetlands are requiring frequent assessment and monitoring to sustain their ecosystem function, values and services (Krishnakumar and Venkatakrishnan, 1998; Schlepner, 2011; Nghiem *et al.*, 2017). This is due to the nature of their regular dynamics in terms of vegetation composition, soil amendment, hydrological recurrent and booming of invaded weeds (Klemas, 2013). Satellite remote sensing plays a great role by providing time series data to investigate such recurrent variation (Klemas, 2011). However, there are a certain challenges that faced the researchers when satellite remote sensing used for wetland monitoring. (a) The diverse nature and character of

wetlands has made it difficult for scientists (Mwita et al., 2012) to use satellite remote sensing for identification of vegetation species, water and soil (Lang et al., 2015). (b) Wetland environment requires relatively high quality satellite data (Srivastava et al., 2009; Mwita et al., 2012; Mosime and Tesfamichael, 2017), even though, the spatial, temporal and spectral resolution of open sources satellite product data is low. This is becoming a challenge for wetland's researchers specially who are from developing countries and lacks financial support to buy high resolution satellite image like QUICK BIRD, SPOT and IKOKNS (Sensing, 2008; Teodoro, 2016). (c) According to Ritchie and Das (2015); Ozesmi and Bauer (2002) some literatures are described as satellite remote sensing is not stand alone; rather it needs ancillary field survey data to be used for validation (Yan et al., 2017) and considering as challenge since non-remote sensing researchers have a reservation on the efficiency of satellite remote sensing data.

Conclusion

We can draw a conclusion based on this review as monitoring, inventory and management of wetlands is a critical issue in order to seek function and services of those wetlands which are becoming decline and lost permanently in alarming rate. For this, applications of satellite remote sensing techniques are vital and increasingly used. It reduces the challenges that related to huge investment costs and time since wetlands need frequent assessment and monitoring due to its complex, variable and alterable nature of the ecosystem. Moreover, wetlands are spatially fragmented and cover large area and then satellite remote sensing techniques help the researcher's task to be easier and safer. Satellite remote sensing application on wetland's monitoring and inventorying needs high resolution data to be more viable and efficient. However, still there is a challenge associated with spatial, temporal and spectral resolution especially for researchers from developing Countries. To get high quality data like QUICK BIRD, SPOT and IKOKNS by ordering from the producers, it is time taking and the price of this data extremely expensive unless some sponsor organization is found. Therefore, it is challenging for young and developing Country's researcher and they are forced to use open source satellite remote sensing data which are low in resolution.

Recommendation

Wetland ecosystem needs frequent monitoring and inventory to sustain its providing service and function for the environments. To do this, high quality satellite remote sensing is recommended. Enough amount of budget or free access to high quality satellite data for researchers is highly recommended.

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Cite this Article as:

Tadesse, M. 2019. Significance of satellite remote sensing data for wetland inventory, monitoring and management. *J. Acad. Indus. Res.* 7(8): 98-101.