PERFORMANCE CHARACTERIZATION OF AN IRRIGATION SYSTEM USING SATELLITE REMOTE SENSING AND GIS TECHNIQUES

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ABSTRACT

Pakistan being an agricultural country is currently facing serious problems of water shortage, land degradation, low agricultural productivity and inequity in distribution & access to water resources. Their solution requires an efficient and integrated use of available water resources, which can be done by improving the irrigation management. Assessment of irrigation system performance is the basic element of irrigation management which demands frequent data collection and processing. It is customarily expensive and is difficult to replicate and carryout regularly for longer durations and large irrigation systems. The core objective of this study was to assess the irrigation system performance and to develop guidelines for crop yield estimation using remotely sensed (RS) data and Geographic Information System (GIS). For the purpose of this study, command area of Main Branch Lower (MBL) canal of Bambanwala Ravi Bedian Depalpur (BRBD) canal was selected.

Traditionally irrigation performance is being assessed by collecting the relevant data manually on irrigation deliveries and analyzing it for estimation of efficiencies at various levels. The researchers have developed several indicators to describe the irrigation system performance. Among these indicators, the most commonly used indicators are: adequacy, reliability, equity and water productivity. These indicators can be estimated by conventional method as well as remotely sensed data analyzed in the GIS environment. In this research study remotely sensed data in Red- and Near Infra Red (NIR) bands derived from Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) satellite imageries were used to find Normalized Difference Vegetation Index (NDVI) values and the thermal infrared spectrum was used to determine surface temperatures. Applying energy balance approach these values along with weather

parameters were converted to evaporative fraction maps. Consequently, actual vapo(transpi)ration (ET) was derived which described the irrigation system performance.

Spatial disparity in evapotranspiration and irrigation supplies were estimated from head to tail of the irrigation system using satellite imageries. The results revealed that maximum evaporation was taking place from the water surfaces i.e. canals and the minimum from the bare soil/buildings/roads. Further classification of evapotranspiration into different ranges showed that more area under higher evapotranspiration range was lying near head of the irrigation system than its tail and this indicates that more canal water was available at the head of the system. The results also showed that the total seasonal water consumed by wheat crop was reasonably comparable with the water available to the crops from all sources.

Moreover, estimation of adequacy, reliability, equity and water productivity revealed that 74% of the MBL command area was served adequately, 37% of the command area falled under 65% adequacy and 26% of the area falled under 50% adequacy when the entire cropping season was considered. However, on monthly basis the adequacy remained best during the month of November and worst during the month of January. The reliability of the irrigation system varied from 35-73% during the months of November to April. These results showed that the system was the most reliable during the month of March and the least during the month of February. The coefficient of variance (C_v) varied from 0.15-0.94 averaging to 0.43, showing that overall performance of the MBL system was not reliable. Average C_v at head, middle and tail of the system was found as 0.29, 0.39 and 0.42 respectively, showing that reliability of the system was better at head as compared to the middle and tail of the irrigation system. Assessment of MBL canal performance in equity terms revealed that areas lying at heads of water channels were receiving more water supplies than that of the middle and tail areas. The crops on an area of 5-23% (lying on tails) remained under the lowest water supplies consequently the crops remained under extreme stress. Whereas the crops on an area of 11-35% (lying in the middle of water channels) remained under low stress and the crops on an area of 5-37% (lying at heads) received sufficient quantities of water. From the correlation between water supply and crop yields, it was found that water supplies were strongly correlated with crop yield ($R^2 = 0.80$).

Crop production being a vital element of rural development and the major indicator of the national food security were also estimated by developing an algorithm using high resolution SPOT & LandSat data along with ground data on wheat harvest index and historic yield records. Red- and NIR bands were derived from satellite imageries and NDVI maps were. Absobed Photosynthetical Active Radiations (APAR) absorbed by the canopy were calculated using Montieth model and Field et al. (1995) model for determination of the light use efficiency. All these images were placed together and biomass production of wheat was derived. It was found that biomass production varied from 597 to 1123 $gm.m^{-2}$. These estimates were then coupled with wheat crop harvest index to estimate the wheat yield resulted in 2932 kg ha^{-1} to 5516 kg ha^{-1} grain yield. These results were compared with manualy collected data as well as reported by the Crop Reporting Services (CRS) of Agriculture Department, Punjab and found 7.6% and 14.6% higher respectively.

Spatial variability in canal water supplies (i.e., the fields lying near head of the canals/distributories/minors were receiving comparatively more canal water as compared to the fields lying at middle and tail ends of the system) along the system is evident from the results of this study which consequently effect the yield of crops. This variation caused water scarcity, degradation of land & environment and poverty of the farmers in lower reaches of the irrigation channels.