Investigation on Flood Irrigation System in Gash Delta, East Sudan Using Satellite Image

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ABSTRACT: Gash Delta is located in the east Sudan and is formed by Gash River which starts in Eritrea, the neighbor country. This river is a seasonal river that has a vast basin of 21,000 km^2 and it supplies more than one billion m^3 of water to this semi dessert area through flood continuing for about 3 months and supporting living basis of about 150,000 people. The irrigation system in this area leads flood flow in rivers to the main canal and, then, flushes to agricultural lands in gentle slope through smaller water channels. It is called as "Misga", which penetrates irrigation water to planar agricultural lands through short water channels provided with sluice gates.

This system is inefficient and the area actually planted is said to be about a half of 315,000 ha in arable area. In this paper, the "Misga" irrigation system is analyzed using satellite images in the attempt to investigate a technique for efficient management of the system

INTRODUCTION

Sudan with its area of 2,506,000 km^2 is the largest country in Africa. The Blue Nile flowing from Ethiopia and White Nile flowing from South Sudan and Uganda converge in Khartoum, the capital. In this paper, we pay attention to Gash River passing L

Kassala in the east part of Sudan. This river originates at a point about 25 km south of Asmara, Eritrea. It is called Mareb river and travels down in a relatively narrow valley to begin with and enters Sudan passing through a sandy clay plain. Therefore, this river travels down with a massive amount of sediment (fine sand and silt). The total amount of sediment passing Kassala bridge annually is said to be about 5.5 million tons. Gash/Mareb river is nearly a waterless river through the year but it floods suddenly in the rainy season from July to September.

Gash river caused terrible floods many times in the past. On the historical side, this river used to flow west of present Gash Delta, adjacent to the area that has become New Halfa irrigation district now. This river is a rough river beyond human control. In addition, its river requires dredging all the time as running sand gradually accumulates. The dredged sand in the river bed is mounded on the adjacent embankment. The river bed becomes unstable when there is a large amount of running sands and the river bed configuration changes consistently due to changing of current direction over and over.

Fig. 1 Map of Sudan and the location of Gash Delta near Kassala City.

When the river sand accumulates raising the river bed (1 to 2 m at times), the river water dammed there was let out of the flow path and used for irrigation.

Fig. 2 Gash River in October

Fig. 3 Flood flow of Gash River at Kassala Bridge

Irrigation system in Gash Delta

Irrigation water is introduced from Gash River to the main canal and is supplied eventually to the irrigation plots (Misga) through branch canals. Fig. 4 shows a photograph of a sluice gate for intake of water from Gash River. It has a permanent stop log to stop water intake and is used to adjust the amount of water intake.

Fig. 4 Sluice gate from Gash River

Fig. 5 Irrigation water flowing down the main canal

Fig. 6 Water master monitoring the link canal

Fig. 7 Cutout of the canal bank to let water flow to farm fields

Fig. 8 Supply of water to field plots (Misga)

Fig. 9 Irrigated field surface

The flow volume per unit width is quite large filling the irrigation blocks (about 3000 fedan; 1260 ha) called Misga. The forefront of irrigation water is controlled to minimize flow resistance by a waterman under instruction of the water master of Misga. The elements affecting most seriously in Misga blocks are inclination, soil characteristics, surface unevenness (nature, texture of soil), soil surface characteristics and coverage (surface character). Designing of this irrigation system was attempted first in 1930s and modified in late 1950s. It was originally intended for cotton growing and modified with the flush irrigation technique. This system was one of spate irrigations utilizing effluent water varying greatly in a seasonal stream, Gash River.

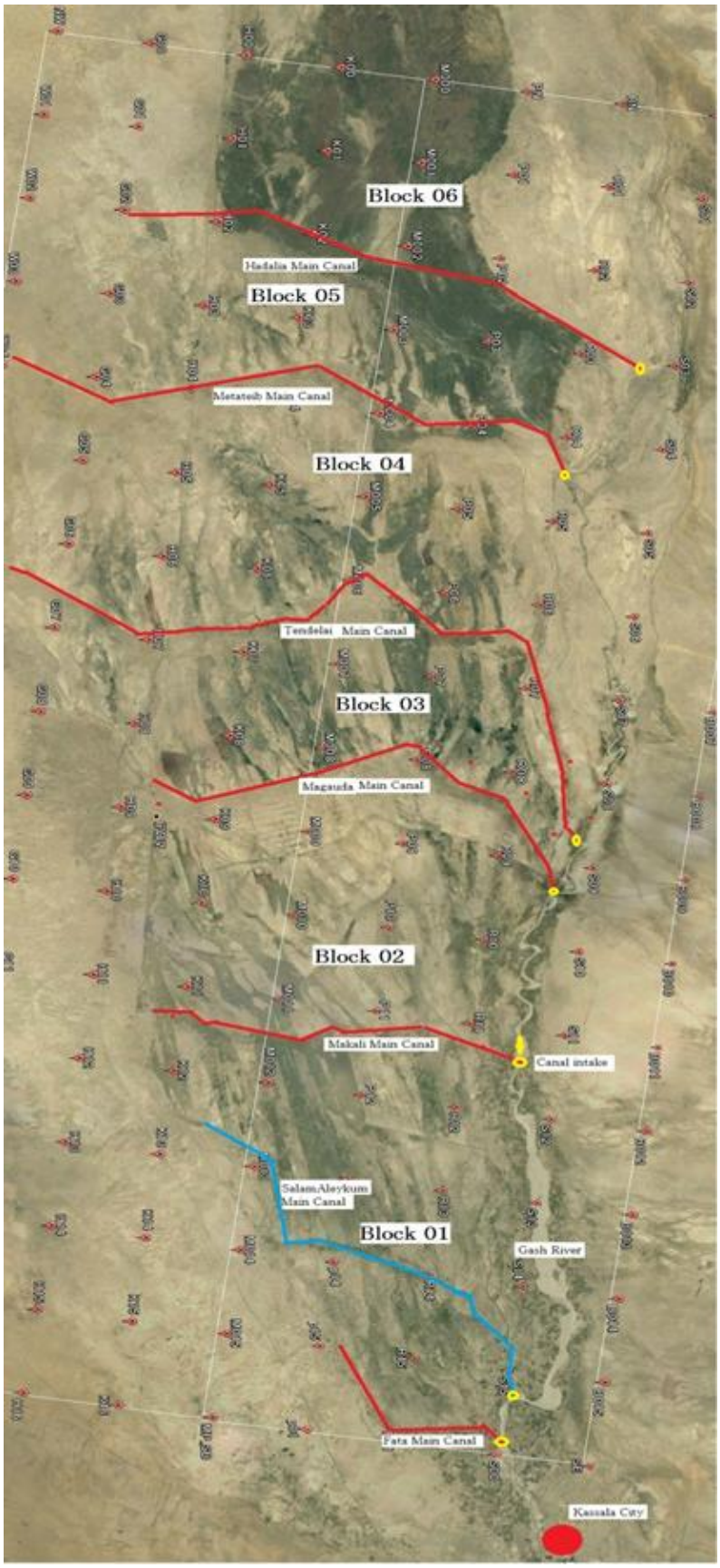


Fig. 10 Six irrigation blocks in Gash Delta

While irrigation utilizing water of Gash River is practiced in six blocks, suspended sediments such as silts broght by the river accumulate in irrigation canals to considerable amounts (5% in volume percent) raising the maintenance cost of canals to eliminate the sediments and to maintain the slope and flow rate of the main system.

Thus, following points are considered as tasks in the future; to practice flood control of the river safely and simply, to maintain a constant flow rate without interferring flowing down of the river water, to utilize limited water resources as efficiently as possible, and to device water use in accordance with planting patterns of new agricultural crops.

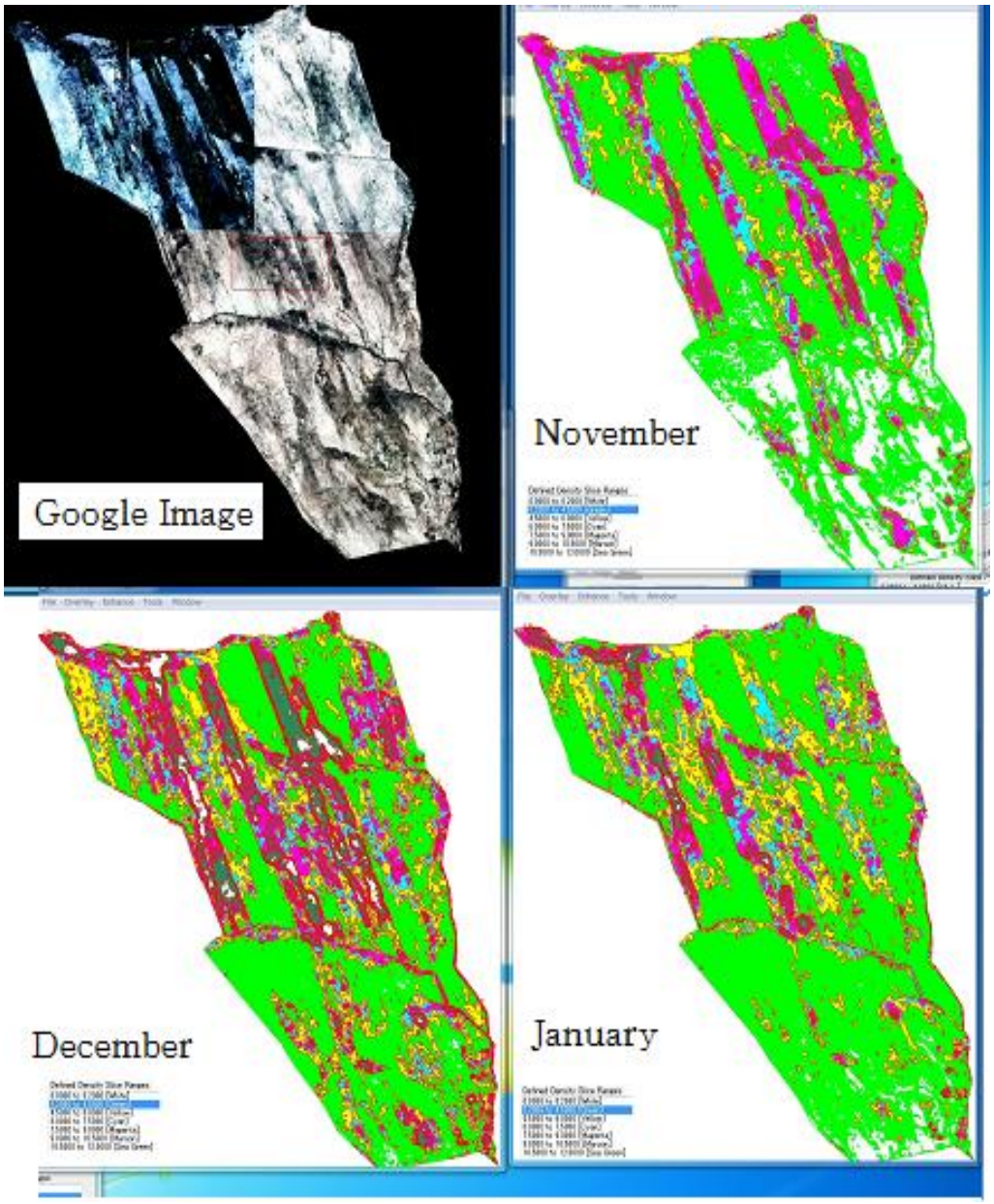


Fig. 11 Block 01 (Fota, Salam Aleykum main canal)

Verification by the SEBAL[5] program of Gash Delta

Gash Delta stretches 40 km from east to west and 80 km from north to south as Fig. 10 shows. This is a zoomed-in image of Google Earth and grid points are plotted every 5 km using UTM coordinate system. Gash Delta consists of reed-shaped compartments measuring 1 km in width and 10 to 15 km in length and each compartment is called "Misga". As Figs. 7 and 8 show, the south ridge of a "Misga" is cut out to let water flow in from the irrigation canal. When the irrigation water reaches all parts of Misga, irrigation water is switched to the next Misga scheduled for irrigation. Gash Delta is blocked by six main canals, (1) Fota, Salam Aleykum, (2) Makali, (3) Degain, (4) Tendelai, (5) Metateib and (6) Hadaliya in the order from the south.

We have drawn a scatter diagram of evapotranspiration (ET) in the whole area of Gash Delta from Landsat satellite images using SEBAL data processing procedure[1]. As the zoomed-in Google image can be enlarged to the resolution of about 5 m, it was possible to demarcate the boundary of each block. As sorghum is the main crop after completion of irrigation, time-series images from the seeding period (November) through the growth period (December) to the harvesting period (January) to investigate the state of utilization of Gash Delta.

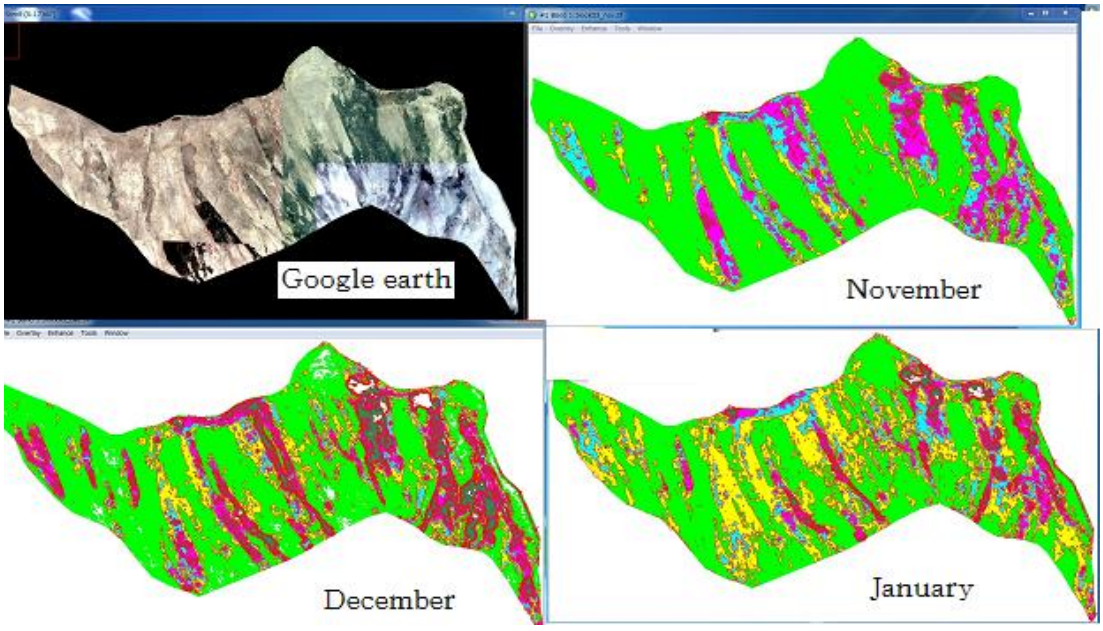
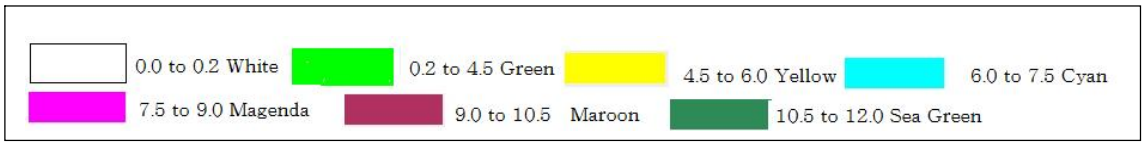


Fig. 12 Block 03 (Degain main canal)

Figs. 11 to 14 show distribution images of ET values in Blocks 01, 03, 05 and 06 referring to the Google earth images. Here, ET values in the range between 0.0 and 12.0 are shown. This range is divided into 8 grades and presented by the following colors in relation to the growth of sorghum.



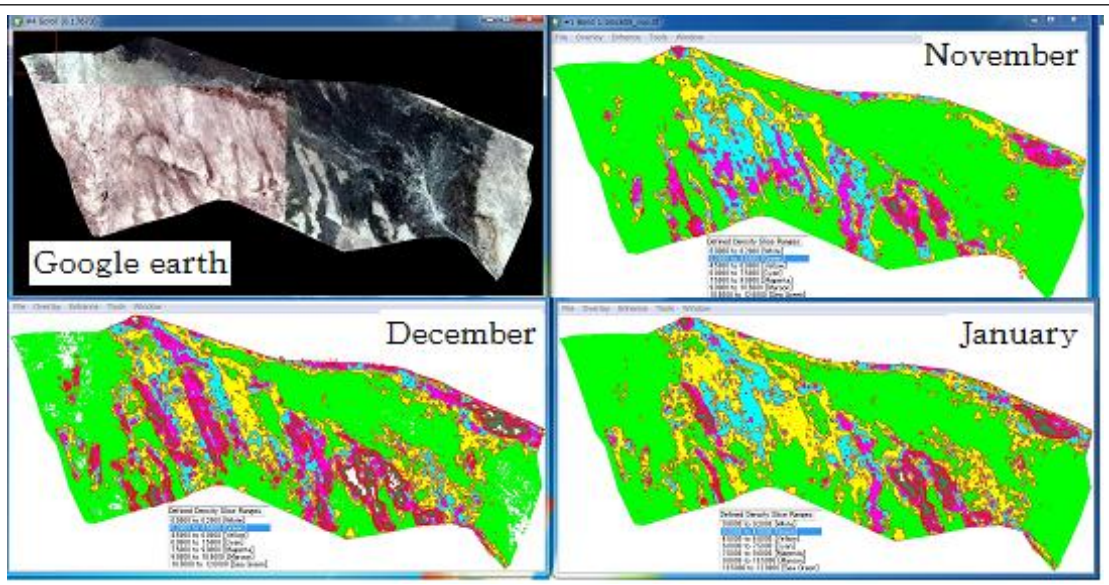


Fig. 13 Block 05 (Metateib main canal)

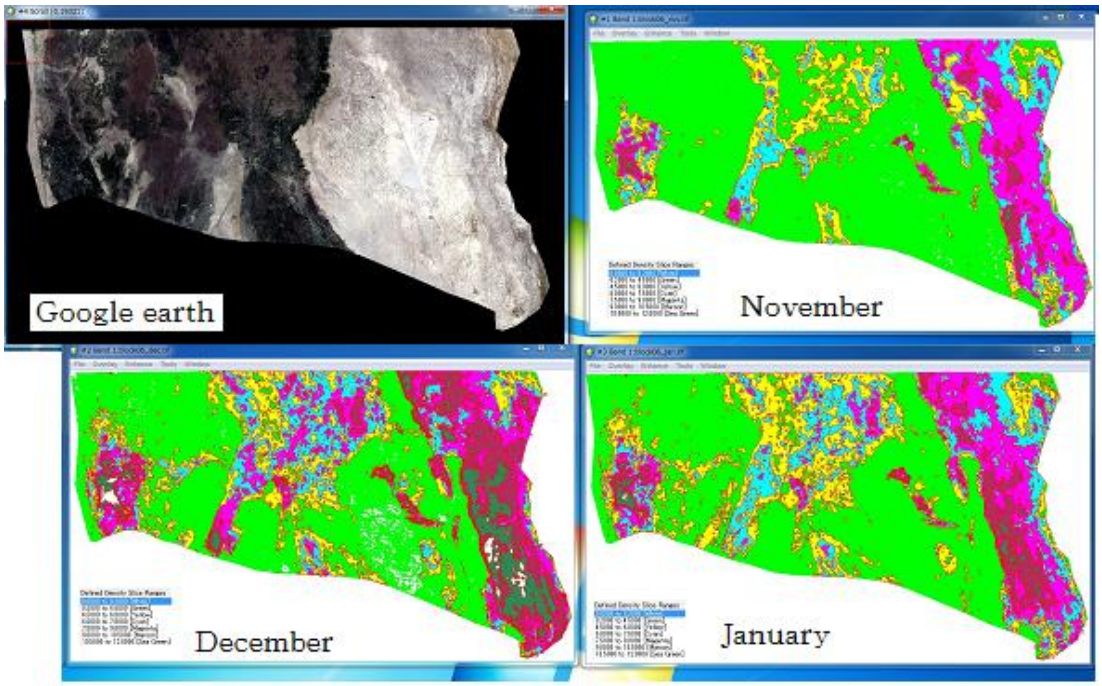


Fig. 14 Block 06 (Hadaliya main canal)

Fig. 15 Sorghum growing in Misga farm in Gash Delta

The areas in white are outside the target areas and those in green show ET values of 4.5 or less indicating that vegetation is negligible. We would like to call your attention to the areas with ET values greater than 4.5 where activation of plants increases in the order yellow → cyan → magenta → maroon → sea green. The images all show that the plants are most activated in December overlapping the growth period of sorghum. In the harvesting period in January, it can be seen that areas with decreasing ET values become conspicuous. The overall image show clearly that blocks called Misga measuring 1 km in width and 10 to 15 km in length are constructed and sorghum is planted in their units. In view of land use efficiency, areas of land uses other than crop cultivation are distinguished in all the blocks. We need to analyse the causes for this in detail.

Conclusion and recommendation

Gash delta is said to have an area of 360,000 ha. Of this, the 168,000-ha land is arable, 105,000-ha land is connected to the network of irrigation canals, and 33,600-ha land is used for growing sorghum. When the scatter diagrams of ET values in Figs. 11 to 14 are viewed with these figures, we can see that this area has sufficient room for development. While it seems extremely difficult to find out a method to utilize this water resources of Gash River flooding repeatedly and seasonally, full use of Landsat satellite images used in this study is expected to find out weak points of the current land uses. Fig. 15 shows

sorghums growing in abundance. Sorghum is the biggest agricultural crop for the inhabitants in this area at present. In such a vast land, the elements relating irrigation efficiency that affect most seriously in Misga blocks are inclination, soil characteristics, surface unevenness (nature, texture of soil), soil surface characteristics and coverage (surface character) as mentioned previously.

It seems possible to find out an efficient technique to control water by progressing analysis of satellite images more frequently in time series togehter with application of techniques such as geographical information system. It may be necessary to change water balance environment by changing agricultural crop patterns.

Acknowledgment

In this paper, Google earth images were zoomed in to resolution of about 5 m to demarcate the boundaries of irrigation blocks in Gash Delta. The site photographs from Reference 4) are inserted to facilitate understanding of mud flow in Gash River and state of irrigation water in Misga. We take this opportunity of expressing our appreciation.

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