JOURNAL OF WATER AND LAND DEVELOPMENT
e-ISSN 2083-4535

Polish Academy of Sciences (PAN)
Institute of Technology and Life Sciences (ITP)

JOURNAL OF WATER AND LAND DEVELOPMENT
2021, No. 48 (I–III): 65–69; https://doi.org/10.24425/jwld.2021.136147

Available (PDF): https://www.itp.edu.pl/JWLD; http://journals.pan.pl/jwld

Received 06.07.2020
Reviewed 19.06.2020
Accepted 25.08.2020

Extraction of urban construction development with using Landsat satellite images and geoinformation systems

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For citation: Arifjanov A.M., Akmalov S.B., Samiev L.N. 2021. Extraction of urban construction development with using Landsat satellite images and geoinformation systems. Journal of Water and Land Development. No. 48 (I–III) p. 65–69. DOI 10.24425/jwld.2021.136147.

Abstract

In recent times there have been many changes on Earth, which have appeared after anthropogenic impact. Finding solutions to problems in the environment requires studying the problems quickly, make proper conclusions and creating safe and useful measures. Humanity has always had an effect on the environment. There can be many changes on the Earth because of direct and indirect effects of humans on nature. Determining these changes at the right time and organizing measurements of them requires the creation of quick analysing methods. This development has improved specialists' interest for remote sensing (RS) imagery. Moreover, in accordance with analysis of literature sources, agriculture, irrigation and ecology have the most demand for RS imagery. This article is about using geographic information system (GIS) and RS technologies in cadastre and urban construction branches. This article covers a newly created automated method for the calculation of artificial surface area based on satellite images. Accuracy of the analysis is verified according to the field experiments. Accuracy of analysis is 95%. According to the analysis from 1972 to 2019 artificial area enlargement is 13.44%. This method is very simple and easy to use. Using this data, the analysis method can decrease economical costs for field measures. Using this method and these tools in branches also allows for greater efficiency in time and resources.

Key words: *ArcGIS, geographic information system (GIS), Landsat satellite image, remote sensing (RS), urban*

INTRODUCTION

The change in the land cover happens very quickly. The most important problem of specialists is how to determine these changes in a time effective manner [CHEN *et al*. 2012].

Learning of these wide changes, analysing each component and determining its effectible radius are the main problems of ecology. Remote sensing (RS) technologies, which were created in the 20th century, are very important solution in solving these problems [GINIYATULLINA *et al*. 2015]. Remote sensing technologies include land surface analysis and the environment sensing at a distance, theories, instruments, methods and interpterion by a means which helps to collect, re-use and create new information [ARIFJANOV *et al*. 2019a; BRIGANTE, RADICIONINI 2014]. This is done by taking images of land by active or passive sensors that are placed on board of planes or satellites.

Active sensors take images by spreading rays and capturing the rays' reflections from different objects and surfaces of the Earth. However, passive sensors are based on the rule that different objects absorb the sun's rays by different amounts. Because of these features of objects, at this time there is a possibility of learning land cover and events happening on the Earth by different spectral bands [BRIGANTE, RADICIONINI 2014]. Development and modernization of RS are working on these demands. Researchers in this sphere divided the RS development period into four stages [BALAWEJDER, NOGA 2016; BIEDA *et al*. 2020; NAVULUR *et al*. 2013].

1. Resolution. In this stage, spectral, spatial and temporal resolutions improved. There are super spectral satellites with 0.5 m spatial resolutions.
2. Accuracy and precision. In this stage, positional accuracy errors of satellites decreased from 23 to 3 m.
3. Speed. In this stage, the speed of data delivery is highly improved; modern satellites send the image to the user in an hour after taking images.
4. Analytics. In this stage a database is created.

The creation of the Landsat program in 1970 and the launch of the Landsat satellite were the start of the satellite remote sensing period. It was a medium resolution of satellite imagery. The launch of IKONOS (1-m pixel resolution) satellite in the 1990s, and afterward launches of SPOT-5, IRS, Quick Bird and OrbView-3 satellites were the basis of a high-resolution satellite imagery period. Nowadays, there are nearly 15 high-start satellites in the sky [NAVULUR 2006]. They are widely used in observing land surface, environmental protection and ecologic monitoring. Using this program, it is possible to observe ecologic processes like anthropogenic effects, the covering condition of land surface, natural resources, natural and ecological processes on a large scale [GINIYATULLINA *et al.* 2015].

According to Impactmin [2010] and GINIYATULLINA *et al.* [2015] using RS in ecology helps us to solve the aformaentioned difficulties and requirements, presented in a traditional ecologic analysing method.

Now it is possible to study different processes and natural objects on a large scale. As RS develops, it now gives the opportunity to take data on a global, regional and local scale.

It is possible to analyse the duration and repetition prostheses for a long period (Because satellites send images from one point in a certain period. For instance, Landsat arrives at the same point every 16 days and sends the image of the same area. According to scientists [CAPOLUPO *et al.* 2020; Impactmin 2010] they concluded that it is possible to observe the development period of any natural object or process gradually because of these features of the satellite.)

It prevents increasing the range of errors in the analysis, as different climates do not have effect on satellites.

It is possible to analyse the same data in different ways.

RS is used widely in forest and agriculture branches, ecology and in other branches because of its efficiency, being cheap (some satellite data are free), with a feature like this it is possible to take images of large areas. According to RS users' demands, dates should have the following features [NAVULUR *et al.* 2013]: small size, trustworthiness, cheap, modern and in an available format.

Scientists are mapping, modelling, analysing monitoring and predicting the different infections and viruses between human and animals and their spreading conditions by RS imagery. In some cases, determining the of spread of some of these diseases, RS is playing a major role [MACHAULT *et al.* 2011]. The main reason of it is the wide development of RS imagery and the creation of different RS analysing programmes [AYRES-SAMPAIO *et al.* 2012; BEKHIRA *et al.* 2019; MACHAULT *et al.* 2011].

The nature-protection branch is becoming more and more interested in remote satellite sensing. RS is used successfully in mining areas [Impactmin 2010]. RS helps us to realize that the changes in nature are greater as the population increases. We can determine the changes of forest and urban areas by RS. Nowadays, scientists use RS widely in determining the changes happening in nature. These analyses are called change detection analyses. RAMOELO and CHO [2014] and XU *et al.* [2014 analysed the death of biomass in arid areas by RS, here they have used high-resolution Landsat images for large areas. RS technologies have also developed so that satellites in space with 50 sm spatial resolution can send data back to Earth about the land surface [BRIGANTE, RADICIONINI 2014]. These technologies are used widely in measurements like monitoring forests on a large scale, learning about and preventing huge natural disasters and their resulting consequences. In addition, it is possible to use RS imagery and analysing programs in urban areas' land-cover extraction analysis, as well as predict and study the development and effects on nature of townships [DINKA, CHAKA 2019; RONCZYK, WOJTASZEK-LEVENTE 2012; TOGAEV *et al.* 2020].

RS is the most important resource for creating a GIS database of the environment and it started to be used widely in water branches. Especially in integrated water management [ARIFJANOV *et al.* 2019b].

MATERIALS AND METHODS

The research area of the thesis is Syr Darya province. Syr Darya is one of the regions of Uzbekistan, which was established on 16 February 1963. The Syr Darya area is located in the East of the country, on the left riverbank of Syr Darya River, on the output of the Fergana valleys. Latitude is 40°30'42"N, longitude is 69°00'38"E [TUKHLIEV, KREMENSOVA 2007; Uzkommunkhizmat 2010].

Data collection. For the analysis used Landsat long-term data. Landsat images were downloaded from glovis.usgs.gov. The parameters of Landsat satellite that were used in the analyses are the following:
– WRS-2 Part = 154;
– WRS-2 Row = 32;
– WRS-2 Part is equal to 166 only in Landsat 1-3MSS satellite.

Analyse step. Shape and compactness' homogeneity is of high quality: channel borders are clear, and wide arid areas are divided into huge segments, water, ground, and vegetation are also separated accurately. In Table 1 you will see optimal variants of all chosen and compared SP shape and compactness. To sum up, the following parameters are considered as the most suitable segmentation parameters for Landsat satellite images of Syr Darya region (Tab. 1).

Classification. Classification in eCognition has been carried out with the help of an assign class algorithm. Benefits of this algorithm are mentioned above in our review. In this classification the scientists have used clarifying indices and indices for defining the image layer value. In this process, the objects in the Landsat images are allocated to the following classes:

Table 1. Used segment parameters for Landsat images

Satellite name	Image layers	Image layer weight	Scale parameter	Shape	Compact-ness
L1-1972	green, red	1	10	0.01	0.9
	NIR, NIR2	2			
L8-2019	pan, coastal	3	300	0.50	0.1
	blue, green, red	1			
	NIR, SWIR, SWIR2	2			

Source: own elaboration.

– water bodies and irrigation sets,
– vegetated area,
– non-vegetated area,
– desert,
– aquatic vegetation,
– artificial area,

Short description of all classes is given in the Table 2.

Table 2. Short description of classes

Class name	Objects included in classes	Short description about extraction	Colour
Water objects	rivers, canals, lakes, ponds and other objects with water	NIR, *NDWI* and *NDVI* indices have possibilities to extract it	blue
Non-vegetated area	areas with no vegetation deserts ploughed area and others	low value of NDVI	yellow
Vegetated area	areas covered with vegetation agricultural fiends, gardens, pasture and other areas	high value of NDVI	light-green
Aquatic vegetation	vegetation which grows in water objects (rice and vegetation in collectors and canals)	extracted from vegetated area according to high value of brightness	dark-green
Desert	desert zones	extracted from non-vegetated area according to their area	red
Artificial area	buildings, roads, minerals, salty area	extracted according to high value of standard deviation of blue and coastal bands	pink

Explanations: *NIR* = near-infrared, *NDWI* = normalized difference water index, *NDVI* = normalized difference vegetation index.
Source: own elaboration.

In this analyse we used photographs, GPS, and GIS data of the region in visual classification.

Supervised classification has been done. For the land surface classification, we have used the “Rule-based data classification” method. Classification assigns class and merge region of eCognition have been used mainly. The merge region algorithm is an additional algorithm working on the basis of data inserted data by the user [ARIFJANOV *et al*. 2019b; NAVULUR 2006].

At the beginning of the analysis, the most acceptable combination of layers was selected by trying combinations of images in eCognition. The acceptable combination is the one in which the types of objects and their borders are clearly seen (Fig. 1).

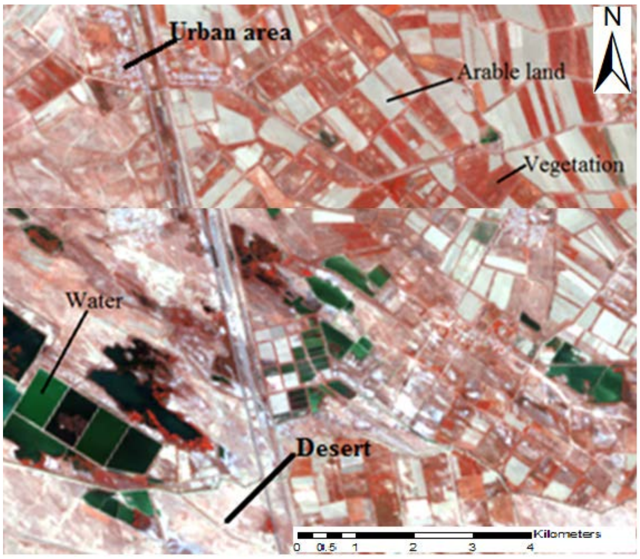

Fig. 1. Selection of the most acceptable combination in eCognition; source: result of analysis of Landsat images

RESULTS

Analysis of Landsat primarily included the data for the years 1972 (L1) and 2019 (L8). The changes of land cover in the territory of the region have been analysed. According to the analysis changes of land surface occurred as follows (Figs. 2, 3).

Looking at Figure 2, we can see that most of the region consists of desert area. The aquatic vegetation class in particular consists of weeds on the coast of rivers and water objects. Low image resolution and fewer varieties of bands classification especially were conducted by creating and using *NDVI* and *NDWI* indices. Due to the absence of the blue band and the impossibility of visual observation of the analysis, an urban area was created according to GIS information of Land cadaster in ArcGIS (Fig. 2). There we included an urban area shape file to eCognition as a thematic layer and gave a high value in segmentation and in classification in order to create an algorithm according to this thematic layer.

In this map we can see that artificial areas have increased considerably, and water objects are built and desert areas slightly increased. The aquatic vegetation area is mainly consisting of rice fields (Fig. 3).

The aforementioned classes above have many more mistakes compared to other classes in the determination of artificial area. The reason for this is the sanitation and salt on the surface of the land; it causes division of these territories into an artificial area class. If we carefully observe the map, we can see the artificial area in the desert territory. This is a clear example for the previous case, mentioned above.

If we estimate these figures visually, we can see that desert areas decreased, and agriculture lands increased during the period 1972–2019. Analysis in 2019 showed the smallest desert area.

The whole area of the province is 426.6 ha and areas of classification in percentages is as shown in Figure 4.

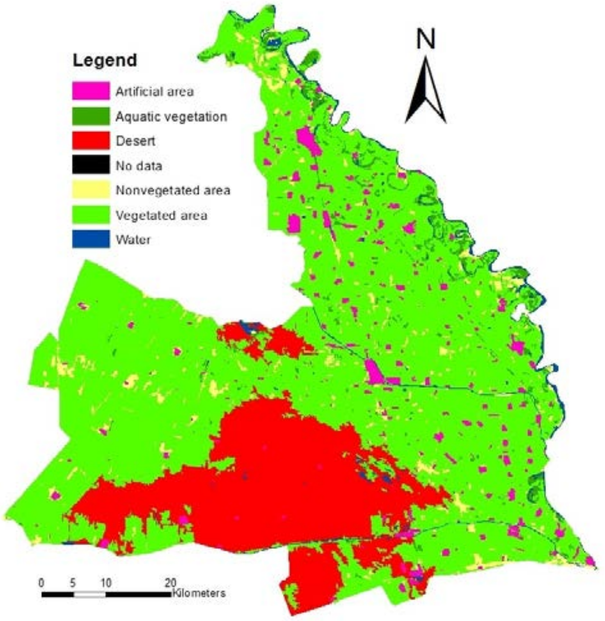

Fig. 2. The classification map of Syr Darya region for 1972; Landsat 1 MSS (30 Sept. 1972); source: own study

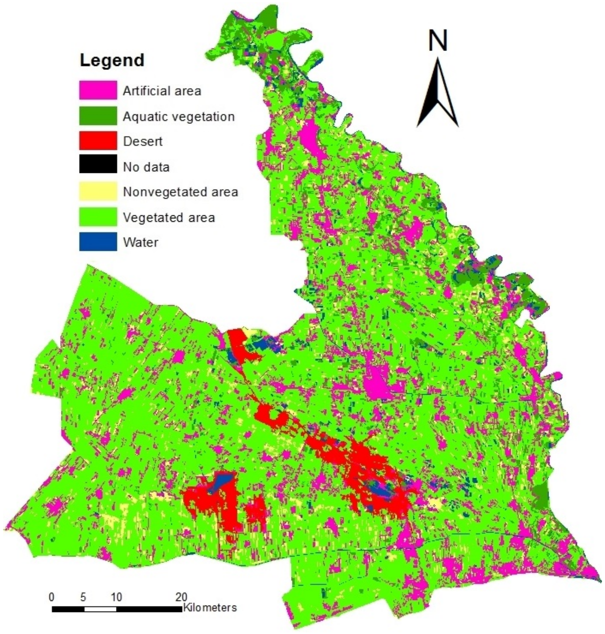

Fig. 3. The vegetation map of Syr Darya region for 2019; Landsat OLI TIRS (27 Jul. 2019); source: own study

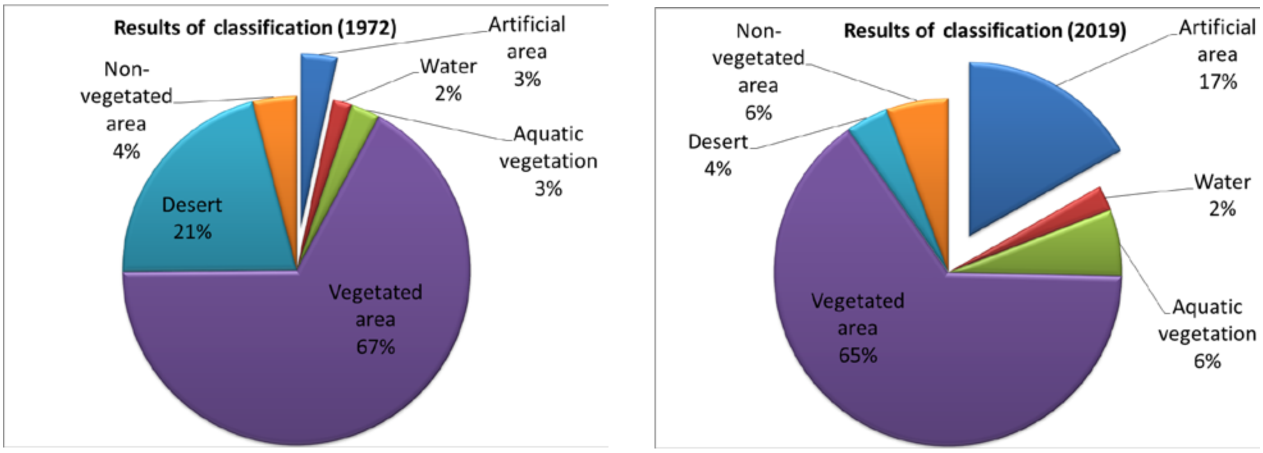

Fig. 4. Land use changes in percentages; source: own study

According to the Figure 4 the urban area increased 13.44 compared with 1972 data. This increase influenced by the decreasing natural area.

Accuracy assessment of classification. Accuracy assessment has been conducted for these maps. Accuracy assessment for every map has been conducted according to GPS points, photos, rotation map, GIS map and visual research.

In accordance with the statistical and comparison analysis, the average produced accuracy had a very high value of 90–95%, but in Thematic Mapper (TM) images classification it had decreased. This is because in the classification of these images, we have created more classes, in contrast with the images mentioned above. Furthermore, we have found a number of mistakes in the classification of the artificial area; these two reasons have influenced the accuracy of the results. But the growth of the resolution of OLI (Operational Land Imager) and the quantity of bands have influenced the accuracy of results, in the result of which this index has reached 95%. In other words, we have received better results by creating the map for the Republic of Uzbekistan by using object-based image analysis (OBIA) method instead of the traditional pixel-based image, analyse and middle resolution images. In its turn, we have had the opportunity to extract more classes during analysis.

CONCLUSIONS

This article describes using GIS and RS analysis programs to ensure accurate and fast information is provided to the construction and cadastre organisations. By using these programs and data we have created a map of construction development from 1972 to 2019, an overview of long-term land use in the region.

According to the analysis in last 50 years the urban development growth has been 14% and it predicts continued enlargement in the future. The advantage of this method is that it is easy to use and can save the expense of travelling and measuring costs for cadastre activities. Analysis brought some general results.

Object-based image analysis (OBIA) is the most reliable and advanced method for analysing remote sensing (RS) images, it gives the possibility of analysing even low-resolution images.

Regarding the many yearly analyses of Landsat data it was identified that, province desert area had been decreased and presently it is increasing. It has been proposed to research these reasons. Natural fenlands and virgin lands have been assimilated.

GIS information of the region needs to be renewed.

REFERENCES

ARIFJANOV A., APAKHODJAEVA T., AKMALOV SH. 2019a. Calculation of losses for transpiration in water reservoirs with using new computer technologies. In: International Conference on Information Science and Communication Technologies (ICISCT). 04–06.11.2019 Tashkent. IEEE p. 1–4. DOI 10.1109/ICISCT47635.2019.9011883.

ARIFJANOV A., SAMIEV L., APAKHODJAEVA T., AKMALOV SH. 2019b Distribution of river sediment in channels. In: XII International Scientific Conference on Agricultural Machinery Industry. 10–13.09.2019 Don State Technical University, Russian Federation. IOP Conference Series: Earth and Environmental Science. Vol. 403, 012153. DOI 10.1088/1755-1315/403/1/012153.

AYRES-SAMPAIO D., TEODORO A.C., FREITAS T.A., SILLERO N. 2012. The use of remotely sensed environmental data in the study of asthma disease. Remote Sensing for Agriculture, Ecosystems, and Hydrology 14. Vol. 8531, 853124. DOI 10.1117/12. 974539.

BALAWEJDER M., NOGA K. 2016. The influence of the highway route on the development of patchwork of plots. Journal of Water and Land Development. No. 30 p. 3–11. DOI 10.1515/jwld-2016-0015.

BEKHIRA A., HABI M., MORSLI B. 2019. Management of hazard of flooding in arid region urban agglomeration using HEC-RAS and GIS software: The case of the Bechar's city. Journal of Water and Land Development. No. 42 (VII–IX) p. 21–32. DOI 10.2478/jwld-2019-0041.

BIEDA A., BYDŁOSZ J., WARCHOŁ A., BALAWEJDER M. 2020. Historical underground structures as 3D cadastral objects. Remote Sensing. Vol. 12. Iss. 10, 1547 p. 1–29. DOI 10.3390/rs12101547.

BRIGANTE R., RADICIONINI F. 2014. Use of multispectral sensors with high spatial resolution for territorial and environmental analysis. Geographia Technica. Vol. 9. No. 2 p. 9–20.

CAPOLUPO A., MONTERISI C., TARANTINO E. 2020. Landsat Images Classification Algorithm (LICA) to automatically extract land cover information in Google Earth engine environment. Remote Sensing. Vol. 12. Iss. 7, 1201. DOI 10.3390/rs12071201.

CHEN Z., NING X., ZHANG J. 2012. Urban land cover classification based on WorldView-2 image data. In: International Symposium on Geomatics for Integrated Water Resource Management. IEEE p. 1–5.

DINKA M.O., CHAKA D.D. 2019. Analysis of land use/land cover change in Adei watershed, Central Highlands of Ethiopia. Journal of Water Land Development. No. 41 p. 146–153. DOI 10.2478/jwld-2019-0025.

GINIYATULLINA O.L., POTAPOV V.P., SCHACTLIVTCEV E.L. 2014 Integral methods of environmental assessment at mining regions based on remote sensing data. International Journal of Engineering and Innovative Technology (IJEIT). Vol. 4. Iss. 4 p. 220–224.

Impactmin 2010. WP4-Satelite remote sensing deliverable D4. 1 Report on the limitations and potentials of satelite EO data [online]. Contract No. 244166. Impact Monitoring of Mineral Resources Exploitation pp. 143. [Access 08.05.2020]. Available at: https://impactmin.geonardo.com/downloads/impactmin_d41.pdf

MACHAULT V., VIGNOLLES C., BORCHI F., VOUNATSOU P., BRIOLANT S., LACAUX J.P., ROGIER C. 2011. The use of remotely sensed environmental data in the study of malaria. Geospatial Health. Vol. 5. No. 2 p. 151–168. DOI 10.1117/12.974539.

NAVULUR K. 2006. Multispectral image analysis using the object-oriented paradigm. UK CRC Press. ISBN 987-1-4200-4306-8 pp. 204.

NAVULUR K., PACIFICI F., BAUGH B. 2013. Trends in optical commercial remote sensing industry [Industrial profiles]. IEEE Geoscience and Remote Sensing Magazine. Vol. 1. Iss. 4 p. 57–64. DOI 10.1109/MGRS.2013.2290098.

RAMOELO A., CHO M. 2014. Dry season biomass estimation as an indicator of rangeland quantity using multi-scale remote sensing data. In: 10th International Conference on African Association of Remote Sensing of Environment (AARSE). University of Johannesburg p. 27–31.

RONCZYK M., WOJTASZEK-LEVENTE H. 2012. Object-based classification of urban land cover extraction using high spatial resolution imagery. In: The impact of urbanization, industrial, agricultural and forest technologies on the natural environment. Eds. M. Neményi, B. Heil. Sopron. Nyugat-magyarországi Egyetem p. 171–181.

TOGAEV I., NURKHODJAEV A., AKMALOV SH. 2020. Structurally decryptable complexes-a new taxonomic unit in cosmo-geological research. In: E3S Web of Conferences. EDP Sciences. Vol. 164 p. 07027. DOI 10.1051/e3sconf/2020164 07027

TUKHLIEV N., KREMENSOVA A. 2007. O'zbekiston milliy ensiklopediyasi [National encyclopedy of Uzbekistan]. State Scientific Publishing. Tashkent. Uzbekistan p. 560.

Uzkommunkhizmat 2010. Water supply of Syr Darya province. World Bank Project [online]. Uzbekistan, Tashkent Agency «Uzkommunservice» pp. 152. [Access 12.02.2020]. Available at: http://documents1.worldbank.org/curated/pt/198941468127470671/pdf/E23850P11176001C10EIA71Report1Final.pdf

XU D., GUO X., LI Z., YANG X., YIN X. 2014. Measuring the dead component of mixed grassland with Landsat Imagery. Remote Sensing of Environment. Vol. 142 p. 33–43. DOI 10.1016.j.rse.2013.11.017.