International Journal of Science, Environment and Technology, Vol. 7, No 5, 2018, 1509 – 1519

ISSN 2278-3687 (O)
2277-663X (P)

COMPARISON STUDY OF MODERN TECHNOLOGY APPLICATION FOR PAVEMENT REHABILITATION IN THE GOBI REGION OF MONGOLIA

Enkhbaatar D[1], Bold B[2], Tsetsgee M[3] and Tsolmon R[4]
[1,2,3]Mongolian University of Science and Technology
[4]Department of Physics, School of Arts and Sciences, National University of Mongolia
E-mails: enkhbaatar@uilsroad.mn[1], tsolmon@num.edu.mn[4]

Abstract: The Mongolian road network has consisted of mainly "natural" tracks. The registered network includes national roads (11210km), which connect the aimag centers, local and rural roads. Mongolian government mainly supports for construction and rehabilitation of the roads for last five years. Two pavement rehabilitation methodologies which are traditional and cold recycling technology were applied in this study. The objective of this study is to compare two methodologies which are old traditional and new cold recycling for pavement rehabilitation and its impact on environment in the Gobi region of Mongolia. The study area is Gashuun sukhait road basin which located in Umnugobi province, Mongolia. In this study, we used statistical and economic data, laboratory analysis and Landsat satellite images for 2014 and 2016. Cold recycling is the term used for recovering and re-using material from an existing pavement, without the addition of heat. The old traditional methodology needs more construction area which cause land degradation. Pavement, additionally cement and lime were used for the new methodology. The cold recycliyng technology is very important for road construction and rehabilitation in Mongolia. The advantage of this study is to apply statistical, economic, laboratory analysis data and satellite images for monitoring the road rehabilitation. The economic results and satellite images show that the new methodology is friendly for environment and economically beneficial.

Keywords: pavement rehabilitation, GIS, technology, remote sensing.

1. Introduction

There is less studies about the pavement rehabilitation in Mongolia. The roads important in Mongolia specially in Gobi region. The roads are extending and developing with mining in the study area. Old traditional methodologies for road pavement does not meet environmental protection requirements. There is need to apply environmental friendly methodology for pavement rehabilitation in Mongolian roads.

Therefore, land degradation expanding due to road development and mining exploration in some areas in the Gobi Mongolia. It is necessary to input new technology which is environmental friendly and economically beneficial for road construction in Mongolia. Due to higher age and fault/damage/ half of pavement requires reconstruction in the study area.

*Received Sep 7, 2018 * Published Oct 2, 2018 * www.ijset.net*

The purpose of this research is to apply new methodology in order to improve the pavement system which is available for Mongolian condition.

Cold recycling technology is to use a specific machine to mill the pavement material in the work zone and that material is the term used for recovering and re-using material for existing pavement. Cold recycling technology is currently employed to construct all types of pavements. Where a pavement is in a distressed state, there is always an option to recycle the existing material and reap the benefits in terms of lower construction costs, improved durability and equally important, a significant reduction in the negative impact that construction has on the environment (GmbH 2012).

In this research, we selected pavement from TavanTolgoi mining to Gashuun Sukhait/ 239km/ which is located in Umnugobi province in the Southern part of Mongolia. This research investigated the possibility and suitability of using cold in-place recycling methodology. For this reason, comparison for old traditional and new cold in-place recycling methodology has been developed.

For the comparison cold in-place recycling methodology with the traditional methodology we used social-economic data, and satellite Landsat data for 2014 and 2016. The purpose of using satellite data (Modified Soil Adjusted Vegetation Index) is to monitor road basin area before and after of using new methodology. MSAVI images allowed to see which methodologies were environmental friendly.

2. Study area

The study area is located in South of the country which is Gobi region (E105.084-106.6, N43.30-44.36) (Figure 1). The climate is very dry and soil is a sandy. In summer 45-50□, in winter -18□ and in springtime have a clump storm. As regard pavement, depth's overlap 7.5m has a 2 side within 1.5 depth margin. It estimated to transfer 1000 cars in ordinary one side for 24 hours. The new methodology was used from 2015, while old methodology applied for the study area until 2014.

The areahas 100 to 125mm precipitation and mean air temperature is 5 Celsius. There is dust storm is high during the spring. We selected the road from Tavantolgoi mining to Gashuunsukhait border point for this study. Umnugobi province is one of the biggest mining area where is Oyutolgoi, Rio Tinto's enormous copper-gold mine and Tavantolgoi, the world's largest coking coal deposit. This roadis congested, so the road rehabilitation needs to be done quality and safely.

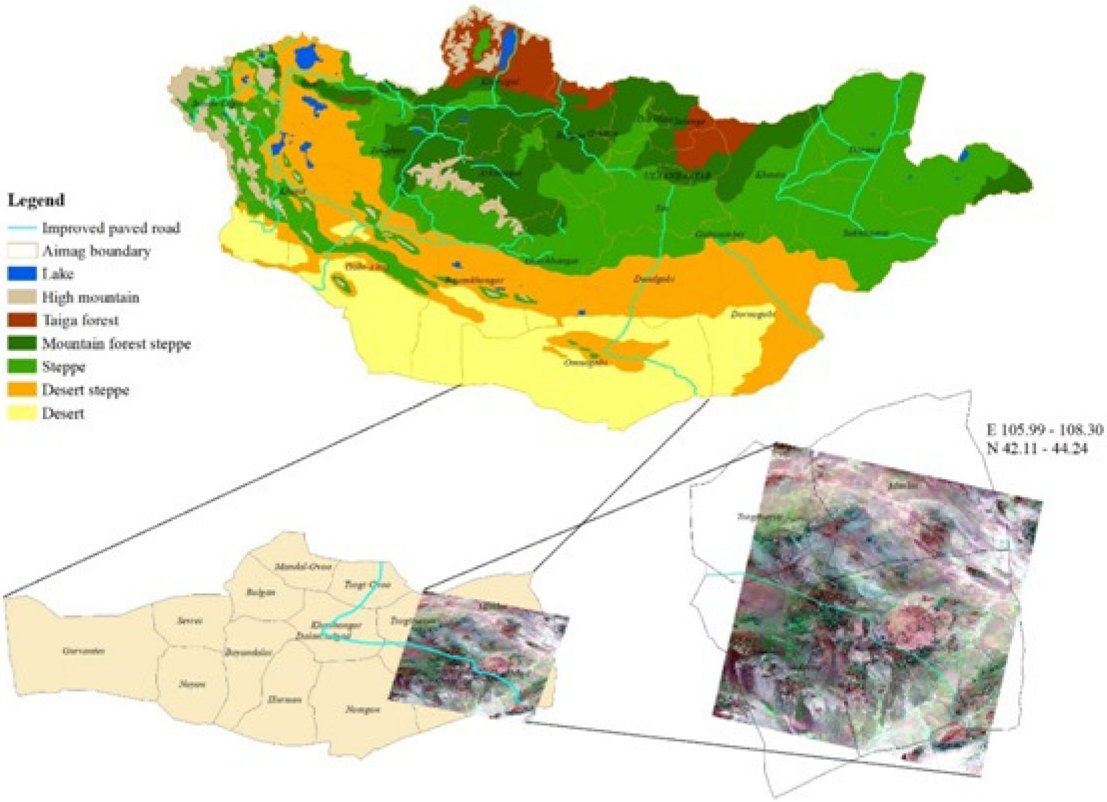


Figure 1. Study area (Umnugobi province)

3. Data

We used remote sensing data from Landsat OLI with 30m resolution for the July and August for years 2014 and 2016.

Table 1. Landsat 8 OLI band wavelength (Markham 2013)

Landsat-8 OLI and *TIRS* Bands (µm)		
30 m Coastal/Aerosol	0.435 - 0.451	Band 1
30 m Blue	0.452 - 0.512	Band 2
30 m Green	0.533 - 0.590	Band 3
30 m Red	0.636 - 0.673	Band 4
30 m NIR	0.851 - 0.879	Band 5
30 m SWIR-1	1.566 - 1.651	Band 6
100 m TIR-1	*10.60 – 11.19*	Band 10
100 m TIR-2	*11.50 – 12.51*	Band 11
30 m SWIR-2	2.107 - 2.294	Band 7
15 m Pan	0.503 - 0.676	Band 8
30 m Cirrus	1.363 - 1.384	Band 9

Landsat 8 Operational Land Imager (OLI) image (path 130, row 30) was downloaded from the USGS earth resource observation and science center (EROS) website, and applied for this

research (http://glovis.usgs.gov/). MSAVI was calculated using spectral bands 5 and 4 (Table 1).

The old material from traditional methodology and new material for cold in-place recycling technology was measured in the laboratory for testing. The materials taken from the selected 19 samples (table 2).

Table 2. Ground truth measurement

Samples	Latitude	Longitude	Samples	Latitude	Longitude
1	43°25'46.78"N	105°56'9.01"E	11	42°49'59.30"N	106°57'48.10"
2	43°19'20.10"N	106°4'39.88"E	12	42°44'43.14"N	107°4'19.24"E
3	43°17'23.00"N	106°8'41.43"E	13	42°42'31.64"N	107°8'54.43"E
4	43°12'7.60"N,	06°22'25.05"E	14	42°40'49.17"N	107°10'4.71"E
5	43°12'8.62"N,	06°22'21.09"E	15	42°40'30.10"N	107°12'17.17"
6	43°9'5.71"N,	6°33'49.01"E	16	42°39'0.99"N,	07°18'33.46"E
7	43°6'41.16"N,	06°36'53.82"E	17	42°38'29.32"N	107°20'36.11"
8	43°1'44.23"N,	06°40'38.01"E	18	42°39'6.33"N,	07°27'31.20"E
9	42°57'52.59"N	106°41'56.46"	19	42°37'16.42"N	107°29'46.46"
10	42°49'35.89"N	106°55'57.69"			

Table 3 displayed comparison between old pavement materials and improved pavement materials with 8% cement. The improved pavement material was high quality than old pavement materials. It shown by under strength laboratory conditions (mPa) were 0.5 (old material) and 5.05 (improved material).

Table 3. Comparative samples of pavement materials/sample material analysis in laboratory.

Criteria	Old pavement materials	Improved old pavement materials with 8% cement
Maximum amount of granules, mm	37.5	25
Liquid limit (LL) %	24.8	25.1
Plasticity index	3.6	2.7
Soil carrying capacity (CBR) %	49	82
Indicator of soil shaft (CBR) %	0.07	0.05
Maximum amount of dry density (gr/cm3)	2.163	2.170
Suitable moisture content (%)	5.8	5.9
Under compressive strength laboratory conditions (mPa)	0.5	**5.05**
Note: In specification of laboratory condition the strength of the week must be 3.75-6.0 mPa.		

The traditional and cold in-place recycling technology was compared also by economic results. Table 4 and table 5describe the results by types of work for traditional and cold-place recycling technologyrespectively.

Table 4. Traditional /old/ technology

	Types of work	scales	units	cost of per unit		cost		Total cost	Working time	%
				cost of materials	cost of labor & transportation	cost of materials	cost of labor & transportation			
Existing Surface Preparation for Overlays		m3	**14,830**	**-**	**4,504**	**-**	**66,794,320**	**66,794,320**	**7**	**11%**
1	removing an old pavement layers at full depth									
2	transporting a removed old pavement materials									
construction			**14,830**	**521,054**	**99,471**	**352,829,700**	**192,254,780**	**545,084,480**	**9**	**89%**
3	base	m3	1,440	25,000	7,889	36,000,000	11,360,160	47,360,160	2	8%
4	subbase	m3	3,300	12,429	1,500	41,015,700	4,950,000	45,965,700	2	8%
5	subgrade	m3	9,600	1,500	12,429	14,400,000	119,318,400	133,718,400	3	22%
6	Asphalt base layer	m3	490	480,000	76,278	235,200,000	37,376,220	272,576,220	2	45%
7	Asphalt wearing surface	m2	14,000	1,125	1,375	15,750,000	19,250,000	35,000,000	2	6%
8	water usage	ton	10,464	1,000	-	10,464,000		10,464,000		2%
Total			**29,660**			**352,829,700**	**259,049,100**	**611,878,800**	**16**	**100%**

Table 5. New /Cold in-place recycling/ technology

#	types of work	scales	units	cost of per unit		cost		Total cost	Working time	%
				cost of materials	cost of labor & transportation	cost of materials	cost of labor & transportation			
Existing Surface Preparation for Overlays		m3	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0%**
1	removing an old pavement layers at full depth									
2	transporting a removed old pavement materials									
Constriction			**12,754**	**508,755**	**118,292**	**241,624,000**	**127,708,420**	**369,332,420**	**5**	**100%**

3	Base	m3	1,440	13,000	22,223	18,720,000	32,001,120	50,721,120	1	14%
4	Subbase	m3	3,300	13,255	18,791	43,740,000	62,010,000	105,750,000	2	29%
5	Subgrade	m3	-	-	-	-	-	-		0%
6	Asphalt base layer	m3	350	480,000	76,278	168,000,000	26,697,300	194,697,300	2	53%
7	Asphalt wearing surface	m2	7,000	1,500	1,000	10,500,000	7,000,000	17,500,000	1	5%
8	water usage	ton	664	1,000	-	664,000		664,000		0%
Total			**12,754**			**241,624,000**	**127,708,420**	**369,332,420**	**5**	**100%**

4. Methodology

In this research we applied both Traditional and Cold in-place recycling technologies. The traditional technology is described in the figure 2. The traditional technology process was applied in the following steps: Firstly, construction area was preparedand then rip and break up pavement and applied base materials. That process removes ripped and broken up pavement materials. Subgrade course consist of subsoil compaction and subgrade elevation which are followed by subbase course, prime coat, binder course and tack coat seal coat (figure 2).

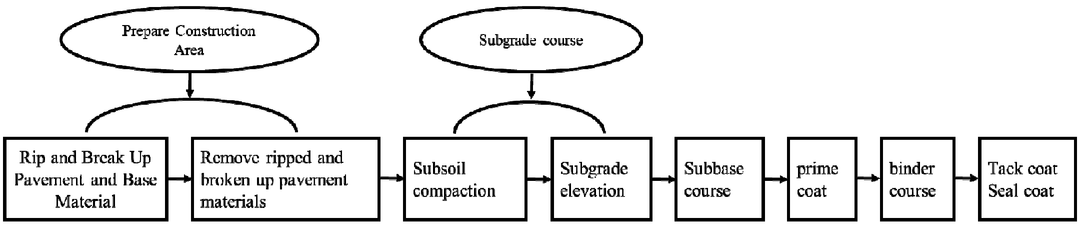


Figure 2. Traditional Flexible Pavement Steps

The figure 3 shows cold in-place recycling technology and its general process which included machine, equipment and processing.

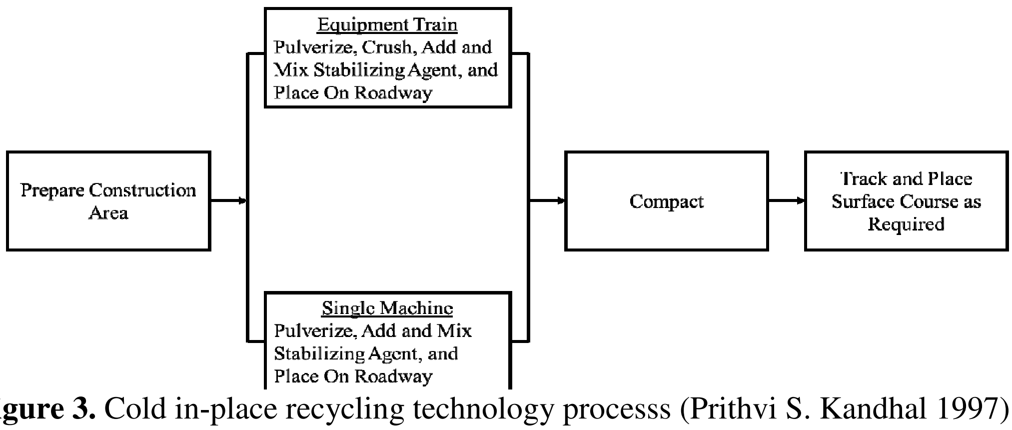


Figure 3. Cold in-place recycling technology processs (Prithvi S. Kandhal 1997)

We applied and conducted cold in-place recycling using for Milling. The milling procedure is displayed in the figure 4 (Prithvi S. Kandhal 1997).

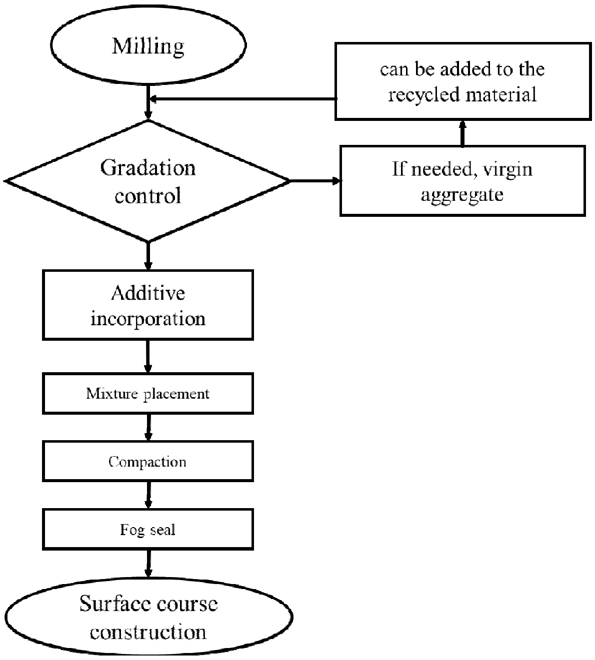


Figure 4. Cold in-place recycling using milling

With regard to monitoring land degradation with remote sensing, we applied Modified Soil Adjusted Vegetation Index (MSAVI) indexes from Landsat to monitor land degradation due to pavement. We usedMSAVI indexes before to apply and after cold in-place recycling in 2014 and in 2016 respectively. The spectral bands from Landsat (Near Infrared 0.85-0.88μm, Visible RED 0.64-0.67μm) (Table 1) and equation 1 were selected for estimation for vegetation and land degradation process.

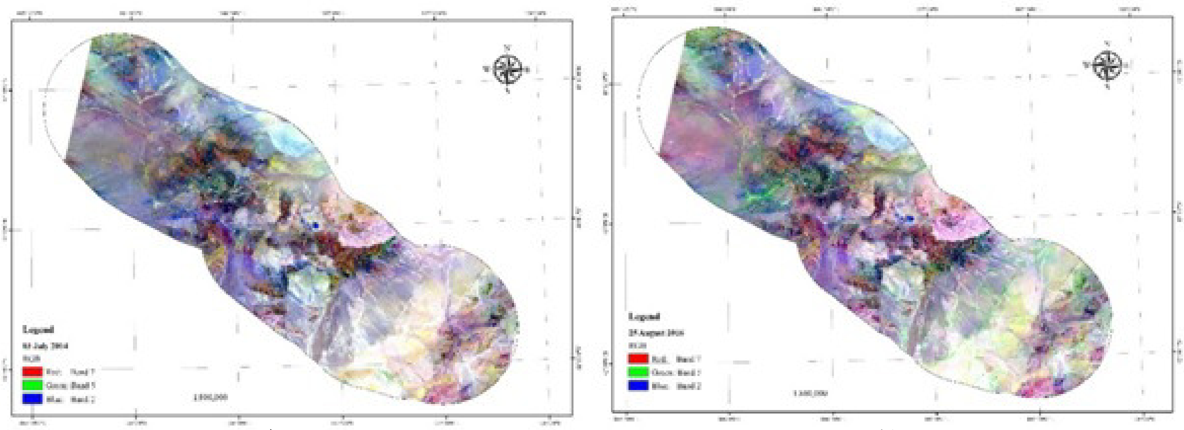
Heute (1988)suggested a new vegetation index, which was designed to minimize the effect for the soil background, which called the soil adjusted vegetation index, developed from an iterated version of this vegetation which is called MSAVI (1).

$$MSAVI2 = \frac{\left(2*NIR+1-\sqrt{(2*NIR+1)^2-8*(NIR-RED)}\right)}{2} \quad (1)$$

5. Image processing

The traditional methodology was used in July, 2014 and cold in-place recycling methodology was used in August 2016.

Figure 5a shows false color of land cover condition using traditional technology in July 2014 while figure 5b describes land cover condition using cold in–place recycling technology in August 2016.



a) b)

Figure 5. False color combinations of Landsat OLI bands. Infrared plus visible color. Bands 2-5-7 = BGR (a) July 2014, (b) August 2016

6. Analysis

In order to compare two methodologies,we estimated the costs for traditional and cold in-place recycling technologies per km area. Figure 6 and figure 7 displays comparison for rehabilitation costs and transportation pavement respectively.

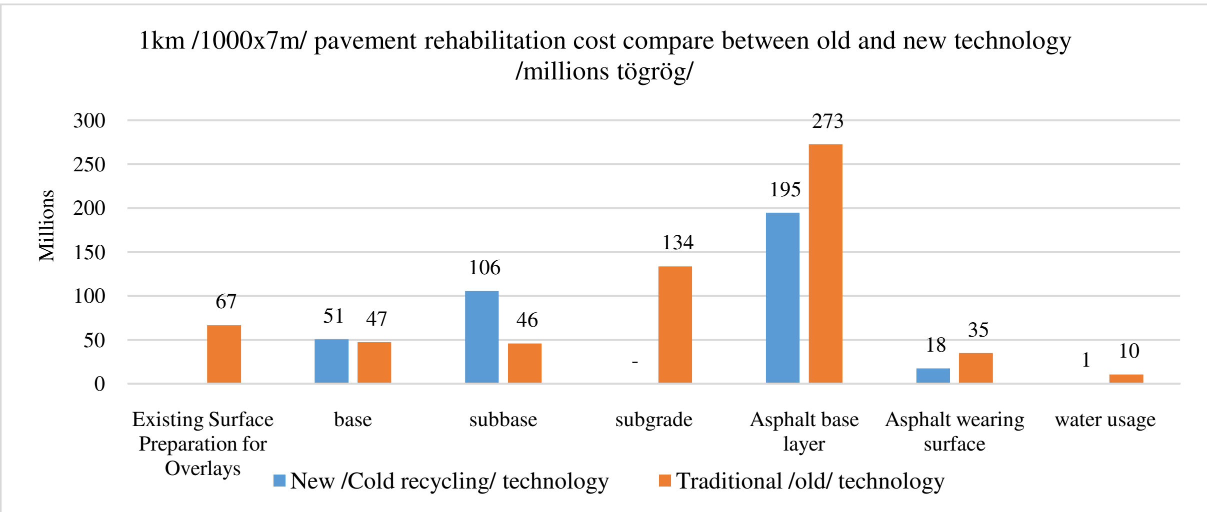


Figure 6. The pavement rehabilitation costs for traditional and cold in-place recycling technologies

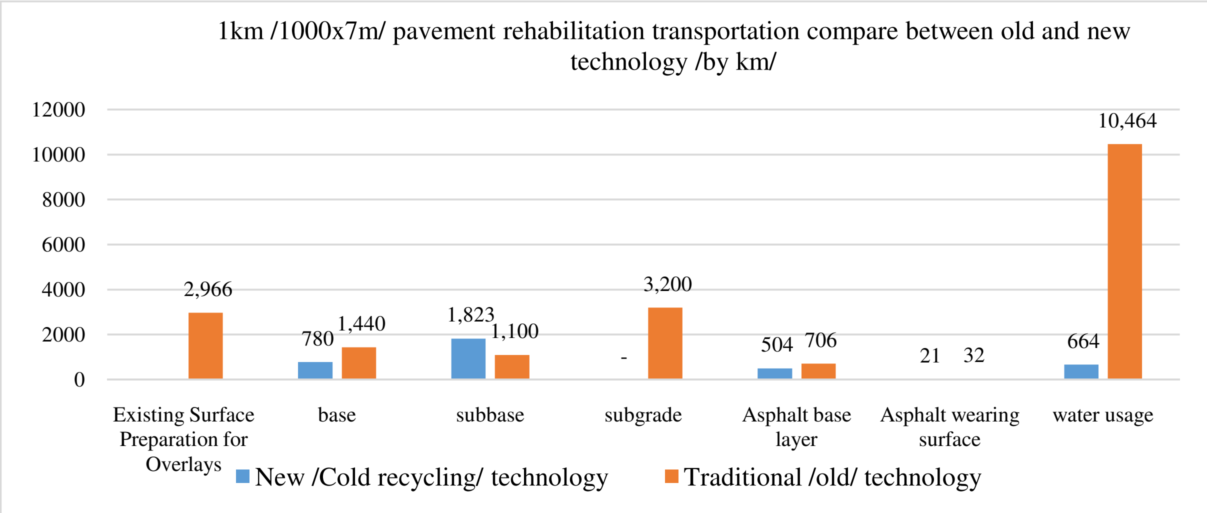


Figure 7. 1km pavement transportation for traditional and cold in-place recycling technologies

The output MSAVI images vary from -1(low)to 1(high) vegetation. MSAVI maps by green colors (high vegetation), while red and orange colors indicate low vegetation (figure 8a and b).

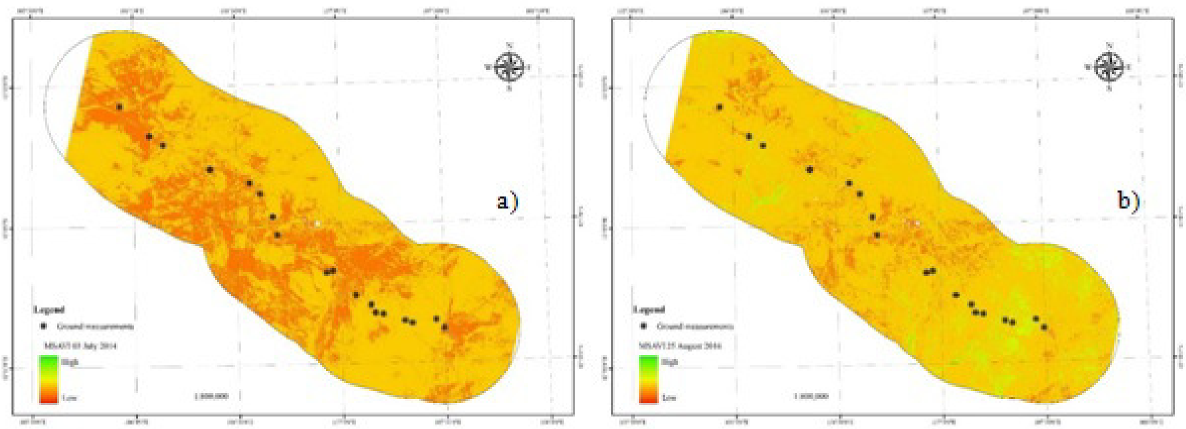


Figure 8. MSAVI change map for the July, 2014 (a) and August, 2016 (b).

The figure 8 (a) shows MSAVI of July 2014 which used traditional technology while figure 8 (b) shows MSAVI of August 2016 where used cold in-place recycling technology for the pavement rehabilitation.

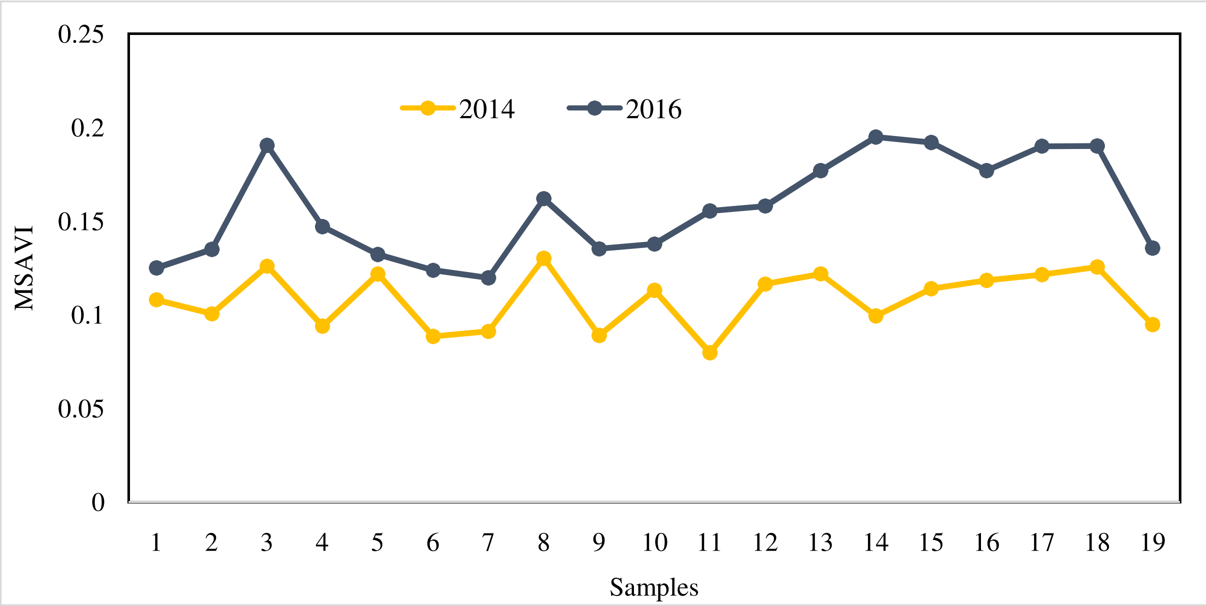


Figure 9. MSAVI values for the July 2014 and August 2016.

The figure 9describes the difference for vegetation regarding of the two methodologies for pavement rehabilitation. There are higher values for MSAVI in 2016 where new cold in-place recycling applied. MSAVI values are between 0.12-0.2 for 2016 and for the 2014 MSAVI are 0.8-0.13. From this analysis, the cold in-place recycling technology is suitable and environmental friendly methodology in the study area.

7. Results and discussion

Satellite Landsat data was applied to monitor land degradation and rehabilitation process during of applying traditional and new (cold in-place recycling) technology for pavement of the roads in the study area. Modified Soil Adjusted Vegetation Index (MSAVI) was used as indicator of land degradation and rehabilitation during pavement roads in the study area. MSAVI shows higher result for year 2016 in the road area where cold in-place recycling technology was applied (Figure 8b and figure 9).

The materials for laboratory test for pavement using old and new cold in-place recycling technology were different. From the comparison analysis of the materials it seen that there is improvement for quality materials and low cost for new (cold in-place recycling) technology.

The advantage of this study is to use satellite data and vegetation index. Remote sensing data can be useful tool to monitor road rehabilitation. New technology cold in-place recycling is economicallyimportant tool for pavement in Mongolia. This cold in-place recycling methodology can be applied for other region where is same land condition. There is need more road related research using satellite data and Geographic Information System (GIS) in Mongolia. Application of Remote sensing (RS) and Geographic information system (GIS) data for road rehabilitation monitoring can be important future development of new technologies for land development and rehabilitation in different region.

The cold in-place recycling technology used in this study will potentially improve regional road pavement rehabilitation of areas where roads needed to be under reconstruction. High resolution satellite data can also be used for road construction deformation as in the cases of bridges and pipelines in the region. This study for road pavement and rehabilitation maybe extended beyond mining and road basin areas by using satellite image and GIS analysis.

References

[1] (AASHTO), American Association of State Highway and Transportation Officials. 1998. *Report on Cold Recycling of Asphalt Pavements.* Washington, D.C: American Association of State Highway and Transportation Officials.

[2] GmbH, Wirtgen. 2012. *Wirtgen Cold Recycling Technology.* Windhagen.

[3] n.d. *http://www.pavementinteractive.org/.* http://www.pavementinteractive.org/cold-in-place-recycling/#footnote-1.

[4] J.Barsi, L. Rocchio and. 2018. *Landsat science.* March.
https://landsat.gsfc.nasa.gov/landsat-data-continuity-mission/.

[5] Markham, B. 2013. *Landsat science.* July. https://landsat.gsfc.nasa.gov/landsat-data-continuity-mission/.

[6] Prithvi S. Kandhal, Rajib B. Mallick. 1997. "FHWA-SA-98-042." Final Report, Washington, DC.