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Original Research Article

Threats of sedimentation to agricultural land due to land use and degradation of watershed physical environmental

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ABSTRACT

Background: The Lake Lindu sub-watershed has experienced environmental damage, mainly as a result of various activities of the surrounding community who are less aware of the principles of environmental sustainability. This study aims to determine the effect of land use area and environmental physical conditions on sedimentation and water debit in the Lake Lindu sub-watershed.
Methods: This research was carried out by implementing survey and non-experimental method at 3 rivers: Langko (P1), Wongkodono (P2), and Kati (P3). The dependent variable in this study is the area of land use (area of farm, shrub, paddy field, forest, and settlement) and the physical condition of the environment (the width of the catchment area and annual average rainfall). Then, the independent variables are sedimentation and water debit. Statistical analysis used is a multiple regression model.
Results: The results of this study are that the wider shrub (X_2) reduces the sedimentation (Y_1) and increases the water debit (Y_2). Each addition of one shrub unit will reduce the sediment by 0.208 mg/L and affect the water debit of 0.258 m^3/ s-1. The regression equation is Y_1=185.903 - 0.208X_2-587.269X_8 and Y_2=6.854+0.258 X_2 - 71.708 X_8. As for the coefficient of the shape of the river (X_8). The bigger the shape of the river, the smaller the average of the water debit. Thus, each reduction of one coefficient unit of the river shape will affect the water debit of 71,708 m^3 /s-1.
Conclusions: The significant predictor factors for sedimentation and river water debit are the shrubs and the coefficient of the river shape.

Keywords: Land use, Environmental physical condition, Shrubs, River shape, Sedimentation

INTRODUCTION

The causes of the disruption in the condition of a watershed ecosystem may vary. One of which is the human beings who live in the ecosystem area.[1] If the watershed function is disrupted, the hydrological system which is the main function of the watershed is disturbed. Then, the water absorption and storage are reduced.[2] This condition causes the runoff of surface water in the rainy season, and reduced water during the dry season. This also causes a very sharp fluctuation in the river water debit/ flow rate between the dry season and the rainy season. Very sharp fluctuations indicate that the watershed function is unstable.[3,4]

Watershed as an ecological controller has a strategic function.[5] Therefore, the damage to the watershed has implications for many things, including the possibility of degradation of the physical environment and destruction of the agricultural land.[6] Physical environmental degradation stimulates damage to chemical and biological characteristics of the land as the determinant of agricultural business productivity. In addition, the lake as a reservoir in the watershed greatly determines the reservoir functions. Strong indicators of watershed malfunctions as biological controllers can be detected in siltation of the lake due to sedimentation.[7] The maximum depth of Lake Lindu measured in 2017 was 72.6 meters. There are indications of siltation of almost 30 meters compared to 1970 in which the depth reached 100 meters. The high level of sedimentation that has affected the silting of Lake Lindu needs tactical measures to be taken so that damage to agricultural land due to surface runoff in the form of flash floods can be controlled. Flash floods that take place due to the inability of the watershed to control surface flow are ecologically and economically a serious threat for the long term in the future.[8]

Land use is a human intervention both permanently and periodically to meet the needs of life both materially and spiritually, to the land resource complex. Land use patterns of an area can provide an overview of the economic life of the region concerned and at the same time can be used as an indicator of the level of environmental pollution so that there is an interest in providing more extensive land in order to develop a growing base of economies.[9,10]

Lake Lindu watershed has experienced environmental damage due to the activities of the surrounding community who are not paying attention to the principles of environmental sustainability. Currently, Lindu Watershed has lost more than 16,000 ha of forest area.[11] The main cause is the illegal conversion of forests into agricultural land. This can cause the lake to be in a state of succession, which changes it from aquatic ecosystems into terrestrial ecosystems. The main environmental physical factors that influence watershed management are the climate factor of rainfall.[12,13] There are several factors that influence the water debit, namely rainfall intensity, deforestation, conversion of forests to agricultural land, interception, evaporation and transpiration, wind, and surface flow velocity.[14] The magnitude of the fluctuations in river flows and sedimentation reflects the pattern of land use and the physical condition of the environment.[15]

This study aims to determine the effect of extensive land use, conversion of forest functions, and physical environmental conditions on sedimentation and water debit in the Lindu watershed.

METHODS

This research was conducted by survey and descriptive methods from January to April 2017 located in the Lindu watershed with Langko, Wongkodono, and Kati Sub watersheds. Determination of the amount of sediment measured in the field continued at the Laboratory of Geology, Faculty of Agriculture, Tadulako University.

Table 1: Sub watersheds of the research.

Sub watersheds	Observation station	Area (km^2)
Langko	P1	9,68
Wongkodono	P2	2.794
Kati	P3	138,04

Research variables

The dependent variables in this research are the area of land use (area of farm, shrubs, paddy field, forest, and settlement) and the physical condition of the environment (the width of the catchment area, and annual average rainfall). And the independent variables are the sedimentation and water debit (Table 2).

Table 2: Dependent and independent variables of the research.

Variable	Sub variable	Notation	Unit*
Land use pattern area	Farm	X_1	%
	Shrubs	X_2	%
	Field	X_3	%
	Primary forest	X_4	%
	Secondary forest	X_5	%
Environmental physical condition	Sub watershed area	X_6	km^2
	Rainfall average	X_7	$mm\ th^{-1}$
	River shape coefficient	X_8	Km^2
Sedimentation		Y_1	$Ton\ ha^{-1}\ th^{-1}$
Water Debit		Y_2	m^3/det

Data collection

The points and period of the observation

- There are 3 (three) catches of observation points, each observation point is measured twice on the edge
- The river and at the middle of the river. Thus, the number of water samples in each of the 3 observation points is 6 samples in each measurement.
- For the observation period, each point was repeated at 7-day intervals (1 week), so the measurements during the study were 7 measurements.

The measurement of the flow rate

The measurement of river water debit and flow rate used the direct method with the equation of buoyancy formula:

Q=V. A

Information: V=Average flow rate (m/sec); A=Area of river cross section (m^2); Q=river flow rate (m^3/sec)

Water sampling technique (floating sediment)

Water sampling technique by using bottle is a modification of Depth – Integrating Suspended technique. The bottle of sediment sample is made simpler with two holes. The first hole for water sample entry and another one for air hole.

Floating sediment analysis

The amount of sediment concentrate is determined from sediment sample analysis using evaporation method with the following equation:

C=x (*b-a)* x 1000 (*mg/l)*

Data collection

The amount of points and observation time

- The number of observation points is 3 (three) catchments. Twice measurements were done for each observation point, which were from the edge of the river and the middle of the river. Therefore, the number of water samples in each of the three observation points was 6 samples from each measurement.
- For the observation time, the observation of each point is repeated with an interval of every 7 days (1 week) then the measurement during the study was 7 times measurements.

The measurement of flow velocity

The measurement of the water debit and the velocity of river flow used the direct method with the equation of the floating ball formula:

Q=V. A

Information: V=Average flow rate (m/sec); A=Area of river cross section (m^2); Q=river flow rate (m^3/sec)

Water sampling technique (floating sediment)

The water samples were taken by using a bottle which is a modification of the Depth-Integrating Suspended technique. Bottles of sediment samples are made simpler where the bottle is equipped with two holes. The first hole is for the entry of water samples and the other hole is for the air.

Surface sediment analysis

The amount of sediment concentration is determined based on the analysis of the sediment samples using the evaporation method with the following equation:

C=x (*b-a)* x 1000 (*mg/l)* Information:

C=Sediment Concentration (mg/l)
V=sediment sample volume (ml)
b=The weight of the cup contains sediment deposits (gram) a=The weight of the empty cup (gram)

The amount of sediment concentration and water debit which is determined by the following equation: Qs=0,00864 C. Q. in which Qs=total of sediment (ton/day).

C=Sediment concentration (mg/l), and Q=river debit (m^3/sec).

Transported sediment value

The amounts of sediment per unit of are calculated by the following equation:

In which determination of the amount of erosion (a) is obtained from the implementation of USLE formula simulation: A=R. K. LS. C. P.

Then, the transported sediment is: Y=SDR/A.

Statistical analysis

The statistical analysis method used is multiple regression model to determine the relationship of independent variables (X) with the response variable (Y). In this research, the regression equation used is:

$$\mathbf{Y=a+b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5+b_6X_6+b_7X_7+b_8+X_8+\varepsilon}\text{..............}$$

In which:

Y_1 =Sedimentation
Y_2 =Water Debit
X_1 =Farm
X_2 =Shrubs
X_3 =Field
X_4 =Forest
X_5 =Settlements
X_6 =Sub Watershed
X_7 =Average rainfall
X_8 =River shape coefficient
a =Constant value
$b_{(1-8)}$ =Regression coefficient value
ε =Error

RESULTS

The fluctuating condition of river water debit is very dependent on the duration and the heavy rainfall that falls on the catchment area. The condition of water debit in the research location is presented in Table 3.

Table 3 shows that the river with the largest water debit was Kati River (P3) with an average of 10.0 m^3/sec when it was not raining, and after raining, it was 24.58 m^3/ sec. The smallest water debit was found in the Wongkodono River (P2) which was 0.125 m^3/sec when it was not raining, and after raining, it was 1.25 m^3/sec.

Table 4 shows that the river with the largest sedimentation was Kati River (P3) with an average sedimentation rate (when it rained and after rain) was 165 mg/L and the lowest was Langko River (P1) with an average sedimentation (when it rained and after rain) of 109.42 mg/L. Table 5 shows that the land use by the surrounding community is farm and rfield. The biggest use of land as farm was in Langko River (P1) of 16.91% and field of 8.78%.

Table 3: River water debit based on the rain time during research.

Name of river	Water debit (m^3/sec)							
	Before raining				After raining			
	1	2	3	4	1	2	3	4
Langko (P1)	0.4	0.5	0.6	0.9	1.1	1.2	7.2	1.1
Wongkodono (P2)	0.1	0.2	0.1	0.1	0.5	0.5	3.6	0.4
Kati (P3)	6.8	6.8	13.7	12.7	15.1	15.6	52.5	15.1

Table 4: River sedimentation data based on rain time during research.

Nama of river	Sedimentation (mg/L)	Note
Langko (P1)	100	Not Raining
	128	Not Raining
	108	Raining
	168	Raining
	126	Not Raining
	118	Not Raining
	18	Raining
Wongkodono (P2)	124	Not Raining
	124	Not Raining
	122	Raining
	144	Raining
	174	Not Raining
	120	Not Raining
	126	Raining
Kati (P3)	144	Not Raining
	190	Not Raining
	303	Raining
	264	Raining
	14	Not Raining
	56	Not Raining
	184	Raining

Table 5: Land use of the watershede.

Land Use	Langko (P1)		Wongkodono (P2)		Kati (P3)	
	Area Ha	%	Area Ha	%	Area Ha	%
Farm (X1)	163.73	16.91	336.76	12.06	974.31	7.06
Shrubs (X2)	14.75	1.52	0	0	46.88	0.34
Field (X3)	84.98	8.78	112.41	4.03	116.83	0.85
Primary Forest (X4)	314.08	32.43	1,662.70	59.56	5,396.10	39.07
Secondary forest (X5)	390.84	40.36	678.64	24.31	7,275.87	52.69

Table 6: Area of catchment in sub watersheds.

Environmental physical conditions	Langko (P1)		Wongkodono (P2)		Kati (P3)	
	Value	Unit	Value	Unit	Value	Unit
Catchment area (X6)	968.38	Km^2	2,790.54	Km^2	13,809.99	Km^2
Average rainfall (X7)	2,205.42	mm $year^{-1}$	2,205.42	mm $year^{-1}$	2,205.42	mm $year^{-1}$
River shape coefficient (X8)	0.125	-	0.089	-	0.036	-

Table 7: The Damage to the agricultural area in Lindu watershed and farmer economic loss.

No	Sub watersheds	Damaged agricultural area (ha)	Economic loss (Rp)	Year of occurence	Cause
1	Langko	1.570	2,412,342,000	2015-2017	Water Runoff and sedimentation on agricultural land
2	Wongkodono	2.076	3,214,546,441	2016-2017	
3	Kati	1.763	2,809,997,000	2015-2017	

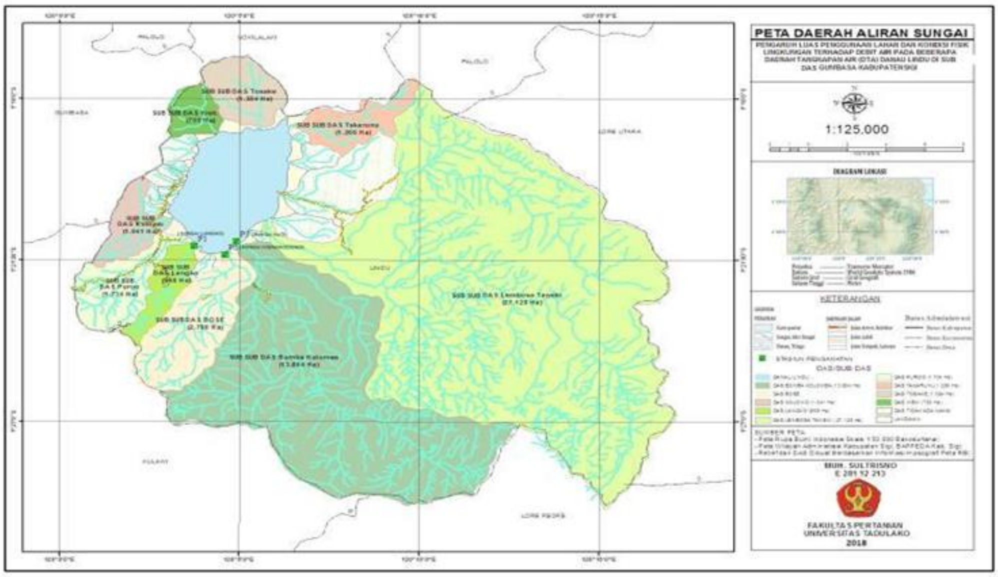

Figure 1: Map of Lake Lindu watershed.

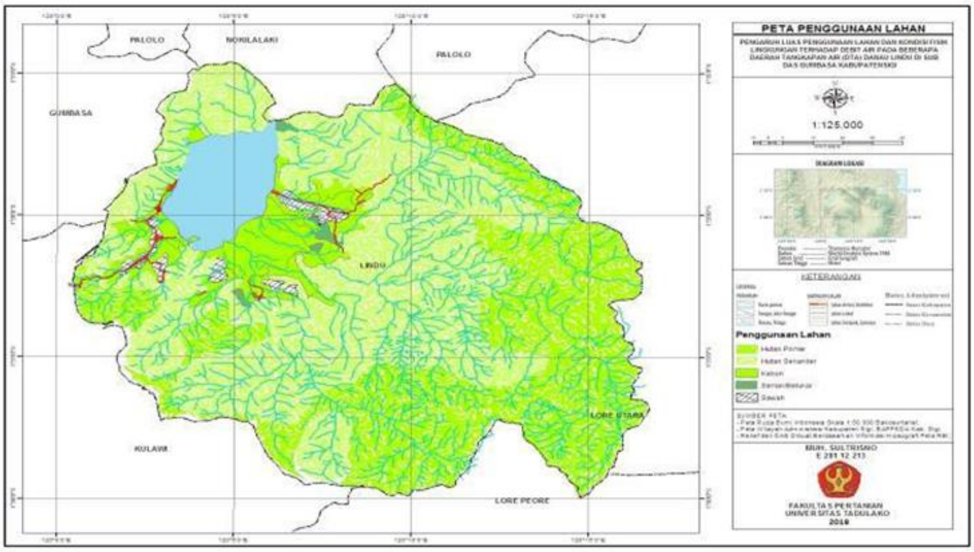

Figure 2: Map of land use.

Table 6 shows that the largest catchment area (watershed) was found in Kati Rver (P3) of 13,809.99 km2 and the lowest was in Langko River (P1) of 968.38 km2. The average rainfall was 2,205.42 mm/ year-1 and the largest river shape coefficient was the Langko River (P1) of 0.125.

Factors affecting sedimentation (Y_1)

The results of multiple linear regression analysis of eight variables included in the equation shows that only two variables have a significant effect on sedimentation and the following equation was obtained:

$$Y_1=185,903 - 0,208X_2 – 587,269X_8$$

Where Y_1=Sedimentation, X_2=Shrubs, X_8=river shape coefficient.

These results indicate that the variables that significantly influence the process of sedimentation are the coefficient of river shape and the shrubs (very negative), in which the wider the coefficient of river shape will increase the sedimentation by 587.269 mg / L as it had been done with multiple linear regression calculations, the Lake Lindu watershed area has a broad river shape coefficient so that the sedimentation is greater.

Factors that influence the river Debit (Y_2)

The results of multiple linear regression analysis of the eight variables included in the equation show that only two variables have a significant effect on the change in the average measured debit and the following equation was obtained:

$$Y_2=6,854 + 0,258 X_2 – 71,708 X_8$$

Y_2=average measured debit, X_2=shrubs, X_8=river shape coefficient.

From the regression relationship in equation (1), it is found that R2 is very good, that is 1 or 100% change in the average measured debit which is closely related to the variable of shrubs and the coefficient of river shape.

Agricultural land damage and economic loss

The results of the calculation of agricultural area in the Lindu Watershed which was damaged by surface runoff and economic loss can be seen in Table 7. Based on Table 7 shows the level of damage in the three sub-watersheds. In the Lindu watershed, there is a Wongkodono Sub-watershed of 2,076 ha with economic losses reaching Rp 3.2 billion. Kati and Longko Sub-watersheds with losses of Rp.2.8 and Rp.2.4 billion respectively. The cause of land damage was surface runoff which resulted in accumulation of material or sediment on the agricultural land.

DISCUSSION

The results of the research showed that the wider shrub reduced the level of sedimentation and enlarged the water debit. The addition of a shrub area reduced the sediment by 0.208 mg/L and affected the water debit by 0.258 m^3/sec. The presence of shrubs can maintain the long-term sustainability of the Lake Lindu watershed so as to prevent the occurrence of silting of the lake. However, a large water debit can be minimized by the presence of shrubs. The principle of kinetic energy that works on the land surface will be minimum and at the same time the level of infiltration and percolation will increase.[16,17] High percolation water can increase the water table as a reservoir function in the catchment area. In addition, a high percolation can reduce the volume of surface flow which has the potential to erode the top soil that will become sediment in the lakes and rivers.[17]

Shrubs are areas of land that are overgrown with a variety of heterogeneous and homogeneous natural vegetation with various density level.[18,19] Shrubs in Indonesia are usually ex-forest areas that do not have logged area anymore.[20] Shrubs are generally areas that are not economically productive so that they are abandoned by farmers. Hydrologically, shrubs have important hydrological functions, especially to maintain the microclimate, soil moisture and microorganism activity.[21,22] The range of shrubs in some areas is quite large. Shrub areas in general have never been touched by farmers' activities, so they tend to be original.[23] The encroachment by the community around the protected forests or catchment areas is a threat that may lead to land damage that will be eliminating the function of shrubs in suppressing the flow rate.[24]

The higher the river shape coefficients, the smaller the average water flow. Therefore, each reduction of one-unit coefficient of the river will affect the water debit of 71,708 m^3/sec. When the amount of water in an area continues to increase, the time needed for the water to flow will be faster. Thus, this causes an increase in water debit when it rains.

Increasing the amount of water debit after rain occurs at the sampling points is still in the normal range. The highest amount of the debit after rain occurs at Kati River with a debit amount of 52.5 m^3/sec. If the water flow of the surface flow continues to increase to exceed 65 m^3/ sec, it will have a negative impact on the activities of the local communities, especially the activities in the rice fields.[25,26] Meanwhile, the amount of the debit will not affect other agricultural activities, such as the fields of seasonal plants that are located around the sampling point as long as the surface flow is still within controlled limits.

The amount of the water debit has an influence on agricultural activities and the amount of water that will enter the agricultural area.[27,28] If the water debit is too low, the water supply probably cannot meet agricultural needs. On the contrary, if the water debit is too high, it will have a negative impact on the agricultural crops, especially the rice fields.[29] The availability of water is very important for agricultural activities, especially for the seasonal crops. The need for water for seasonal crops is much greater than the annual crops.[30,31]

Good watershed management through proper land use is a key factor in preventing sedimentation and flash floods that can destroy agricultural businesses, even the threat of degradation of the physical environment and settlements.[32,33]

CONCLUSION

The main factors and predictors of sedimentation and water debit in the Lake Lindu Watershed are the shrubs and river shape coefficients, in addition to suitable land use based on soil capacity and capability. Keeping the shrub will reduce the rate of erosion that can reduce crushing in the top soil while increasing the infiltration and percolation forces to encourage groundwater accumulation as a reservoir.

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REFERENCES

1. Ni J, Xu J, Zhang M. Constructed wetland modelling for watershed ecosystem protection under a certain economic load: A case study at the Chaohu Lake watershed, China. Ecological Modelling. 2018;368:180–90.
2. Covino T. Hydrologic connectivity as a framework for understanding biogeochemical flux through watersheds and along fluvial networks. Geomorphology. 2017;277:133–44.
3. Mander Ü, Kull A, Tamm V, Kuusemets V, Karjus R. Impact of climatic fluctuations and land use change on runoff and nutrient losses in rural landscapes. Landscape and Urban Planning. 1998;41(3–4):229–38.
4. Gupta M, Goyal VC, Tarannum F, Patil JP. Designing a watershed scorecard as a performance evaluation tool for Ur River watershed, Tikamgarh District, Madhya Pradesh. Int Soil and Water Conservation Res. 2017;5(4):280–92.
5. Miardini A, Gunawan T, Murti SH. Kajian Degradasi Lahan Sebagai Dasar Pengendalian Banjir Di Das Juwana. Majalah Geografi Indonesia. 2016 30;30(2):134.
6. Salvati L, Carlucci M. Estimating land degradation risk for agriculture in Italy using an indirect approach. Ecological Economics. 2010;69(3):511–8.
7. Barreiro-Lostres F, Brown E, Moreno A, Morellón M, Abbott M, Hillman A, et al. Sediment delivery and lake dynamics in a Mediterranean mountain watershed: Human-climate interactions during the last millennium (El Tobar Lake record, Iberian Range, Spain). Sci Total Environ. 2015;533:506–19.
8. Entrekin SA, Austin BJ, Evans-White MA, Haggard BE. Establishing the linkages among watershed threats, in-stream alterations and biological responses remains a challenge: Fayetteville Shale as a case study. Current Opinion Environ Sci Health. 2018;3:27–32.
9. Agustiningsih D, Sasongko SB, Sudarno. Analisis Kualitas Air dan Strategi Pengendalian Pencemaran Air Sungai Blukar Kabupaten Kendal. J PRESIPITASI. 2017;9(2):64–71.
10. Toumbourou T. Using a Delphi approach to identify the most efficacious interventions to improve Indonesia’s forest and land governance. Land Use Policy. 2018. Available at: http://linkinghub.elsevier .com/retrieve/pii/S0264837716307463. Accessed on 3 March 2018.
11. Lukman, Ridwansyah. Kondisi Daerah Tangkapan Dan Cirri Morfometri Danau Lindu. Oseanologi dan Limologi Indonesia. 2003;35:11–20.
12. Yan Q. Effects of watershed management practic-es on the relationships among rainfall, runoff, and sed-iment delivery in the hilly-gully region of the Loess Plateau in China. Geomorphology. 2015;228:735–45.
13. Ningkeula ES. Analisis Karakteristik Meteorologi Dan Morfologi DAS Wai Samal Kecamatan Seram Utara Timur Kobi Kabupaten Maluku Tengah. J Ilmiah Agribisnis dan Perikanan. 2015;8(2):81–91.
14. Khuc QV, Tran BQ, Meyfroidt P, Paschke MW. Drivers of deforestation and forest degradation in Vietnam: An exploratory analysis at the national level. Forest Policy Economics. 2018;90:128–41.
15. Vesipa R, Camporeale C, Ridolfi L. Effect of river flow fluctuations on riparian vegetation dynamics: Processes and models. Advances in Water Resources. 2017;110:29–50.
16. Bassett K, Carriveau R, Ting DS-K. Underwater energy storage through application of Archimedes principle. J Energy Storage. 2016;8:185–92.
17. Bughici T, Wallach R. Formation of soil–water repellency in olive orchards and its influence on infiltration pattern. Geoderma. 2016;262:1–11.
18. Fiorillo E, Maselli F, Tarchiani V, Vignaroli P. Analysis of land degradation processes on a tiger bush plateau in South West Niger using MODIS and LANDSAT TM/ETM+ data. Int J Applied Earth Observation Geoinformation. 2017;62:56–68.
19. Stafford W, Birch C, Etter H, Blanchard R, Mudavanhu S, Angelstam P, et al. The economics of

landscape restoration: Benefits of controlling bush encroachment and invasive plant species in South Africa and Namibia. Ecosystem Services. 2017;27:193–202.
20. Ghazoul J, Burivalova Z, Garcia-Ulloa J, King LA. Conceptualizing Forest Degradation. Trends in Ecol Evol. 2015;30(10):622–32.
21. Schwarz K, Heitkötter J, Heil J, Marschner B, Stumpe B. The potential of active and passive infrared thermography for identifying dynamics of soil moisture and microbial activity at high spatial and temporal resolution. Geoderma. 2018;327:119–29.
22. Kai-lou L, Ya-zhen L, Li-jun Z, Yan C, Qing-hai H, Xi-chu Y, et al. Comparison of crop productivity and soil microbial activity among different fertilization patterns in red upland and paddy soils. Acta Ecologica Sinica. 2018;38(3):262–7.
23. Schaller L, Targetti S, Villanueva AJ, Zasada I, Kantelhardt J, Arriaza M, et al. Agricultural landscapes, ecosystem services and regional competitiveness—Assessing drivers and mechanisms in nine European case study areas. Land Use Policy. 2018;76:735–45.
24. Oladi R, Emaminasab M, Eckstein D. The dendroecological potential of shrubs in north Iranian semi-deserts. Dendrochronologia. 2017;44:94–102.
25. D.P Suadyana, J.S. F Sumarauw, T. Mananoma. Analisis Debit Banjir dan Tinggi Muka Air Banjir Sungai Sario Di Titik Kawasan Citraland. J Sipil Statik. 2017;5(3):143–50.
26. Wagner K, Neuwirth J, H.etschek. Prevention and Impact on Agricultural Lands," in The 83rd Annual Conference of the Agricultural Economics Society. 2009: 1–7.
27. Zou Y, Duan X, Xue Z, E M, Sun M, Lu X, et al. Water use conflict between wetland and agriculture. J Environ Manag. 2018;224:140–6.
28. Kourgialas NN, Anyfanti I, Karatzas GP, Dokou Z. An integrated method for assessing drought prone areas - Water efficiency practices for a climate resilient Mediterranean agriculture. Sci Total Environ. 2018;625:1290–300.
29. Wang Z, Deng X, Chen J. Impacts of sparing use of water on farmer income of China. Physics and Chemistry of the Earth, Parts A/B/C. 2015;89–90:18–24.
30. Liu Y, Sun Y, Huang G. Preparation and antioxidant activities of important traditional plant polysaccharides. Int J Biological Macromolecules. 2018;111:780–6.
31. Ma J, Wang Y, Feng X. Optimization of multi-plants cooling water system. Energy. 2018;150:797–815.
32. Behmel S, Damour M, Ludwig R, Rodriguez MJ. Participative approach to elicit water quality monitoring needs from stakeholder groups – An application of integrated watershed management. J of Environmental Management. 2018;218:540–54.
33. Ratna Reddy V, Saharawat YS, George B. Watershed management in South Asia: A synoptic review. J Hydrol. 2017;551:4–13.

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