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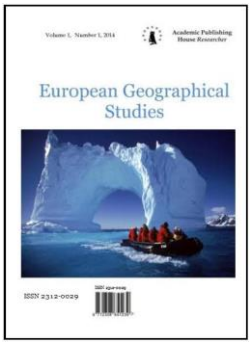

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The Climate of Soils in Adjara

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Abstract

The climatic regime of soils in Adjara is examined. There are studied the soil heating coefficient, the peculiarities of heat exchange in the soil-air system, the effect of soil type and terrain altitude on temperature, as well as regularities of heat distribution in top and deep soil layers and soil humidity conditions. The climatic zoning of soils of Adjara is made.

Keywords: climate, soil, humidity, climatic zoning.

Введение

Исследования почв Грузии имеет давнюю историю, начиная с работ таких выдающихся представителей русской географической и агрономической науки, какими были А.И. Воейков, В.В. Докучаев, К.А. Тимирязев и др. После организации сети гидрометеорологических наблюдений в Грузии климатические особенности почв исследовались в Институте гидрометеорологии Грузии [2, 8, 12]. За последнее десятилетие под руководством одного из авторов данной статьи были проведены глубокие исследования

теплового режима системы почва–атмосфера, а также отдельных почвенных зон, выполнено почвенно-климатическое районирование территории Грузии [11, 15, 16, 17].

В настоящей статье, являющейся логическим продолжением этих исследований, более подробно исследован климатический режим различных типов почв Аджарии.

Аджария расположена в юго-западной части Грузии на побережье Черного моря. Ее территория по особенностям природных условий делится на две части — приморскую и нагорную. Приморская Аджария отличается характерной для субтропической зоны высокой температурой, обилием осадков и солнечных дней. Субтропики прибрежной Аджарии относятся к влажному подтипу и отличаются от сухих средиземноморских субтропиков в Северном и Западном Причерноморье. В нагорной Аджарии влияние Чёрного моря из-за горных преград ослаблено, поэтому воздух здесь отличается большей сухостью. Средняя высота гор составляет 2000-3500 м. Многообразие природы – Черное море, равнинный и сложный горный, сильно расчлененный рельеф, а также характерные для Аджарии циркуляционные и радиационные процессы атмосферы обуславливают большое разнообразие почв. В приморской зоне преобладают болотные и аллювиальные почвы, а также красноземы и желтоземы, в горной зоне – горно-луговые торфянные, лесные бурые и черноземы [3, 4, 5].

Материалы и методы исследования

Для выполнения работы в качестве исходных данных были использованы материалы наблюдений Гидрометслужбы Грузии, проводимых на 11 метеорологических станциях, расположенных на территории Аджарии, и данные справочников [1, 5]. Метеорологические станции, проводимые наблюдения над температурой и влажностью почвы, на территории Аджарии расположены неравномерно. Они в основном занимают прибрежные и, частично, предгорные районы, слабо освещена горная часть территории. Поэтому за сферой исследования оказались некоторые типы горных почв. Тем не менее, выполненное исследование позволило оценить гигротермические особенности основных почв Аджарии и выполнить их климатическое районирование.

Исследованы коэффициент прогреваемости почвы, особенности теплообмена в системе почва-воздух, изменение температуры поверхности почвы с высотой местности, температурный режим поверхности различных типов почвы, закономерности распространения тепла в верхних и глубоких слоях почвы, водный режим почвы. Использованы методы статистического анализа климатических рядов.

Обсуждение результатов

Коэффициент прогреваемости почвы. Степень нагревания почвы характеризуют коэффициентом прогреваемости, представляющей собой отношение продолжительности безморозного периода на поверхности почвы к продолжительности такого же периода в воздухе. Этот коэффициент в целом хорошо характеризует основные климатические особенности территории. В частности, на территории Грузии на Черноморском побережье он составляет около 0.90, на Колхидской низменности несколько возрастает, в степных и полупустынных ландшафтах Восточной Грузии превышает 0.95, в горах уменьшается и его наименьшие значения отмечаются в гляциально нивальной зоне (менее 0.7) [17].

В таблице 1 представлены продолжительности безморозного периодов на поверхности почвы и в воздухе, и коэффициенты прогреваемости почвы для различных физико-географических условий Аджарии.

Таблица 1. Коэффициент прогреваемости почвы в различных физико-географических условиях

Станция	Высота, м	Тип почвы	Продолжительность безморозного периода, дни		Коэффициент прогреваемости
			на почве	в воздухе	
Батуми, город	5	аллювиальная бескарбонатная	235	289	0.81
Батуми, авиа	10	аллювиальная бескарбонатная	249	295	0.84
Чарнали	310	аллювиальная бескарбонатная	221	280	0.79
Махинджаури	15	краснозем	245	286	0.86
Чаква	30	краснозем	225	282	0.80
Цецхлаури	82	краснозем	229	276	0.76
Аламбари	192	краснозем	247	293	0.84
Кобулети	7	иловато болотная	221	246	0.90
Кеда	256	бурая лесная	228	257	0.89
Хуло	923	бурая лесная	190	205	0.93

Из таблицы 1 следует, что в изменении коэффициента прогреваемости почвы на территории Аджарии решающим не является высота местности. В частности, наибольшое значение коэффициента прогреваемости характерно для горной части Аджарии (Хуло, бурая лесная почва) и составляет 0.93, в то время как на некоторых станциях, расположенных на Черноморском побережье (Чаква, Батуми, Махинджаури) он составляет всего 0.80-0.86. В то же время высокое значение коэффициента характерно для приморской станции Кобулети (иловато болотная почва, 0.90).

В условиях одинаковых типов почвы не выявляется однозначная зависимость изменения коэффициента прогреваемости почвы с увеличением высоты местности, о чем свидетельствует пример, приведенный на рис. 1 для красноземов. Согласно рис 1 в условиях красноземов с увеличением высоты местности коэффициент прогреваемости сначала уменьшается, примерно до высоты 80-100 м, а далее возрастает.

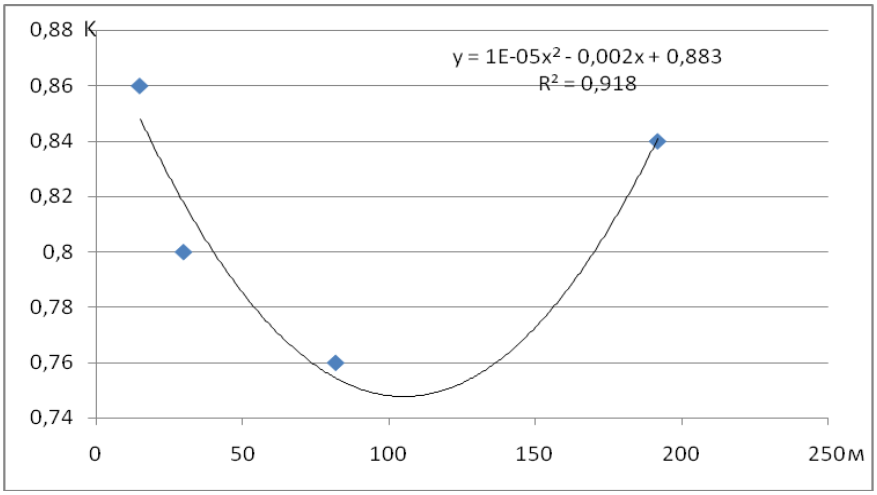


Рис. 1. Изменение коэффициента прогреваемости почвы с высотой для красноземов, уравнение регрессии и коэффициент детерминации(R^2)

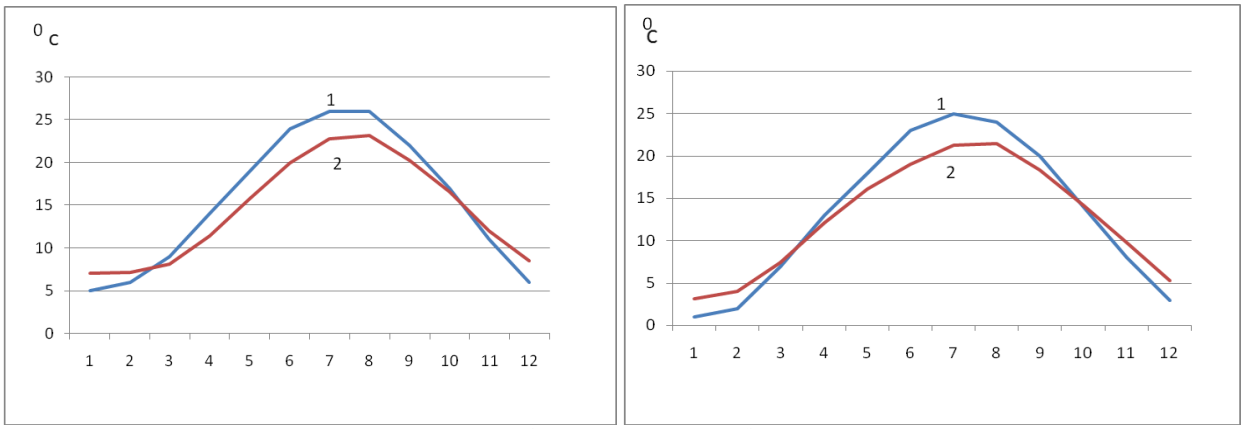
Из рис.1 следует, что изменение коэффициента прогреваемости почвы с высотой для красноземов хорошо описывается полиномом второй степени. Коэффициент детерминации довольно высок и достигает 0.92.

Кроме того из таблицы 1 следует, что в условиях аллювиально бескарбонатных почв коэффициент прогреваемости с высотой изменяется также нелинейно, в частности он сначала возрастает, а далее уменьшается.

Таким образом можно заключить, что распределение коэффициента прогреваемости почвы на территории Аджарии определяется не высотой местности, а особенностями физико-географических условий местоположения станции, типом, грануллометрическим составом и физическими свойствами почвы.

Теплообмен в системе почва-воздух. Перенос тепла от почвы в атмосферу осуществляется путем молекулярной теплопроводности, турбулентного обмена, тепловой конвекции, радиационной теплопроводности и испарения, и дальнейшей конденсации влаги. Одновременно эти процессы по-разному проявляются в различных почвенно-климатических условиях [7, 8, 9, 18 и др.].

На рис. 2 сопоставлены графики годового хода температуры почвы и воздуха для двух станций: Батуми, расположенной на уровне 5 м (аллювиальные бескарбонатные почвы) и Кеда, расположенной на уровне 256 м (бурые лесные почвы).



а) б)

Рис. 2. Годовой ход температуры почвы (1) и воздуха (2): а) Батуми, город; б) Кеда

Из рис. 2 следует, что в Батуми, период с положительным теплообменом, когда температура почвы превышает температуру воздуха длится с марта по октябрь. На станции Кеда длительность периода с положительным теплообменом меньше- с апреля по сентябрь.

Более подробно о продолжительностьях периодов с положительным и отрицательным теплообменом на территории Аджарии можно судить из таблицы 2.

Таблица 2. Периоды с положительным и отрицательным теплообменом

Станция	Высота, м	Тип почвы	Положительный теплообмен	Отрицательный теплообмен
Батуми, город	5	аллювиальная бескарбонатная	март-октябрь	ноябрь-февраль
Батуми, авиа	10	аллювиальная бескарбонатная	март-сентябрь	октябрь-февраль
Чарнали	310	аллювиальная бескарбонатная	апрель-сентябрь	октябрь-март
Махинджаури	15	краснозем	март-октябрь	ноябрь-февраль
Чаква	30	краснозем	март-сентябрь	октябрь-февраль
Цецхлаури	82	краснозем	апрель- октябрь	ноябрь-март
Аламбари	192	краснозем	апрель-сентябрь	октябрь-март

Кобулети	7	Иловато болотная	апрель-ноябрь	декабрь-март
Кеда	256	бурая лесная	апрель-сентябрь	октябрь-март
Хуло	923	бурая лесная	март-октябрь	ноябрь-февраль

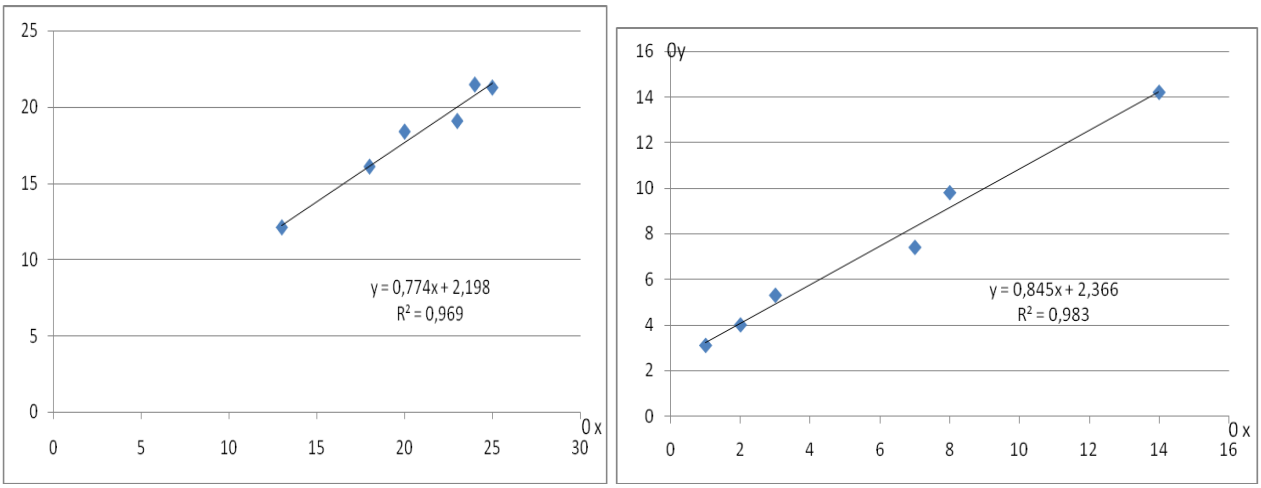
Из таблицы 2 следует, что в наступлении периодов с положительным или отрицательным теплообменом между почвой и воздухом решающим является не высота местности, а тип почвы. В частности, период с положительным теплообменом в горной части Аджарии (Хуло) длится в течении 8 месяцев, с марта по октябрь, а на некоторых станциях, расположенных на черноморском побережье (Чаква, Батуми, авиа) длится 7 месяцев, с марта по сентябрь. Такая длительность периода с положительным теплообменом в Хуло обьясняется высоком значением коэффициента прогреваемости почвы.

В условиях одинаковых типов почвы с увеличением высоты местности длительность периода с положительным теплообменом в основном уменьшается, и наоборот длительность периода с отрицательным теплообменом увеличивается. В частности, в условиях красноземов в Маханджаури (15м над уровнем моря) продолжительность периода с положительным теплообменом составляет 8 месяцев (март-октябрь), в Чаква (30 м) и Цецхлаури (82 м) - 7, а в Аламбари (192 м) - 6 месяцев. В условиях аллювиальных бескарбонатных почв продолжительность периода с положительным теплообменом в Батуми (побережье) составляет 7-8 месяцев (март-октябрь), а в Чарнали (310 м) уменьшается до 6 месяцев (апрель-сентябрь).

Термический режим бурых лесных почв не подчиняется этой закономерности. В Кеда (256 м) продолжительность периода с положительным теплообменом длится с апреля по сентябрь (6 месяцев), а в Хуло, на высоте 923 м, продолжительность периода увеличивается до 8 месяцев (март-октябрь). Это, по всей вероятности, можно объяснить уменьшением влажности почвы в Хуло, в связи, с чем почва нагревается быстрее и, благодаря инерции, долго сохраняет тепло.

Соотношения между температурой поверхности почвы и температурой воздуха. Процессы теплообмена между почвой и атмосферой формируют определенное соотношение температур почвы и воздуха. На рис. 3 представлен пример такого соотношения для станции Кеда.

Из рис. 3 следует, что зависимость температуры воздуха от температуры почвы довольно тесная и линейная, о чем свидетельствуют высокие значения коэффициентов детерминации.



а) б)

Рис. 3. Зависимость температуры воздуха (y) от температуры поверхности почвы в Кеда (x): а) период положительного теплообмена; б) период отрицательного теплообмена; уравнения регрессии и коэффициенты детерминации (R^2)

В[12] было показано, что соотношение между температурой почвы и воздуха в общем виде описывается линейной функцией вида:

$$Тв=кТп+ Тво \quad (1)$$

где Тв – температура воздуха, Тп- температура почвы, Тво – температура воздуха, соответствующая нулевой температуре почвы, к-коэффициент регрессии.

Формула (1) хорошо описывает зависимость температуры воздуха от температуры поверхности почвы и в условиях Аджарии. По материалам наблюдений 10 метеорологических станций Аджарии расчитаны параметры для формулы (1), которые представлены в таблице3.

Таблица 3. Численные значения параметров для формулы (1) и коэффициенты детерминации (R^2)

Станция	Положительный теплообмен			Отрицательный теплообмен		
	К	Тво	R^2	**К**	Тво	R^2
Батуми, город	0.87	0.27	0.97	0.82	3.00	0.94
Батуми, авиа	0.83	0.76	0.96	0.93	1.61	0.96
Чарнали	0.84	0.24	0.91	0.83	2.94	0.97
Махинджаури	0.76	1.39	0.95	0.82	2.32	0.98
Чаква	0.80	0.66	0.97	0.86	2.42	0.99
Цецхлаури	0.76	2.34	0.94	0.79	2.48	0.94
Аламбари	0.90	-0.78	0.94	0.86	2.87	0.95
Кобулети	0.67	2.66	0.87	0.55	2.69	0.84
Кеда	0.77	2.20	0.97	0.84	2.37	0.98
Хуло	0.70	1.50	0.97	0.92	1.42	0.98

О достоверности представленных в таблице параметров можно судить по значениям выборочных коэффициентов детерминации, представленных также в таблице 3. Эти коэффициенты показывают на сколько вариация температуры воздуха зависит от вариации температуры почвы, по существу она является показателем надежности уравнений типа(1).

Как следует из таблицы 3, надежность уравнений довольно высокая и обычно превышает 0.90 за исключением Кобулети, а в более 65% случаях превышает 0.95.

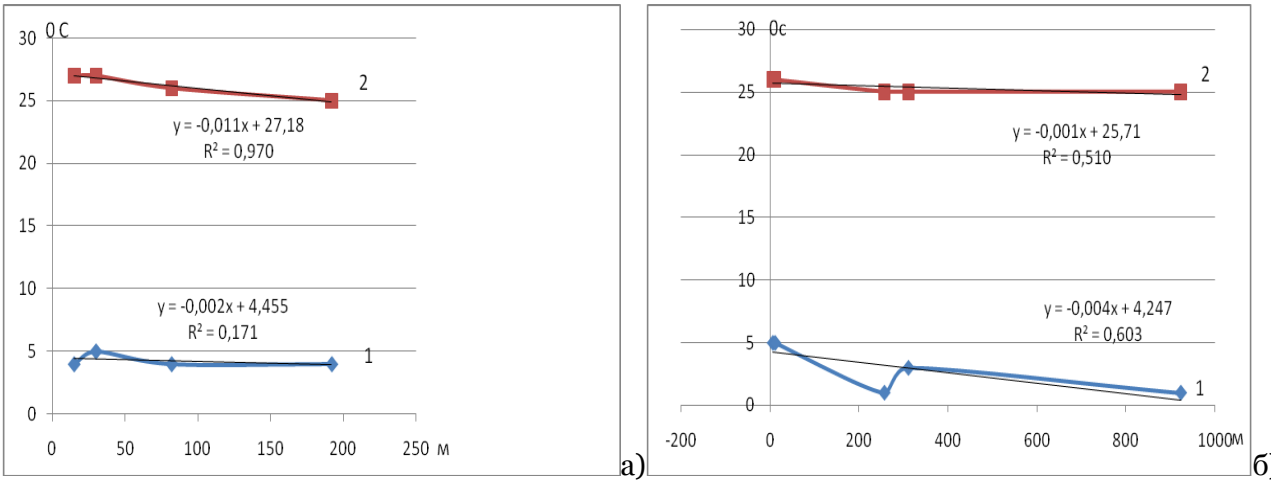
Изменение температуры поверхности почвы с высотой местности.

В предыдущих исследованиях был установлен линейный характер изменения температуры поверхности почвы с высотой местности для обширных почвенно-климатических зон, как Грузии [13, 17], так и Армении [18]. Изменение температуры поверхности почвы с высотой, подобно изменению температуры воздуха [9,10], было описано линейной функцией вида:

$$T_n=T_o-\gamma H, \quad (2)$$

где T_n-температура поверхности почвы на высоте Н, T_o- температура поверхности почвы условно приведенная к уровню моря, которая рассчитывается методом линейной экстраполяции, γ-вертикальный температурный градиент на 1 метр.

На рис. 4 представлена зависимость изменения температуры поверхности почвы от высоты местности для различных типов почв Аджарии, которая также хорошо описывается функцией вида (2).



а) б)

Рис. 4. Зависимость изменения средней месячной температуры поверхности почвы от высоты местности: а) красноземы; б) аллювиально бескарбонатные и бурые лесные почвы. 1 – январь; 2 – июль. Соответствующие уравнения линейной регрессии и коэффициент детерминации (R^2)

Рассчитанные нами параметры для формулы (2) в условиях различных типов почв, а также значения коэффициентов детерминации (R^2) представлены в таблице 4.

Таблица 4. Параметры для формулы (2)

Почва	**Месяцы**					
	Январь			**Июль**		
	T_o	γ	**R^2**	T_o	γ	**R^2**
Краснозем	4.5	0.002	**0.17**	27.2	0.011	**0.97**
Аллювиально бескарбонатная и бурая лесная	4.2	0.004	**0.60**	25.7	0.001	**0.51**

Из таблицы 4 следует, что вертикальный градиент температуры поверхности почвы изменяется в зависимости от типа почвы и сезона. Для аллювиально бескарбонатных и бурых лесных почв градиент наибольшим оказывается в январе, составляя 0.4 ° на 100 м. В июле наибольшие градиенты характерны для красноземов – более 1.1° на 100 м.

Коэффициент детерминации наибольшим является для красноземов в июле, составляя 0.97. Это свидетельствует о том, что вклад высоты местности в изменении температуры почвы составляет 97 %. Вклад высоты местности в изменении температуры аллювиально бескарбонатных и бурых лесных почв составляет 51–60 %, остальная часть доли приходится на другие факторы, главным образом на тип почвы. Несущественным является вклад высоты местности в изменении температуры казноземов в январе (17 %).

Тепловой режим поверхности различных типов почвы. Полученные выше уравнения регрессии могут быть использованы при картографировании температуры различных типов почв, кроме того они позволяют исключить влияние высоты местности и оценить влияние типа почвы на температуру. Такие приведенные, по формуле (2), к стандартным высотам температуры поверхности почвы представлены в таблице 5.

Таблица 5. Температура поверхности почвы приведенная к стандартным высотам по формуле (1), °С

Почва	Месяц	Высота места, м					
		0	200	400	600	800	1000
Краснозем	Январь Июль	4.5 27.2	4.1 25.0	3.7 22.8	3.3 20.6	2.9 18.4	2.5 16.2
Аллювиально бескарбонатная и бурая лесная	Январь Июль	4.2 25.7	3.4 25.5	2.6 25.3	1.8 25.1	1.0 24.9	0.2 24.7

Из таблицы 5 следует, что аллювиально бескарбонатные и бурые лесные почвы зимой на всех стандартных высотах холоднее красноземов. Причем с ростом высоты местности разница между значениями температуры возрастает. Летом отмечается обратная картина, бескарбонатные и бурые лесные почвы теплее красноземов, и разность температур между ними с ростом высоты также возрастает.

Экстремальные температуры поверхности почвы колеблется в значительном диапазоне. Из таблицы 6 следует, что абсолютный максимум температуры в Кобулети превышает 70°, а абсолютный минимум опускается ниже минус 20°. При этом годовой максимум температуры поверхности почвы всегда превышает 40°. Экстремальные значения температуры в Кобулети, по всей вероятности, можно объяснить высоким значением коэффициента прогреваемости почвы (0.90), благодаря чему почва быстро нагревается, а также быстро остывает.

Таблица 6. Экстремальные температуры поверхности почвы

Станция	Высота, м	Тип почвы	Абсолютный максимум °С	Абсолютный минимум °С
Батуми, авиа	10	аллювиальная бескарбонатная	64	-11
Чаква	30	краснозем	66	-17
Кобулети	7	Иловато болотная	72	-21
Махинджаури	15	краснозем	69	-16
Кеда	256	бурая лесная	67	-18

Распространение тепла в верхних и глубоких слоях почвы. Распространение тепла в верхнем, пахотном, слое почвы (до глубины 20 см) можно характеризовать глубинным температурным градиентом, расчетные значения которых представлены в таблице 7.

Из таблицы 7 следует, что наибольшие глубинные градиенты температуры почвы характерны для красноземов, в условиях которых градиент летом превышает 1° на 10 см. В условиях иловато-болотных почв градиенты небольшие, свидетельствующий об их относительно хорошей теплопроводности.

Таблица 7. Глубинный градиент температуры в верхнем слое почвы (до глубины 20 см), °С на 10 см.

Почва	Пункт	Высота, м	Месяцы						
			IY	Y	YI	YII	YIII	IX	X
Иловато-болотная Краснозем	Кобулети Чаква	7 30	0.46 0.60	0.73 0.93	0.80 1.07	0.53 0.93	0.27 0.60	-0,4 -0,2	-0.53 _

Из таблицы 8, где представлены данные о распределении температуры почвы с глубиной по вытяжным термометрам в условиях красноземов, следует, что в переходные сезоны температура почвы с глубиной меняет знак. В апреле температура с глубиной сначала уменьшается, а в октябре – увеличивается, и с определенной глубины отмечается противоположный ход температуры. Глубина, с которой меняется знак градиента температуры зависит от сезона года, типа и гранулометрического состава почвы, и составляет 1,2 – 2,4 м.

Из таблицы 8 следует также, что в условиях одинаковых типов почв величины температуры на одинаковых глубинах могут существенно различаться.

Таблица 8. Средняя месячная температура почвы на различных глубинах ^{o}C в условиях красноземов

Пункт, высота м,	Месяцы	**Глубина, м**				
		0.2	0.4	0.8	1.6	3.2
Чаква(30)	январь	6.1	7.5	9.9	13.0	**15.6**
“	апрель	12.4	11.7	10.7	10.5	**12.9**
“	июль	24.8	22.8	20.2	16.0	**13.3**
“	октябрь	17.5	18.0	19.0	18.7	**16.2**
Зеленный мыс, верхняя (94)	январь	5.9	6.8	8.9	**-**	-
“	апрель	11.9	11.2	9.9	-	-
“	июль	23.9	22.6	20.0	-	-
“	октябрь	17.9	18.3	18.6	-	-

Зимой и летом изменение температуры почвы с глубиной имеет линейный характер, и ее можно характеризовать глубинным градиентом (таблица 9).

Таблица 9. Градиент температуры почвы в различных слоях, ^{o}C на 10 см

Пункт	Интервал глубины, см	**Месяцы**			
		Январь	**Апрель**	**Июль**	**Октябрь**
Чаква	**20-80**	**-0.62**	**0.28**	**0.77**	**-0.25**
	80-320	**-0.23**	**-0.09**	**0.29**	**0.12**
	20-320	**-0.32**	**-0.02**	**0.38**	**0.04**
Зеленный мыс, верхняя	**20-80**	**-0.67**	**0.33**	**0.65**	**-0.12**

Водный режим почвы. Наблюдения над водным режимом почвы на территории Аджарии проводились лишь на станции Чаква [1], в условиях красноземных глинистых почв. На рис. 5 представлен годовой ход запасов продуктивной влаги в Чаква в различных слоях почвы под мандарином и под чайем.

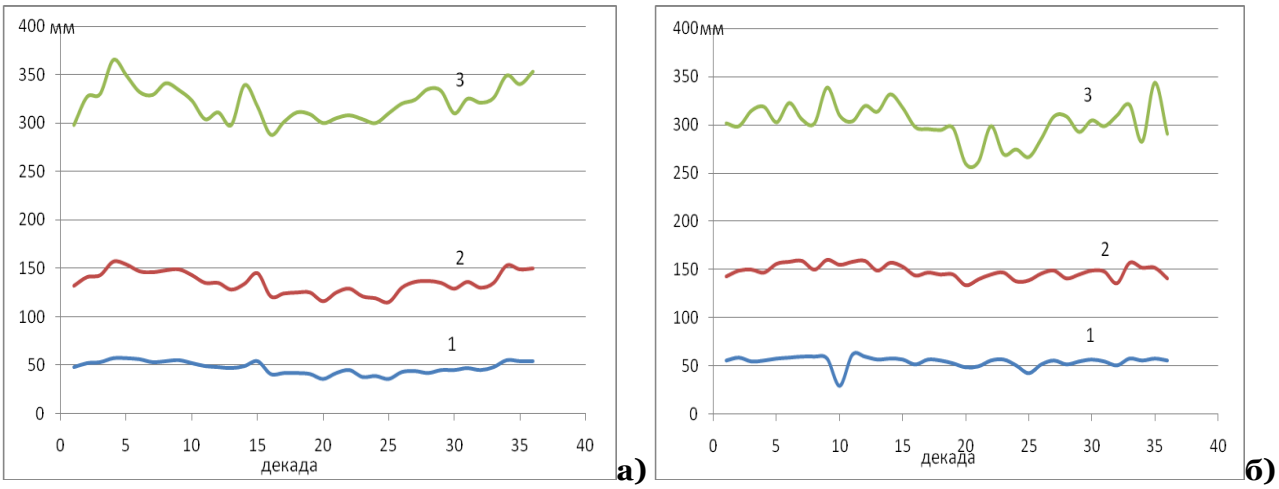


Рис. 5. Годовой ход запасов продуктивной влаги под мандарином (а) и под чайем (б) в Чаква в различных слоях почвы: 1) 0–20 см; 2) 0–50 см; 3) 0–100 см

Из рис. 5 следует, что в годовом ходе запасов продуктивной влаги в почве ярко выраженные максимум и минимум не отмечаются. В течение всего года в почве сохраняются значительные запасы влаги. В метровом слое почвы запасы продуктивной влаги в течение года колеблется под мандарином в пределах 300-360 мм, а под чайем – в пределах 250-350 мм. Слабо выраженный минимум в годовом ходе отмечается в теплый период года, под мандарином в мае, а под чайем – в июне-июле. Максимальные запасы продуктивной влаги в почве имеются зимой, под мандарином в феврале, а под чайем – в декабре. В слое почвы 0-50 см запасы продуктивной влаги в течение года колеблется в пределах 120-150 мм, а в слое 0-20 см, запасы влаги составляют 40-50 см. Такая динамика запасов продуктивной влаги по классификации [11] соответствует типу умеренного обводнения почвы. Аналогичный тип годового хода запасов продуктивной влаги будет характерным для всего побережья Аджарии. С удалением от побережья запасы продуктивной влаги в почве несколько уменьшаются, и могут сформироваться типы слабого обводнения (200-300 мм), а в горах капиллярного увлажнения (100-200 мм).

При типах обводнения годового хода запасов продуктивной влаги [7] в почве уровень грунтовых вод высок и при наибольшой высоте их стояния водное зеркало входит в почвенную толщу, иногда достигая поверхности почвы.

Из рис. 5 следует также, что в начале года запасы продуктивной влаги в метровом слое почве под мандарином и под чайем одинаковы, Далее, по мере роста культур влага расходуется на транспирацию по-разному и в летний период под чайем запасы влаги существенно меньше, чем под мандарином. Осенью, с связи с малыми расходами влаги на транспирацию и понижением температуры, запасы влаги несколько увеличиваются.

Климатическое районирование почв. Климатическое районирование почв Аджарии было выполнено в соответствии с классификацией предложенной в [11]. Согласно этой классификации районирование основывается на закономерностьях термического и влажностного режимов почвы. По термическому режиму различают следующие почвы:

- очень теплые почвы, когда в теплый период года температура поверхности почвы превышает 22°, а температура почвы на глубине 20 см превышает 20°;
- теплые почвы, когда температура поверхности почвы колеблется в пределах 15-22°, а на глубине 20 см составляет 15-20°;
- умеренно теплые почвы, когда температура поверхности почвы и температура на глубине 20 см колеблется в пределах 10-15°;
- умеренные и холодные почвы, когда температура поверхности почвы и температура на глубине 20 см менее 10°.

По водному режиму различают почвы:

- с сильным обводнением, когда в метровом слое почвы запасы продуктивной влаги в течение года составляют 300-400 мм и более;

• с умеренным обводнением, когда запасы продуктивной влаги составляют 250-350 мм и более;

• с слабым обводнением, когда запасы продуктивной влаги в составляют 200-300 мм и более;

• с капиллярным увлажнением, когда запасы продуктивной влаги составляют 100-200 мм и более;

• с полным весенним промачиванием, когда запасы продуктивной влаги составляют 300-400 мм и более;

Для проведения климатического районирования почв Аджарии, кроме материалов использованных в данной статье, были учтены также карты геотермического, агрогидрологического и почвенно-климатического районирования [11], а также карты средних месячных температур поверхности почвы Грузии [14].

На рис. 6 представлена схематическая карта климатического районирования почв Аджарии.

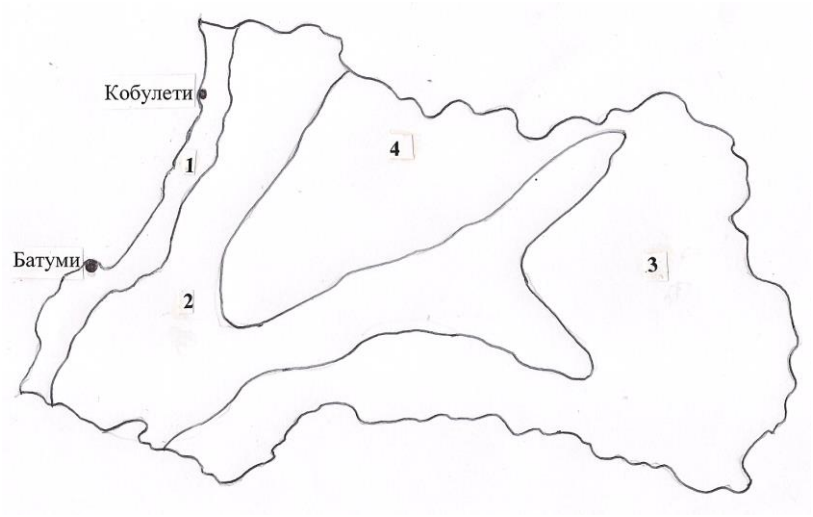


Рис. 6. Схема климатического районирования почв Аджарии (обозначения см. в тексте)

Из рис. 6 следует, что на территории Аджарии выделены 4 климатические районы почв:

1. Узкая прибрежная полоса шириной 5-10 км. Почвы очень теплые с умеренным обводнением;

2. Внутренняя часть побережья, предгорные районы и ущелье реки Аджарисцкали. Почвы теплые с слабым обводнением;

3. Шавшетский хребет, а также северная часть Арсианского хребта. Почвы теплые с капиллярным увлажнением;

4. Западная часть Месхетского хребта в пределах Аджарии. Почвы умеренно теплые с слабым обводнением.

Заключение

В результате проведенного исследования впервые подробно исследован климатический режим различных типов почв Аджарии. Полученные результаты позволили сделать следующие выводы:

- распределение коэффициента прогреваемости почвы определяется особенностями физико-географических условий местности, типом, грануллометрическим составом и физическими свойствами почвы;

- в наступлении периодов с положительным или отрицательным теплообменом между почвой и воздухом решающим является не высота местности, а тип почвы. В условиях одинаковых типов почвы с увеличением высоты местности длительность периода с

положительным теплообменом в основном уменьшается, и наоборот длительность периода с отрицательным теплообменом увеличивается;

- зависимость температуры воздуха от температуры почвы довольно тесная и линейная, о чем свидетельствуют высокие значения коэффициентов детерминации;

- вертикальный градиент температуры поверхности почвы изменяется в зависимости от типа почвы и сезона. Для аллювиально бескарбонатных и бурых лесных почв градиент наибольшим оказывается в январе, составляя 0.4 ^{o} на 100 м. В июле наибольшие градиенты характерны для красноземов – более 1.1^{o} на 100 м;

- вклад высоты местности в изменении температуры красноземов в июле составляет 97%, а в изменении температуры аллювиально бескарбонатных и бурых лесных почв составляет 51-60 %, остальная часть доли приходится на другие факторы, главным образом на тип почвы. Несущественным является вклад высоты местности в изменении температуры кразноземов в январе (17%);

- аллювиально бескарбонатные и бурые лесные почвы зимой на всех стандартных высотах холоднее, а летом теплее красноземов;

- абсолютный максимум температуры поверхности почвы превышает 70^{o}, а абсолютный минимум опускается ниже минус 20^{o}, годовой максимум температуры всегда превышает 40^{o}.

- наибольшие глубинные градиенты температуры почвы характерны для красноземов, в условиях которых градиент летом превышает 1^{o} на 10 см. В условиях иловато-болотных почв градиенты небольшие, свидетельствующий об их относительно хорошей теплопроводности;

- в метровом слое почвы запасы продуктивной влаги в течение года колеблется под мандарином в пределах 300-360 мм, а под чайем – в пределах 250-350 мм, в слое почвы 0-50см запасы продуктивной влаги колеблется в пределах 120-150 мм, а в слое 0-20 см, запасы влаги составляют 40-50 см, что соответствует типу умеренного обводнения почвы. С удалением от побережья запасы продуктивной влаги в почве несколько уменьшаются, и формируются типы слабого обводнения (200-300 мм), а в горах капиллярного увлажнения (100-200 мм);

- на территории Аджарии выделены 4 климатические районы почв: узкая прибрежная полоса шириной 5-10 км, внутренняя часть побережья и предгорные районы, Шавшетский хребет, а также северная часть Арсианского хребта и Западная часть Месхетского хребта.

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Аннотация. Рассмотрен климатический режим почв Аджарии. Исследованы коэффициент прогреваемости почвы, особенности теплообмена в системе почва-воздух, влияние типа почвы и высоты местности на температуру, закономерности распространения тепла в верхних и глубоких слоях почвы, водный режим почвы. Выполнено климатическое районирование почв Аджарии.

Ключевые слова: климат, почва, влажность, климатическое районирование.

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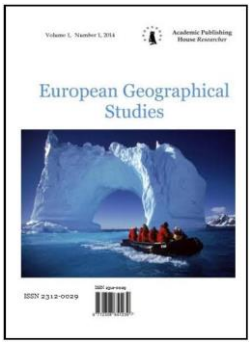

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Structural Changes in Livestock Production in Montenegro (2004–2012): A Review

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Abstract

This paper analyzes the structural changes of livestock production in Montenegro in the period 2003 - 2012 years. To get adequate picture the structure of agricultural land and structural changes in livestock Montenegro in 2004 and 2012 year we applied the method of alternating splitter in the system found the following and 6/6 trends. The structure of use agricultural land prevailing $O_1L_2P_3$ uniformly pasturing trends using agricultural land with a greater share of meadows and participation arable land in 2003 which remained without changes in 2012. While in the structure of changes in livestock recommend 2004 direction with equal participation of breeding bovine animals and sheep farming 0_3 G_3 which is in the year 2012 in the transformed in 0_3 G_2 K_1 direction with equal participation of sheep farming with higher participation herding bovine animals and participation of goat breeding. Montenegro towards membership in the EU will have to comply with the requirements and standards of the EU, which will significantly change the situation in the Montenegrin livestock, which will include the restructuring and diversification of existing livestock production with a view to harmonizing it with the EU standards, increasing quality and productivity, competitiveness development and training for the occurrence outside (global) market.

Keywords: Montenegro, livestock production, structural changes, development.

1. Introduction

In Montenegro, under the influence of industrialization and urbanization proceeded rapidly process deagrarization and de rural shrinking share of the agricultural population in the total population and the population that still lives in the countryside. The process went very quickly, much faster than in the more developed parts of the world. Agricultural population in the total population, for a few decades, declined several times - from about 75% immediately after the Second World War, to around 6%, according to the latest estimates in most of the municipalities today. In a short period of time (even abnormally short for this type of social processes) a huge number of people have changed occupation and place of residence. On the Montenegrin village are

however, remained to live much more people compared to those who are engaged in agriculture (Šarović, 2012).

According to the National Statistical Office of Montenegro (2010), are the Montenegrin households living 98.949 people, which also represent workforce households. The age structure of agricultural holdings is characterized by a high proportion of older working-age population in the farm and a small number of younger members. Of are the total number of working-age residents of these 23.204 persons older than 65 years. Process aging village is deeply affecting all spheres of Montenegrin rural communities, as nearly 44% of the total number of persons employed in the household over 55 years of age. At least those which would be progressive farm that most, only 7% of the workforce in the Montenegrin households younger than 24 years,

According to Šarović (2013), most family agricultural holdings in Montenegro have between one and four. Of the total number of households (48 847) is by far the most of those holdings are counted from 1 to 2 members, even 37.518 or 76.8%; 3 to 4 members is 9.686 (19.84%) households; 5 to 7 members, numbering 1.424 (2.93%) households and is by far the least of those farms with more than 7 members who were once the backbone of the rural areas, they have only 196 or 0.43%. Taking into account the age structure and size of the family on the farm, we can argue that the Montenegrin village most other elderly couples or single people, and they now form the basis on which to build a safe and Montenegrin disappearance of family farms and the village as a whole,

The reasons for the poor state of livestock production are numerous, such as the low purchasing power of the population, the lack of long-term strategy for the development of livestock production, insufficient organization of primary production as well as the weak link between producers and processors, the process of transition and privatization is present in our country, outdated racial composition of livestock, lack of readiness both technically and technologically most manufacturing capacity for export ... (Rajović and Bulatović, 2013; Rajović and Bulatović, 2015; Rajović and Bulatović, 2015).

Montenegro towards membership in the EU will have to comply with the requirements and standards of the EU, which will significantly change the situation in the Montenegrin livestock, which will include the restructuring and diversification of existing livestock production with a view to harmonizing it with the EU standards, increasing quality and productivity, competitiveness development and training for the occurrence outside (global) market.

2. Research Methodology

Two basic group's data sources were we in the study. The first group includes sources statistical data on livestock, available to of the Statistical Office of Montenegro. The second group of data is results of previous studies (Rajović and Bulatović, 2015; Rajović and Bulatović, 2013). The focus of the research is related to the structural changes in livestock production in the time period 2004-2012. Although livestock Montenegro has potentially great development opportunities, current development is characterize by a continuous and extreme decrease. In this paper is been used: a comparative, descriptive method, the method of theoretical analysis, a statistical method (Rajović and Bulatović, 2014; Rajović and Bulatović, 2015; Rajović and Bulatović, 2014; Rajović and Bulatović, 2015). To get adequate picture the structure of agricultural land and structural changes in livestock Montenegro in 2004 and 2012 year we applied the method of alternating splitter in the system found the following and 6/6 trends Kostrovicki (1969), Kostrovicki (1970), Jaćimović (1976), Tyszkiewicz (1978). The method of alternating divisor in system 6/6 has found they are application and in the texts (see Rajović and Bulatović (2013), Rajović and Bulatović (2013), Rajović and Bulatović (2013), Rajović (2010) authors of this paper.

Used were and data from the Internet.

3. Analysis and discussion

Before we approach view of livestock production in Montenegro, it is important to point out the structure of use of agricultural land. In the period 2004 - 2012 in the structure of agricultural land in Montenegro there was a change in the method of exploitation in order to decrease the area of meadows.

Table 1: Agricultural land by categories of use

	Agricultural area	Arable area					Pastures	Ponds, fish ponds and swamps
		Total	Fields and gardens	Orchards	Vineyards	Meadows		
2004	518. 067	189.745	44. 818	9. 580	3. 864	131. 483	325. 671	2. 651
2012	515.717	189.075	45. 809	12. 028	4. 512	126. 726	323. 998	2.644

Source: Statistical Office of Montenegro, Department of Agriculture statistics (2013).

Agricultural areas in Montenegro, was reduced from 518.067 ha in 2004 to 515.717 ha in 2012, or 2.350 ha. Area of meadows in the period was reduced from 131.483 ha to 126.726 ha, or 4.757 ha. In contrast increased are the area under arable land and gardens, orchards and vineyards. Area of arable land and gardens increased from 44.818 ha in 2004 to 45.809 ha in 2012, i.e. 991 ha, while the area under vineyards increased by 648 ha or 3.864 ha to 4.512 ha. In the same period, increased the area under orchards and with 9.580 ha to 12.028 ha, or 2.448 ha. Thus, the total arable land in Montenegro in the period 2004-2012 years was slightly reduced to 670 ha or 189.745 ha to 189.075 ha. Area under pastures in the period 2003-2012 years, recorded a decline from 325.671 ha to 323.998 ha or 1.673 ha. Also, the area under swamps, fish ponds and ponds were reduced to 5 ha or 2.651 ha to 2.644 ha. In order to compare the structure of the agricultural land in Montenegro in 2004 and 2012, we applied the method of alternating splitter 6/6 in the system and to determine the next trends[*]: **O_1 L_2P_3 balanced** pasture trends use agricultural land with a greater share of meadows and participation arable land in 2004 which remained without change in 2012. "Such a large percentage is share of meadows and pastures in the overall structure of agricultural land, are indicating the hilly and mountainous nature of Montenegro"(Rajović *and Bulatović, 2014; Bulatović and Rajović, 2015).*

Table 2: Number of livestock (000)

2004	
Bovine	175
Sheep	252
Pigs	12
Goats	25
Horses	8
Poultry	890
Beehives	42
2012	
Bovine	84
Sheep	207
Pigs	18
Goats	23
Horses	4
Poultry	732
Beehives	43

Source: Statistical Office of Montenegro, Census of Agriculture (2013).

[*] Variables and their symbols used in the formula: O-arable land, V - Orchards and vineyards, L- Meadows, P- Pastures.

To get a proper picture of the structural changes in livestock and here we are apply the method of alternating the divisor in the system 6/6 and found the following direction*: in $_{2004}$ direction with equal participation of breeding bovine animals and sheep farming $\mathbf{o_3\ G_3}$ which is in the year 2012 in the transformed in $\mathbf{o_3\ G_2\ K_1}$ direction with equal participation of sheep farming with higher participation herding bovine animals and participation of goat breeding. In addition to the exceptional importance and favorable natural conditions of animal husbandry in Montenegro is in a big crisis. Number of livestock in the period 2004-2012 years declined in (bovine 175-84, sheep 252-207, goat's 25-23 horses 8- 4, mercury 890-732). The exception is the number of pigs who's the number increased from 12 to 18 thousand and the number of beehives from 42 to 43 thousand. "The reasons for bad state of livestock production are numerous, such as the low purchasing power of the population, the lack of long-term strategy for the development of livestock production, insufficient organization of primary production as well as the weak link between producers and processors, the process of transition and privatization, outdated racial composition of livestock, lack of readiness both technically and technologically most manufacturing capacity for export ... "(Popović et al, 2009).

Table 3: Milk production

	Milk				
	Total (000 liters)	Cow's milk (000 liters)	per cows (liters)	sheep milk (000 liters)	per sheep (Liters)
2004	182 .486	173. 346	2. 184	9 .140	40
2012	159. 240	145. 953	2. 474	9 .584	70

Source: Statistical Office of Montenegro, Census of Agriculture (2013).

The total milk production in Montenegro for the analyzed period was reduced from 182.486 (000) liters per 159.240(000) or 12.74%. Production cow's milk is characterized by decline and with 173. 346 (000) liters per 145.953 (000), or 15.80%, until are increased milk production per cows from 2.184 to 2.474 liters, or 290 liters. Our research evidence based on similar research Kljajić et al (2011), points out that the current placement of milk in the domestic market by keeping large because of favorable producer prices and low purchasing power of home buyers. But the emergence of foreign producers of milk can be a threat to domestic producers by price, quality and assortment. Therefore, it is necessary to improve domestic production through repressive measures - the introduction of a control system for producers of animal feed - a system of national laboratories. Placement of milk on the domestic market is pretty narrowed. Montenegro is competitive with indigenous dairy products, and in its neighborhood as the raw material, and with the produce. However, these problems can be resolved by favoring marketing domestic product (introduction of brands), regulating consumer protection and diversification of production. Great weakness is the gray market, which is very well organized. Ways of overcoming these problems are heightened traffic control and strengthening the implementation of veterinary care.

When it comes to the production of sheep milk in the time period 2004 - 2012 years, we recorded an increase from 9.140 (000) liters in 9.584 (000) or 4.86% per sheep milk 40 to 70 liters. In Montenegro, mainly "placement of milk and milk products from mainly done on farms and vegetable markets. Small dairies produce traditional white cheese and yellow cheese, but are very rare that these cheeses are made from pure sheep's milk, but it is mixed with cow's milk. It reflects poorly on the development of the market of dairy products from sheep's milk. In addition, products are rarely standard quality, insufficiently and inadequately labeled and poorly packaged. Branding, organic certification protection of geographical origin and the like in any other branch of animal husbandry cannot bring many benefits to producers and production development, as for sheep breeding "(Kljajić et al, 2011).

* Variables and their symbols used in the formula: G- breeding bovine, S- Pig farming, O- Sheep farming, K-Sheep goat, Ko- horses.

Table 4: Livestock slaughtered in enterprises and cooperatives and private farms

	Bovine animals	Pigs	Sheep
	Total		
2004	29. 256	27. 711	31. 828
2012	26. 649	39 .470	25 .625
	Enterprises and cooperatives		
2004	20	153	193
2012	1 956	13 113	195
	Private farms		
2004	29. 236	27. 558	31. 635
2012	24.693	26. 357	25. 430

Source: Statistical Office of Montenegro, Census of Agriculture (2013).

The number of slaughtered cattle in the period of 2004-2012 was reduced from 29.256 to 26.649 throats (In enterprises and cooperatives in 2004 - 20.2012- 1956; on private farms 2004 - 29.236, 2012 - 24.693), of sheep with 31.828 to 25.625 heads (in enterprises and cooperatives 2004-193, 2012 – 195, on private farms 2004 - 31.635, 2012 - 25.430). Pork production is dominated by on family farms and has expressed a high degree of in-kind character. The total number of pigs slaughtered in the analyzed period increased from 27.711 to 39.470 throats (In enterprises and cooperatives 2004 - 153, 2012 - 13.113; on private farms 2004 - 27.558, 2012 - 26.357). According to Škorić (2006) of the annual production of poultry meat per inhabitant is around 12 kilograms (as it was at the beginning of the nineties) at about 6 to 8 pounds of what is moving now. The downfall of modern poultry production, intensive branches that twenty years ago, achieved the highest growth rate in agriculture - and one might say in the overall economy - starts closing (decay) large socially owned enterprises. The causes for this should be sought, inter alia, in the disturbed parity price, loss of markets, reduced purchasing power of population, battered by the system of funding, lack of resources in the agricultural budget... In order to overcome the existing problems as well as the necessity of stems the need for defining a comprehensive program of livestock development in Montenegro. "This program should be directed to: the organization of production on the principles of respecting the contemporary world standards in this area, improving the racial composition of all kinds of livestock, increasing the number of animals in breeding particularly on family farms. The program must include specific agricultural policy measures such as tax breaks..., incentive measures relating to export milk premiums and reimbursement for breeding animals, as well as providing funds from the Development Fund for projects in the area of improving livestock production" (Popović et al, 2009).

Table 5: Production of eggs, honey and wool

	Egg		Honey		Wool	
	Total(000)	per hen	Total(t)	per hive (kg)	Total(t)	per sheep (kg)
2004	59.187	134	532	14	345	1,5
2012	68.060	157	554	13	275	1,5

Source: Statistical Office of Montenegro, Census of Agriculture (2013).

Quick turnover, modest investment and small risks, the benefits are poultry production. Thus, the production of eggs in Montenegro in the time period 2004 - 2012 years increased from 59.187 to 68.060 or according to laying hen from 134 to 157 eggs. According to Škorić (2006) in developed countries, the total spending two-thirds of the eggs used in the industry of pasta and confectionery industry, in the production of mayonnaise and other forms of consumption, as well as intermediates, and the other part in consumer, here the egg is still used exclusively in the shell.

The organization of the poultry production on the family farm, and for it to be profitable, they must comply with the necessary conditions that make this production intensive and high technological level (production of 300 eggs per year per hen housed) it is necessary to adopt a "Dutch model". After the "Dutch model" production would be profitable but it is necessary that the owners must join in the cooperative stakeholders (clubs). A number of households, for example, in one municipality only deal rearing pullets to 17 weeks of age. They grow popcorn to secure a buyer for family farms engaged in the production of eggs. This group of producers, produced eggs supplied central sorting center for grading eggs (family farm), which also organizes the network and sells eggs. Profit share in proportion to the funds invested by all participants in the chain of production (Milišević, 2003). However, of all branches of agriculture in Montenegro beekeeping is at this point in the expansion as has never been more bee colonies (2012 - 42.680 hives). Beekeeping Alliance brings together 1.650 beekeepers in 25 associations. These beekeepers according to the National Statistical Office of Montenegro (2013) have a total of 42.680 beehives from which in 2012 had a total honey production of 532 tons, or 13 kg per hive. Thus, the production of honey in Montenegro was higher in comparison to the year 2004 to 22 tons, not counting other bee products, such as wax, propels, pollen, royal jelly ... Montenegrin beekeepers and invest a lot of effort to produce between modern technology with preservatives organic origin with previously planned construction of the "House of Honey" which is supposed to possess the three essential components of the Montenegrin beekeeping. These are the processing plant wax, and then drive for food industry and drive for processing sugar and making cakes for consumption honey bee colonies. . The building area of about 600 square meters is located in a place Daljam, municipalities Danilovgrad and cost about half a million euro (www.pcelarstvo.me). Because of its superior properties such as thermal conductivity, elasticity, process ability, dyeing ... wool despite the huge success achieved in the production of artificial fibers, remains an indispensable raw material in the textile industry and domestic industries to produce various products. However, the total wool production in Montenegro decreased with 345 tons in 2004 to 275 tons in 2012. The average yield of wool per sheep remained unchanged at 1.5 kg. The racial composition dominated pramenka (80%) whose quality wool than 32 micrometers, so that Montenegro is forced to import so-called crossbred wool (26 - 30 micrometers). It is necessary to emphasize that domestic wool mainly low-quality in terms of suitability for the production of fabrics in the textile industry, primarily due to impurities. Only about 23% of domestic wool is higher quality and is used for industrial purposes. The quality of yarn produced in the domestic market does not meet the standards and requirements of manufacturers who deal with handmade. in order to facilitate the work of individual producers, it is necessary to carry out the collection of wool farmers' associations, cooperatives or other associations that should compile a list of vendors and learn about wool and both sides of the needs related to the quantity and quality and what farmers have to offer. Marketing is also a weak component of the agricultural business in Montenegro, and is therefore a strong need to support agro business in this segment.

4. Conclusion

Our research records foundation for similar research Tuan and Tingjun (2001), Stienfeld et al (2006), Seo and Mendelsohn (2007), MacDonald and McBride (2009), Herrero and Thornton (2013), Rajović and Bulatović (2013), Rajović and Bulatović (2014), Rajović and Bulatović (2015), Rajović and Bulatović (2014), Rajović and Bulatović (2015) and Rajović and Bulatović (2015) pointed out in the first, several important conclusions:

1. The structure of agricultural land in Montenegro in 2004 and 2012. The method of alternating divisor in the 6/6 system and determine the next direction: $\mathbf{O_1\ L_2P_3}$ balanced pasture trends use agricultural land with a greater share of meadows and participation arable land in 2004 which remained without change in 2012. Such a large percentage share of meadows and pastures in the overall structure of agricultural land, indicating the hilly and mountainous nature of Montenegro.

2. To get a proper picture of the structural changes in livestock and here we are apply the method of alternating the divisor in the system 6.6 and found the following direction: in $_{2004}$ direction with equal participation of breeding bovine animals and sheep farming $\mathbf{o_3\ G_3}$ which is in

the year 2012 in the transformed in $\mathbf{o_3\ G_2\ K_1}$ direction with equal participation of sheep farming with higher participation herding bovine animals and participation of goat breeding.

3. In addition to the great importance and favorable natural conditions of animal husbandry in Montenegro is in a big crisis. Number of livestock in the period 2004 - 2012 years declined in (bovine 175-84 (000), sheep 252-207 (000), goats 25-23 (000), horses 8 - 4 (000), poultry 890-732 (000)). The exception is the number of pigs whose number increased from 12 to 18 thousand and the number of beehives from 42 to 43 thousand.

4. The total milk production in Montenegro for the analyzed period was reduced from 182.486 (000) liters per 159. 240 (000) or 12.74%. Placement of milk and processed milk is mostly done on farms and vegetable markets. It reflects poorly on the development of the market of dairy products from milk. In addition, products are rarely standard quality, insufficient and inadequately labeled and poorly packaged.

5. The number of slaughtered cattle in the period of 2004-2012 was reduced from 29.256 to 26.649 throats, sheep from 31.828 to 25.625 head. On the other hand an increase to the number of slaughtered pigs from 27.711 to 39.470 head. Annual production of poultry meat per inhabitant is around 12 kilograms (as it was at the beginning of the nineties) at about 6 to 8 pounds as moving now. The causes for this should be sought, inter alia, in the disturbed parity price, loss of markets, reduced purchasing power of population, battered by the system of funding, lack of resources in the agricultural budget ...

6. Egg production in Montenegro in the period 2004 - 2012 years rose from 59. 187 to 68. 060 or hen child-bearing from 134 to 157 eggs. However, while in developed countries, the total spending two-thirds of the eggs used in the industry of pasta and confectionery industry, in the production of mayonnaise and other forms of consumption, as well as intermediates, and the other part in consumer, here the egg and continues to be used exclusively in shell. Also, it is apparent that poultry production in large part still occurs on farms that are often several decades, with worn-out equipment and fleet management, high maintenance costs, as a significant burden on the costs and prevents use of the genetic potential of high productivity and expensive paid imported livestock. As a separate issue to be considered at the existence of zoo hygienic and technological conditions on farms.

7. However, of all branches of agriculture in Montenegro beekeeping is at this point in the expansion as has never been more bee colonies (2012 - 42.680 hives). Beekeeping Alliance organization gathers 1.650 beekeepers in 25 associations. These beekeepers according to the National Statistical Office of Montenegro (2013) have a total of 42.680 beehives from which in 2012 had a total honey production of 532 tons, or 13 kg per hive. Thus, the production of honey in Montenegro was higher in comparison to the year 2004 to 22 tons, not counting other bee products, such as wax, propels, pollen, royal jelly ...

In conclusion, in recent decades, livestock Montenegro have reduce, in a word disappears. In order to keep the population in rural areas, necessary to invest more in the livestock development, development of farm cooperatives liven, to invest in the infrastructure of the village, establish small enterprises of the processing factory for milk and meat, a young farmer from the state especially encouraged to remain the countryside. Agriculture and the village, developed in sustainable system, it is essential that over the long-term development strategies and regulating relationships and obligations that the strategy to be fully state obligation and responsibility to livestock breeding grasp and to accept as the backbone of economic development of a country village as a necessity, and historical development of facts. Agriculture Development Strategy should clearly define macro-zones on which to foster specific livestock species, and based on that subsidizes and assists farmers and households. Law concerning land is necessary to clearly specifies, it is defines the terms of use and disposition of land for the purpose of food production. It should be clear that the specifies how and under what conditions will be used state lands, what about the natural meadows and pastures, by taking advantage of available forest land for livestock ...(Lazić, 2013).

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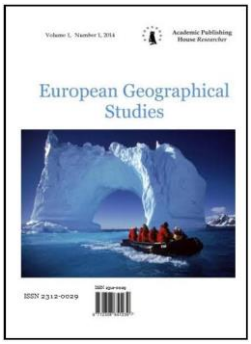

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Application of Remote Sensing Technique to Detect Copper Mineral based Principal Component Analysis and Band Ratio Methods. A Case Study: Laocai Province, Vietnam

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Abstract

Remote sensing technology with advantages such as wide area coverage and short revisit interval has been used effectively in the study of mineral mining and exploration. This article presents study on application of principle component analysis and band ratio method to detect copper mineral using multispectral image LANDSAT 7 ETM+ in Laocai province, the Northern of Vietnam. The results which are obtained in this study can be used to create distribution copper map, and to serve mineral mining and exploration.

Keywords: remote sensing, copper, monitoring, principal component analysis, band ratio, Landsat

1. Introduction

Located in Southeast Asia, Vietnam is rich in mineral resources. Mineral resource is one of the most important natural resources of Vietnam. Mineral is the source material for many industries, such as energy production, building-materials, metal, agricultural and industrial sections... The exploration of mineral composite is a complex and urgent problem in researching and monitoring natural resource. Traditional methods based on field surveys only solve the problem on a small scale because of the high cost. Remote sensing technology with advantages such as wide area coverage and short revisit interval has been used effectively in the study of mineral mining and exploration.

To detect and monitor minerals, researches in various countries have used remote sensing data, mainly Landsat and Aster optical images with average spatial resolution (Abdelsalam et al., 2000; Ramadan et al, 2001; Madani et al., 2003; Ramadan, Kontny, 2004; Maruthi Sridhar, Vincent 2009; Fraser et al., 1997...) [1, 3-8]. In these studies, the authors have been used difference methods, such as band rationing method (Clay mineral index, Iron oxide index, Ferrous minerals index) [1, 6], principal component analysis method based Crosta technique [3], Least square fitting

method (LST) and Minimum noise fraction method (MNF) [3, 8]. Moreover, three band ratio images can be combined as color composites which highlight certain features in distinctive colors (Abrams index, Chica – Olma index, Kaufmann index) [3]. In Vietnam also had some studies in application of remote sensing technique to detect and monitoring clay minerals, iron oxide [10-13].

In this paper, the authors analyze the spectral characteristics of copper mineral to detect copper mineral in Laocai province, the Northern of Vietnam using Landsat 7 ETM+ multispectral images.

2. Study area and Materials

Study area. The Laocai province is located in the Northern of Vietnam, about 338 km of Hanoi, the capital of Vietnam. The area is bounded by 22°22'48" N latitude and 104°09'28" E longitude (Figure 1). The province covers an area of 6383.9 km² and had a population of 656900 people [16].

The province has rich mineral resources, 30 types have been identified with good reserves. The major valuable mineral reserves are: copper (about 53 million tons), apatite and iron (2.5 million tons), molybdenum (15 million tons). There are 150 mines in the province exploiting various minerals [16].

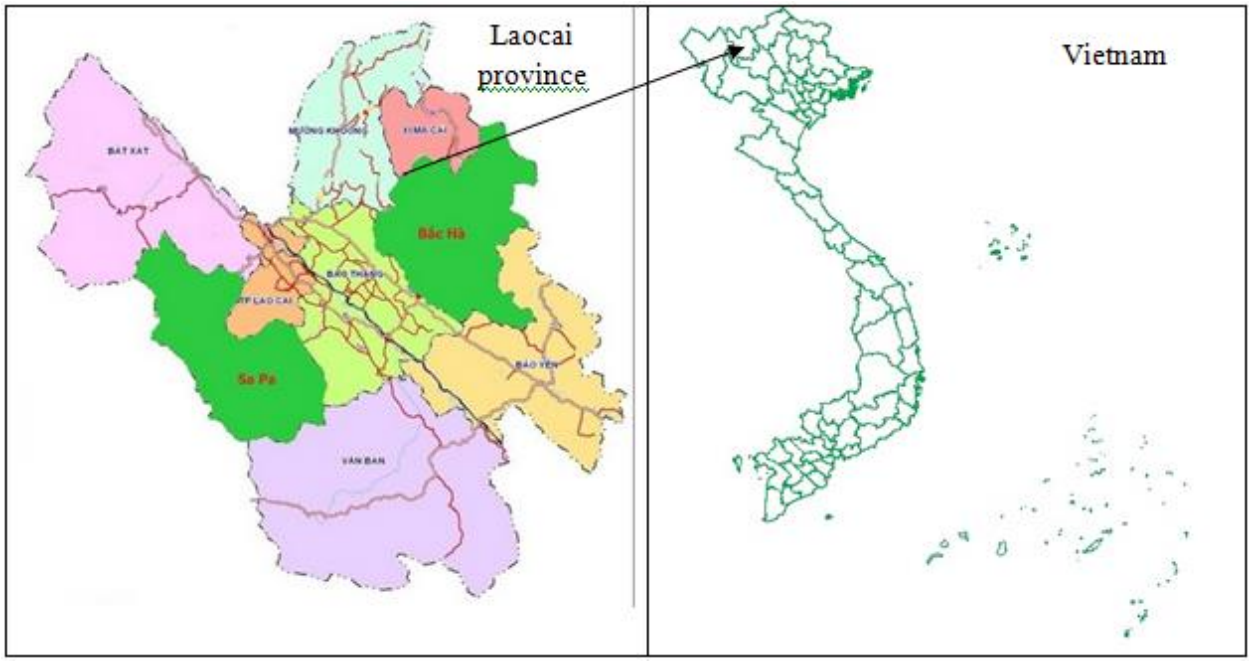


Figure 1. The study area, Laocai province (Vietnam)

Data used. In this study, multi-spectral cloud – free Landsat 7 Enhanced Thematic Mapper Plus (ETM+) data in 20 September 2007 was collected (Figure 1). The Landsat 7 ETM+ data was the standard terrain correction products (L1T), downloaded from United States Geological Survey (USGS – http://glovis.usgs.gov) website [17]. Landsat 7 ETM + images consist of eight spectral bands with a spatial resolution of 30 m for band 1 to 5 and 7. Spatial resolution for thermal infrared band (band 6) is 60 m, but is resampled to 30 m pixels. Band 8 (0.52 – 0.90 μm) is the panchromatic with spatial resolution of 15 m (Table 1) [14].

Table 1: LANDSAT 7 ETM+ characteristics

No.	Band	Wavelength (μm)	Spatial resolution (m)
1	Blue	0.45 – 0.515	30
2	Green	0.525 – 0.605	30
3	Red	0.63 – 0.69	30
4	NIR	0.75 – 0.90	30
5	MIR	1.55 – 1.75	30
6	TIR	10.40 – 12.50	60
7	MIR	2.09 – 2.35	30
8	PAN	0.52 – 0.90	15

Figure 2. Landsat 7 ETM+ multispectral image of the Laocai province 20 September 2007, 321/RGB color composite

3. Methodology

Spectral characteristic of copper. Figure 3 shows reflectance spectra of copper. The vertical axis shows the percentage of incident sunlight that is reflected by the materials [2]. The horizontal axis shows wavelengths of energy for the visible spectral region (0.4 to 0.7 μm) and the reflected portion (0.7 to 3.0 μm) of the infrared (IR) region. Reflected infrared energy consists largely of solar energy reflected from the earth at wavelengths longer than the sensitivity range of the eye.

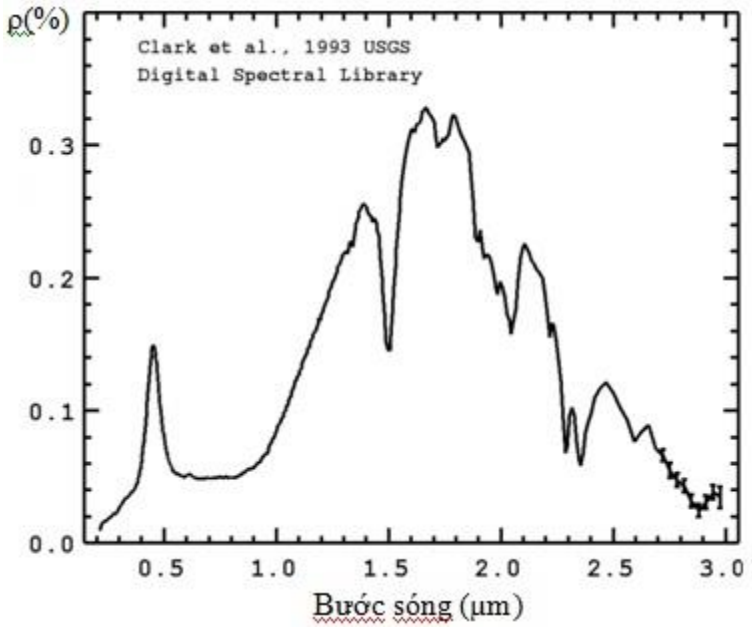


Figure 2. Spectral characteristic of copper minerals in visible and infrared wavelet

Image pre-interpretation. Image processing started with radiometric and geometric correction. Radiometric correction done by converted the digital number value to radiance value. Based on NASA model, the digital values of Landsat 7 ETM+ bands were converted to spectral radiance ($Wm^{-2}\mu m^{-1}$) using following equation [14]:

$$L_\lambda = \frac{Lmax_\lambda - Lmin_\lambda}{Q_{calmax} - Q_{calmin}} (Q_{cal} - Q_{calmin}) + Lmin \quad (1)$$

Where

L_λ - Spectral radiance at the sensor's aperture [W/(m².sr.μm)]
Q_{cal} – Quantized calibrated pixel value
Q_{calmax} – Maximum quantized calibrated pixel value corresponding to $Lmax_\lambda$
Q_{calmin} – Minimum quantized calibrated pixel value corresponding to $Lmin_\lambda$
$Lmax_\lambda$ - Spectral at sensor radiance that is scaled to DNmax [W/(m².sr.μm)]
$Lmin_\lambda$- Spectral at-sensor radiance that is scaled to DNmin [W/(m².sr.μm)]

Table 2: LANDSAT ETM+spectral radiance Q_{calmax}, Q_{calmin} dynamics ranges [14]

No.	Band	Wavelength	Q_{calmax}	Q_{calmin}
1	Blue	0.45 – 0.515 μm	191.600	-6.200
2	Green	0.525 – 0.605 μm	196.500	-6.400
3	Red	0.63 – 0.69 μm	152.900	-5.000
4	NIR	0.75 – 0.90 μm	241.100	-5.100
5	MIR	1.55 – 1.75 μm	31.060	-1.000
7	MIR	2.09 – 2.35 μm	10.800	-0.350

In the second step, for relatively clear Landsat scenes, reflectance (the TOA reflectance) can be determined from the spectral radiance data. The TOA reflectance is computed according to the equation:

$$\rho_\lambda = \frac{\pi . L_\lambda . d^2}{ESUN_\lambda . \cos(\theta_s)} \quad (2)$$

Where

ρ_λ – planetary TOA reflectance
π – mathematical constant approximately equal to 3.14159
L_λ – spectral radiance at the sensor's aperture

D – Earth – Sun distance (astronomical units), which calculate following equation:

$$d = (1{,}0 - 0{,}01674.\cos(0{,}9856(D-4))) \quad (3)$$

D – the day number of the year

ESUN – Mean exoatmospheric solar irradiance ($W/m^2.sr.\mu m$) (Table 2) [14];

θs – solar zenith angle (degree) [14].

Table 2: ESUN values for LANDSAT ETM+ images

No.	Band	Wavelength	ESUN (watts/m².ster. μm)
1	Blue	0.45 – 0.515 μm	1997
2	Green	0.525 – 0.605 μm	1812
3	Red	0.63 – 0.69 μm	1533
4	NIR	0.75 – 0.90 μm	1039
5	MIR	1.55 – 1.75 μm	230.8
7	MIR	2.09 – 2.35 μm	84.90
8	PAN	0.52 – 0.90 μm	1362

The surface reflectance value can be calculated using atmospheric correction method DOS – "dark object subtraction". The DOS is a family of image based atmospheric correction method proposed by Chavez (1988). The basic assumption is that within the image, some pixels are in complete shadow and their radiances received at the satellite are due to mathospheric scattering (path radiance) [9].

Band ratio. Band ratio is a useful method of preprocessing satellite image, especially in areas where topographic effects are important. The band ratio images are known for enhancement of spectral contrast among the bands considered in the ratio operation and have successfully been used in mapping alteration zones [3-8]. As shows in the figure 2, the spectral reflectance curve shows that the maximum reflectance of copper occurs in blue (band 10.45 – 0.515 μm) and red band (band 3, 0.63 – 0.69 μm) and that reflectance is considerably lower in middle infrared bands (band 5, 1.55 – 1.75) and band 7 (2.09 – 2.35). There form, the brightness signatures in the ratio images band5/band1 and band7/band3 correlate with the copper mineral [3-7].

Principal component analysis. The principal component analysis (PCA) method is based on the fact that neighboring bands of multispectral images are highly correlated and often convey almost the same information about the object. This method is based on multivariate statistical technique that selects uncorrelated linear combination (eigenvector) of variables in such a way that each successively extracted linear combination – principal component [7]. This study has used principal component analysis method for ratio images band5/band1 and band7/band3 of Landsat 7 ETM+ data. Table 3 shows the results of calculation Eigen matrix and eigenvalues. The first principal component (PC1) is about 99.5% and the second principal component (PC2) is about 0.5% of eigenvalue of the total variance for unstretched data PCA. Thereform, PC1 is the albedo image and PC2 highlights cooper minerals as bright pixels.

Figure 3 shows the model for detecting and extracting copper minerals from Landsat 7 ETM+ multispectral images.

Table 3. Eigen matrix and Eigenvalues

Band ratio / PC	Band5/Band1	Band7/Band3	Eigenvalues (%)
PC1	0.74301	-0.66927	99,5%
PC2	0.66927	0.74301	0.5%

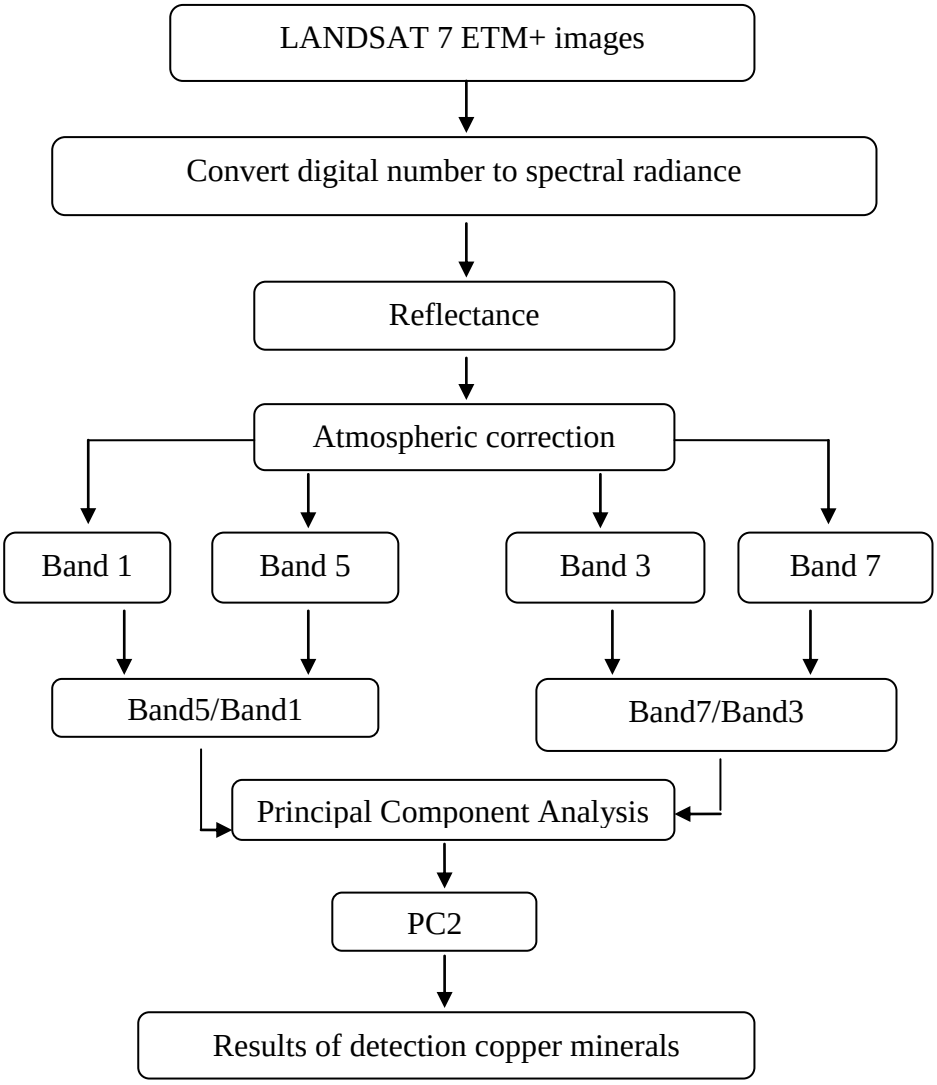
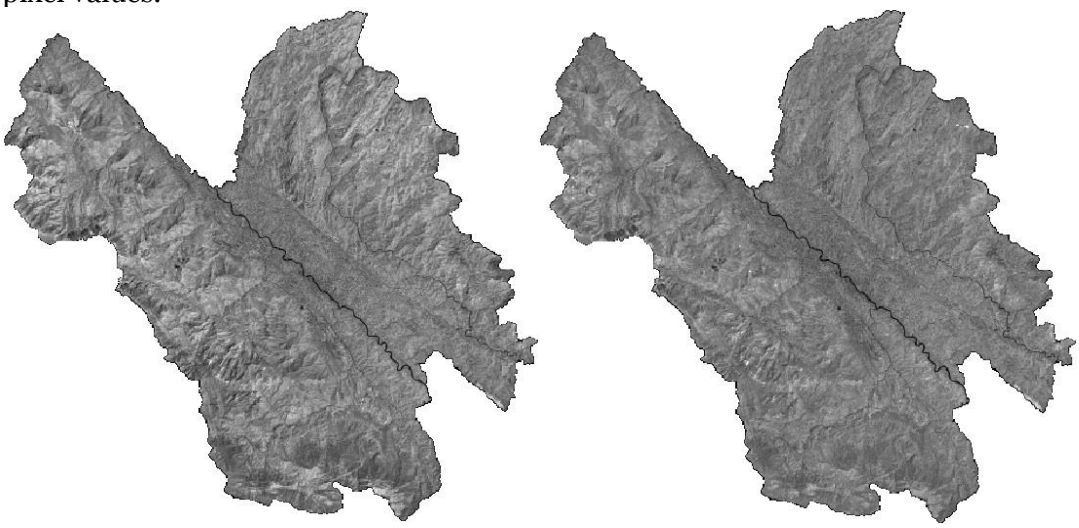


Figure 3. Model for detecting copper minerals using LANDSAT 7 ETM+ image

4. Results and Discussion

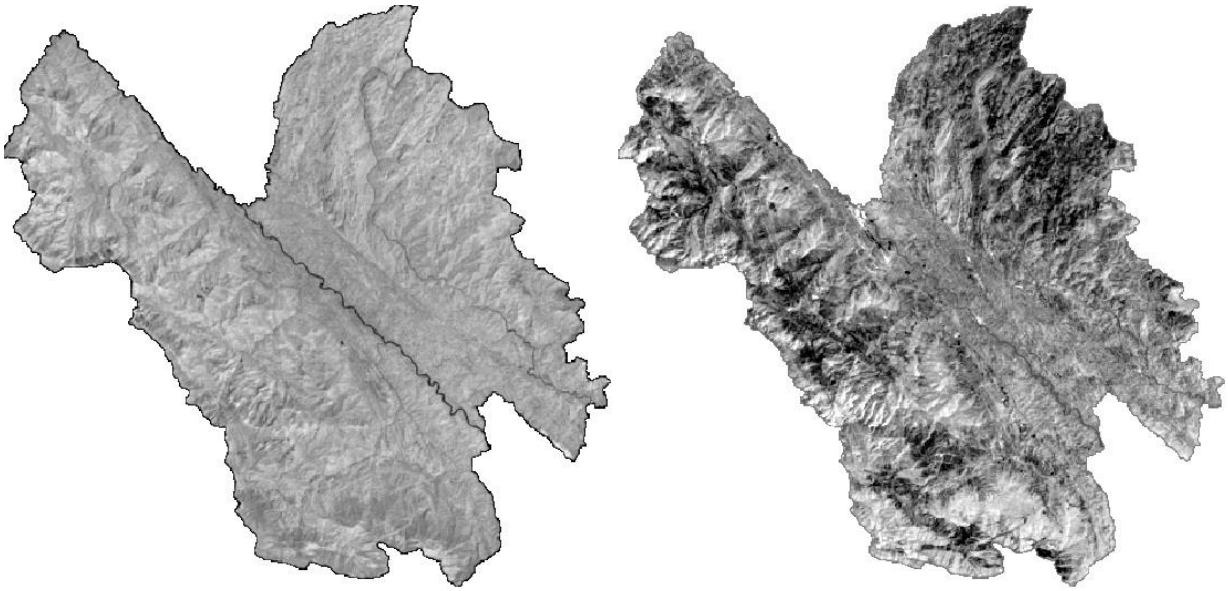
The Landsat 7 ETM+ data in this study have been used to calculate band5/band1 and band7/band3 ratio images (figure 4a, 4b). This ratio images enhanced copper minerals as bright pixel values.



a) *b)*

Figure 4. Band ratio images band5/band1 (a) and band7/band3 (b) LANDSAT 7 ETM+

The principal components transformation on ratio images band5/band1 and band7/band3 of the Laocai province, the Northern of Vietnam are show in table 3 and figure 5 (a, b).



PC1 *PC2*

Figure 5. The first (PC1) and second (PC2) principal components based on band ratio images

To evaluate accuracy, the mineral map at a scale of 1: 200 000 of Laocai province was used [15]. Analysis of results obtained from this study show that, the copper deposits detected from Landsat 7 ETM+ multispectral image consistently with mineral map, such as Suoi Thau, Sinh Quyen, Tong Cao Chay, Ban Vuoc, Lung Thang, Quang Kim, Ta Phoi…copper deposits (Figure 6). It also proves the accuracy of the principal component analysis method in detection copper mineral from remote sensing data.

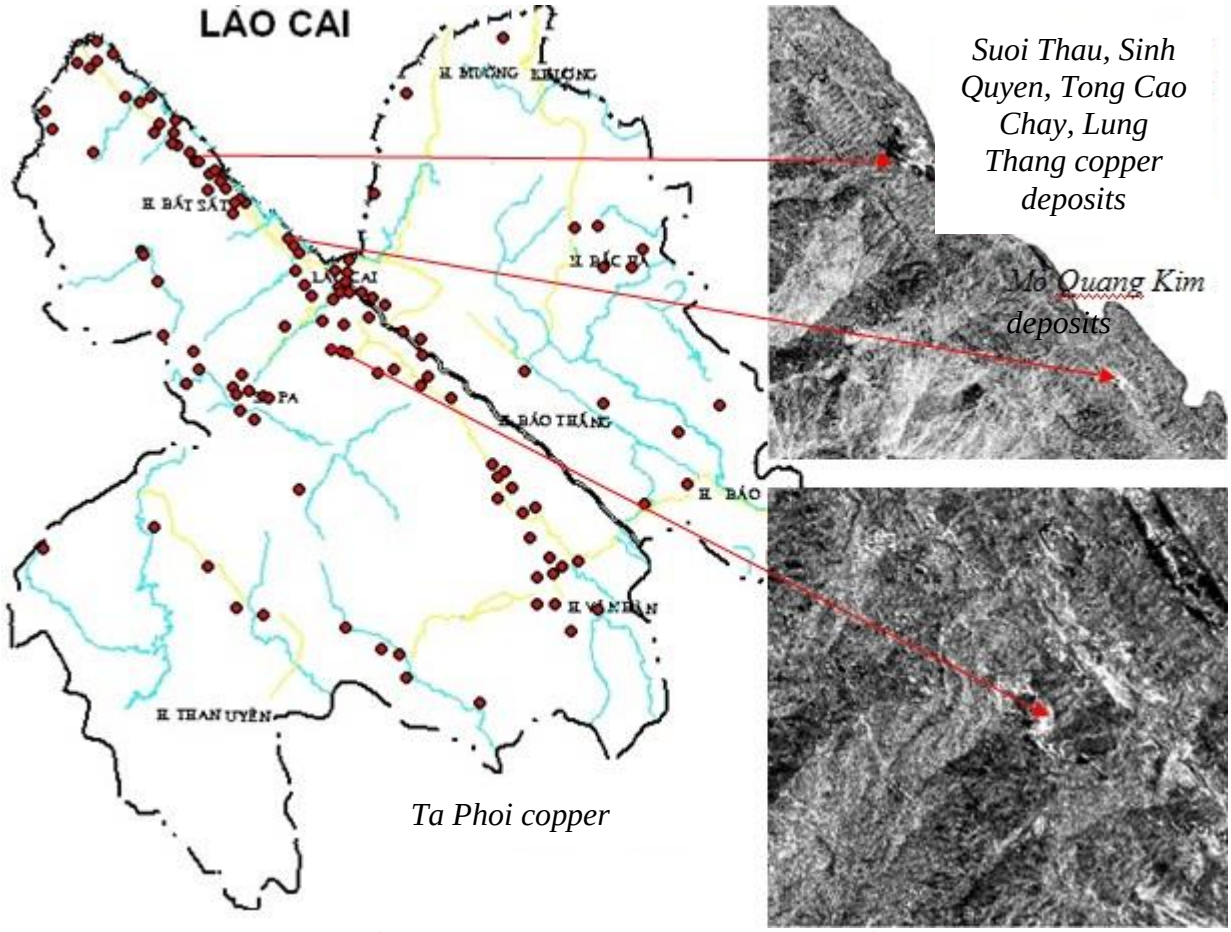


Figure 7. Mineral map of Laocai province, Vietnam at a scale of 1:200 000 and copper deposits in Landsat image

5. Conclusion

Remote sensing technique with many advantages, compared with traditional methods, can be used effectively for detecting and predicting the density distribution of mineral. Analysis of spectral characteristics of copper mineral shows that, the band 5/1 and 7/3 ratios are sensitive to the copper mineral, such that areas of high 5/1 and 7/3 values have relatively high copper contents.

Principal component analysis is widely used for mapping and detecting of mineral. This technique is used on 2 ratio images: band5/band1 and band7/band3 for enhancing copper mineral. The results which are obtained in this study can be used to create distribution copper mineral and to serve mineral mining and exploration.

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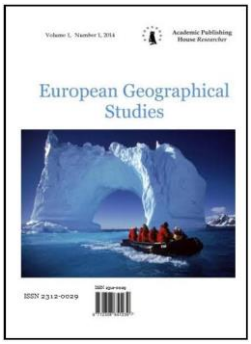

UDC

Analysis of the Spatial Distribution of Public Portable Water Sources in Misau Town, Bauchi State, Nigeria

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Abstract

Access to adequate, safe and equitable distribution of water is fundamental in supporting live hood. The concern about access to water is premised on its multifacet effects on health and well being of man. This paper analyzed the spatial distribution of public portable water sources of Misau town in Bauchi state Nigeria. Location of existing public water points were mapped and analyzed using GIS techniques to guide decision in the study area. The public water taps, bore holes and open wells numbering 33, 59, and 48 respectively were mapped and 200m buffering was made to check their accessibility and adequacy or otherwise. The result indicates areas of high concentration and those lacking the infrastructure visa avis the population density on physical development. The maps and the analysis affirmed the versatility of GIS managerial tool in water distribution management of Misau town.

Keywords: Misau town, mapping portable water, GIS.

Introduction

The fundamentality of water in supporting livelihood on earth is obvious. It is required for biological, domestic, agricultural and industrial purposes. Little wonder the cradles of civilization were close to and associated with sources of water (river valleys) such as the Nile in Egypt, Indus in India, Hangzhou in China, Euphrates and Tigris in Mesopotamia, etc (Ayoade, 1988). Access to adequate, safe and equitable water, now recognized as a human right, is a contemporary global development issue. For instance, the United Nations Committee on Economic, Social and Cultural Rights (General Comment No. 15, 2002) posits that everyone is entitled to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses. The Millennium Development Goals have targeted to reduce by half, the proportion of people without access to safe drinking water by 2015. Some international conferences on water, e.g. The Hague (2000), Kyoto (2003), have underscored the need to support developing countries to improve water supply.

Concern about access to water is premised on its multifaceted effects on the health and well being of man. For example, several diseases are water borne. Schistosomiasis, diarrhea, typhoid and cholera are some of them. Diarrhea alone accounts for an estimated 4.1% of the total daily global burden of disease and is responsible for the deaths of 1.8 million people every year (WHO,

2004). According to water Aid Nigeria, eight children die from water related diseases every hour while about 63.2 million people don't have access to safe water (Olokor,2013)

The average global annual per capita use of water is estimated at 506m^3. Globally, about 9087 billion m^3 of water is used annually (Fischelli, 2012). The population of the world which increased from 2.5 billion in 1960 to 7.2 billion in 2014, is constantly increasing. Increasing industrialization is the trend of the world economy. The implication of these demographic and economic traits of the world is increasing demand for water, especially for domestic, industrial and agricultural uses. Efforts at keeping pace with the demand appear to be strained. Climate change variables have further widened the strain. Already, about 748 million people world- wide have poor access to clean drinking water. By 2030, the number is estimated to reach 40 % of the expected world population of about 9 billion (Daigle, 2015). In Africa, in which Nigeria is situated, 300 million people lack access to safe water and, by 2025, one in two Africans will be in areas of water scarcity.

Since 2008, majority of the world`s population live in urban areas. As at 2013, 53% of the global population of about 7.2 billion was urban dwellers. By 2050, out of the expected world population of 9.3 billion, 6.2 billion i.e. 67.2% will be living in cities (UN, 2012a in Molen, 2014). This implies that demand for water and competition for access to it is higher and will continue to be so for the rest of man`s tenancy on earth. As a consequence, the supply and management of urban water delivery facilities should be properly planned and integrated in line with Integrated Water Resources Management (IWRM) principles to ensure sustainability. Governments should play pivotal roles in this regard. The recognition of access to water as a human right places responsibilities of respecting, protecting, facilitating and providing water to citizens on governments (Cotula, 2006). The governments, especially in developing countries, have taken responsibility for delivering pipe borne (categorized as public) water to homes with little efficiency. To fill the gap, individuals self-supply themselves with water from ground water reserves in form of wells and boreholes. Water drawn from such self- supplied sources may be for personal use or sold for profit. Thus, access to water is from a mix of sources. For instance, in Akure, the mix is made of pipe borne water (2.57%), wells (51%), and wells and pipe borne water (28.35%) (Adewumi and Babalola, 2001).

The need to manage and improve access to water cannot be overemphasized. Perhaps the first step at achieving this requires an inventory of the points where water is accessed. Such inventory is best portrayed in maps. The advent of Geographic Information System (GIS) has widened the versatility of mapping and its application as a guide in decision making about many human endeavors (Chang, 2012).The purpose of this write up is to demonstrate the application of mapping, using GIS techniques, in guiding decisions about water supply in an urban area. Misau, a town in Bauchi State, Nigeria, is the location of the study.

Objectives

The objectives of the study were to;

1 Identify and map the locations of the public water points in the study area

2 Create 200m buffer zones around each of the water points

3 On the basis of the buffer zones, identify parts of the study area that lack water points

The study area

The mapping was carried out in Misau (latitude, 11^{o}30^{I}N---11 ^{O} 35^{I}N; longitude, 10^O 40^I E- -- 10^O 45^I E), a town in Bauchi State, Nigeria. The town is in the Sahel savanna and has a semi tropical climate. There are two distinct seasons; the wet and the dry. The wet season begins in June and ends in October. Mean annual total rainfall is 763mm. Temperatures range from 19^{o}C in the cold hamattan season to 39^o C in the hot season. No surface water bodies exist and on account of the high average temperatures evapotranspiration is high. The 2006 census (the last official census in Nigeria) gave the population of the town as 76, 240. At a growth rate of 3.5%, the population is expected to be 100,252 in 2015. The town is water stressed .Tse and Amadi (2009) gave the borehole yield in the town as 98.67m^3. According to Dike (1990) the total daily water yield from all boreholes tapping the same aquifers was 4.8 million litres. At an average consumption of 96 litres per day per head, this was just enough to supply the water needs of about 50,000. Comparing this

to the 2015 population projection of the town implies that only half of the per capita water need of the population is available.

Discussion

The locations of the public taps and the buffer zone of 200m for each of them are shown in Figure 1.

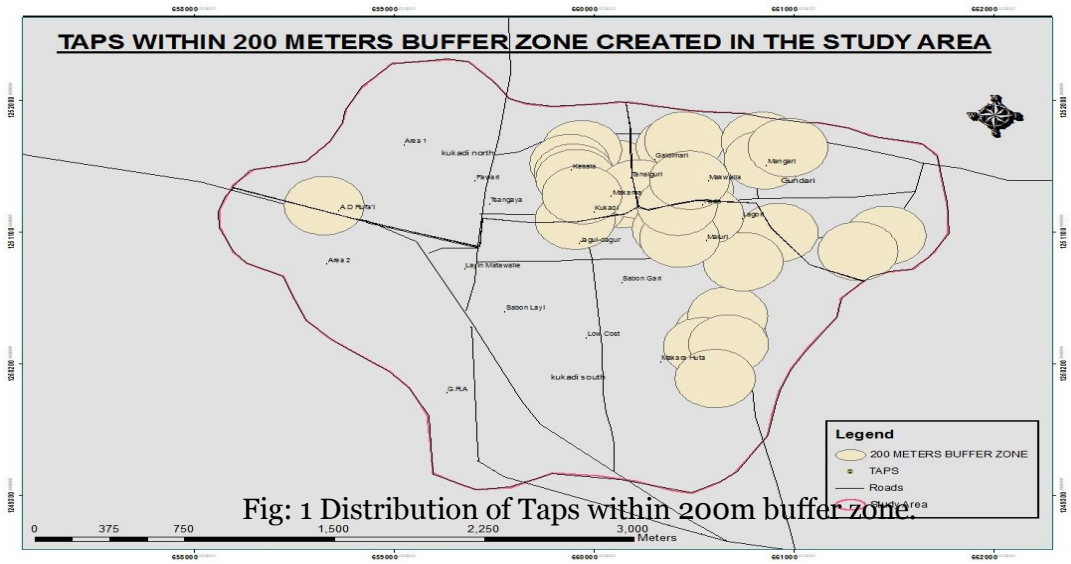

Fig: 1 Distribution of Taps within 200m buffer zone.

The distribution of the taps shows that they are concentrated in particular areas of the town. The other parts are without the facility. This implies that public access to water delivered by the government (presumably, the safest) is grossly inadequate.

As for boreholes, their locations are shown in Figure 2.

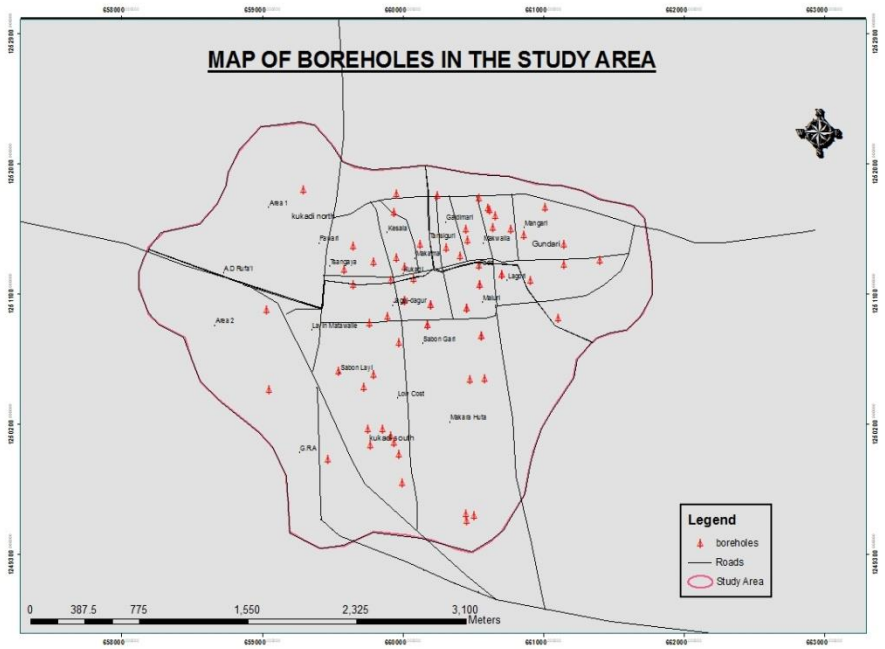

Fig: 2 Distribution of Boreholes in the study area.

The boreholes have a wider spatial coverage of the town. They were established by the government to augment the shortfall from the water supply from taps. Water vendors draw water

from the boreholes and retail to needy houses. It was found out that 26 (representing 44%) out of the 59 boreholes are out of use. The distribution of public wells is represented in Figure 3.

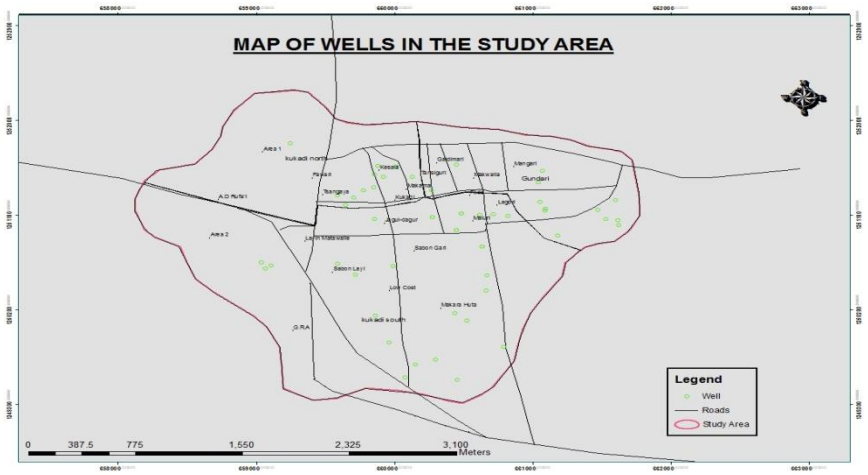

Fig: 3 Distribution of public wells in the study area.

The distribution of wells shows an almost similar coverage like that of boreholes. Out of the 48 public wells in the area, 22 have dried up.

The outcome of the 200m buffer zone analysis of the three public sources of water in the study area is presented in Figure 4.

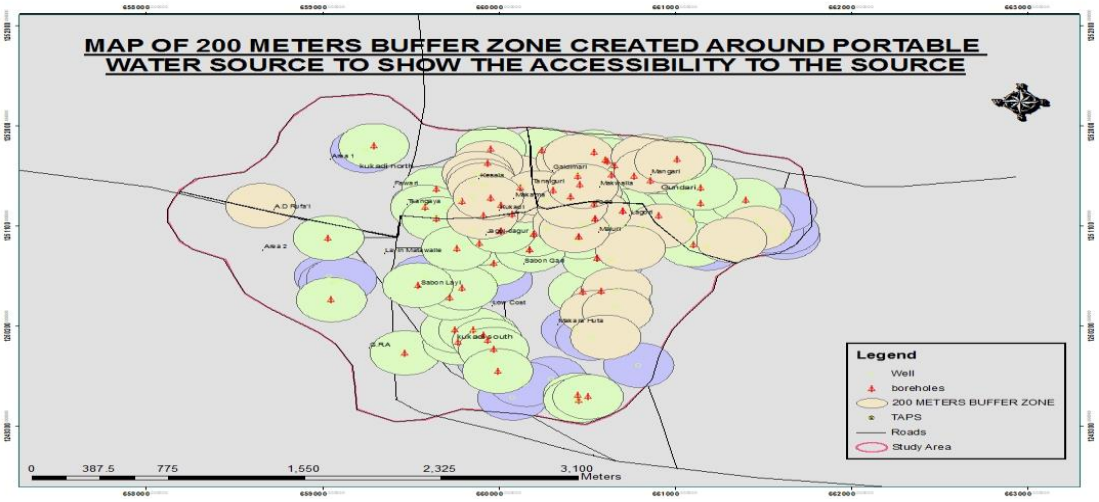

Fig: 4 Outcome of 200m buffer zone created.

The buffers suggest an overlap between the three sources of water in most parts of the town. As suggested by Figure 5, nine areas of the town are inadequately served by the three sources of water.

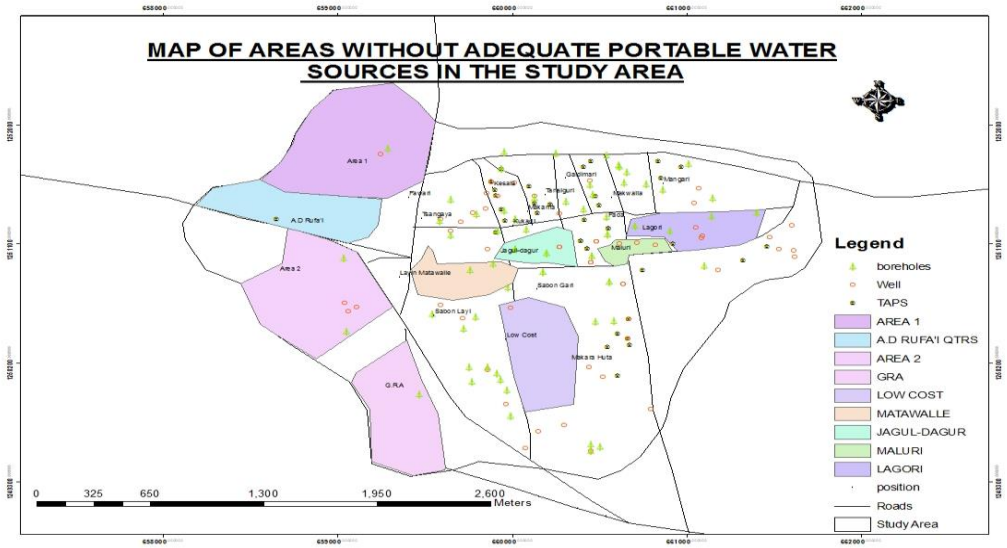

Fig: 5 Areas that are inadequately served by the three sources of water.

Interviews with residents of the areas that are under served by public water sources reveal that they rely exclusively on buying from local water vendors. The vendors fetch water from the areas with water in 25 litre jerry cans which they push over long distances in carts that contain ten of such cans. Usually, families that can afford, buy the ten jerry cans (250 litres) of water daily. This quantity of water is grossly inadequate for domestic uses; hence, the water is strictly rationed among the uses. Each jerry can is sold at N20.00, implying that households expend about N200.00 (equivalent to about one dollar) on buying water daily. By local economic conditions, this amount is high and constitutes a drain on family income. In some instances, difficulty in accessing water for cooking has made families to skip meals. Also, many man hours are lost in efforts to search for water for domestic use. Though no study has been conducted in the study area about the health implications of transporting water in jerry cans, water contamination and associated water borne diseases is a possibility. Because of these difficulties, there is an observed reluctance of residents of the town to live in these parts of the town. On the positive side, the water stress has created off farm employment for the water vendors most of whom are migrant farmers from surrounding rural areas. The income they earn from water vending is utilized for their up keep and purchase of inputs required for their farmlands. These areas should command priority in plans by the government to avail water to the population of the town.

It is also noteworthy, as revealed by Table 1, that out of the one hundred and forty public sources of water, seventy two (representing 51.4%) are non functional. This indicates a poor maintenance culture of public facilities. If not rectified, initial investments made in providing the facilities will become wasted.

Methodology

A 1: 10,000 analogue map of the study area was obtained from the Bauchi State ministry of lands and survey. The map was scanned using A_0 scanner which was taken to into Arc catalog environment where it was spatially referenced to WGS 1984, zone 32. The coordinates of the four selected corner points that relatively appears on the Google earth image were used for the geo-referencing and update was made in the arc map work station. A pyramid was created for both the image and the map which appears in three color Red, Blue and Green (RBG).Both the image and the map were later added in to an Arc map work station. Since both image and the map are not of the same scale, transformation was carried out in order to bring them in to one origin. It was referenced using Arc Map work station. For the purpose of digitization, three shape files (point, polyline and polygon) were created in Arc catalog. Points were used to depict locations of point features (wells and boreholes), polyline were used for linear features (roads), while polygons were used to represent the shapes and locations of homogeneous features (residential areas).

An attribute table was created in a tabular form where the location and type of water sources were recorded. For easy decision making, queries were established in the database to obtain information that will be needed to support decision making such as where there is inadequacy in public water sources. Below are the points used in the georeferencing their coordinates and description. Interviews were conducted with residents of the water stressed areas to gain insight on how they cope with the problem of accessing water.

Points	Easting	Northing	Description
P1	657156.08	1251913.73	AREWA CERAMIC
P2	661112.82	1251976.82	MANGARI PRI. SCH
P3	661180.26	1251114.78	LAGORI
P4	659116.13	1251082.46	GENERAL HOSPITAL

Source: Google Earth (2015)

Results

Table 1: Number of Public Water Sources

S/N	Water Source	Total of Water Sources	Functional water source	% of Total	Non Functional Water Source	% Of Total
1	Boreholes	59	33	55.93	26	44.07
2	Taps	33	9	27.27	24	72.72
3	Open wells	48	26	54.17	22	45.83
		140	68	48.57	72	51.43

Source: Field Survey (2015)

The sources of water mapped were public taps, boreholes and wells. Their respective numbers were 33 (25%), 59 (41%) and 48 (34%). This gives a total of 140. Out of the 59 boreholes, 33 (55.93%) were functional while 26 (44.97%) were not in use due to disrepair. The numbers and percentages of functional and non functional taps were 9 (27.27%) and 24 (72.72%) respectively. As for open wells, 26 (54.17%) were in use while 22 (45.83%) were out of use. Out of the total public water sources, 68 (48.57%) were operational while 72 (51.43%) were not in use.

The result of the query about areas poorly served by public water sources revealed that nine parts of the town were affected (refer to Figure 5). An enumeration of the sources of water in these areas is presented in Table 2.

Table 2: Areas with Inadequate Public Water Sources

S/N	Name of Location	No. of Taps	No. of Boreholes	No. of Open Wells
1	Area 1	0	1	1
2	A.D. Rufa`i	1	0	0
3	Area 2	0	2	3
4	GRA	0	1	0
5	Low cost	0	3	1
6	Matawalle	0	2	1
7	Juggol dagur	3	4	3
8	Maluri	3	3	3
9	Lagori	1	4	3
	Total	8	20	15

Conclusion

Geographic Information System (GIS) is a versatile tool for displaying diverse spatial phenomena. This study demonstrated its use in showing the distribution of the sources of water

used in Misau, a town in Bauchi State, north eastern Nigeria. Buffer zone analysis has graphically displayed the areas of the town that are deficient in the supply of public water facilities. The maps produced can guide local administrators on where to locate water facilities in the study area. It is further recommended that in addition to providing more sources of water, the dysfunctional ones should be repaired. Periodic checks on the functional water sources should be carried out to safeguard them from damage.

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