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Journal of Geographical Research

Volume 4 • Issue 4 • October 2021
ISSN 2630-5070(Online)

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Volume 4 Issue 4 • October 2021 • ISSN 2630-5070 (Online)

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ARTICLE

KRIFS Quartet Model Improving Livelihoods and Fueling Tourism in Kitagwenda District, Western Uganda

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ARTICLE INFO

Article history
Received: 20 July 2021
Revised: 22 August 2021
Accepted: 23 August 2021
Published Online: 30 September 2021

Keywords:
KRIFS
Quartet model
Apiculture
Agro-forestry
Agro-tourism
Climate change

ABSTRACT

Kyabwanswa Rural Integrated Farming Systems (KRIFS) is a Community Based Organization (CBO) with its Head Office in Kitagwenda Town Council. KRIFS quartet model involves emphasis of integrating four agricultural activities namely: Apiculture, agro-forestry, coffee and at least one type of livestock. The paper utilizes data obtained from January 2017 surveys, interviews, focus group discussions and observations by the authors. The authors observe that the four activities are symbiotic income generating enterprises. The quartet model has greatly contributed in reducing poverty, increasing agricultural productivity, facilitating value addition, conserving the environment, halting biodiversity loss and mitigating climate change. The model is strongly hinged on training of farmers in organized groups more especially the youth and the women. The involvement of KRIFS in integrated farming that involves introducing new innovations to improve production and productivity in agriculture through improved breeds of livestock and crops as well as environmental conservation being pivotal in its operations, has culminated to agro-tourism in the district. The authors recommend that the model be implemented in the whole of Uganda. Apiculture should be included in the priority commodity list for the parish model. Agro-tourism is yet another economic activity that should be exploited to reduce unemployment, conserve the environment and reduce effects of climate change.

1. Introduction

Kyabwanswa Rural Integrated Farming Systems (KRIFS) is a Community Based Organization (CBO) that was formed in 2004 with its Head Office in Nyakateramire Ward, Kitagwenda Town Council, Kitagwenda district, western Uganda. KRIFS' Vision is to play a leading role in improving rural agriculture through integrated farming. This is in agreement with Uganda Vision 2040 that aims at "A Transformed Ugandan Society from a Peasant to a Modern and Prosperous Country within 30 years".

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DOI: https://doi.org/10.30564/jgr.v4i4.3474

This paper addresses Uganda Vision 2040's three of the strategic bottlenecks that have constrained Uganda's socio-economic development since her independence namely: weak private sector, underdeveloped human resources and underdevelopment of agriculture. Uganda aspires to transform the agriculture sector from subsistence farming to commercial agriculture. This is intended to make agriculture profitable, competitive and sustainable to provide food and income security to all the people of Uganda. It also creates employment opportunities along the entire commodity value chain of production, processing and marketing [1].

A model can be a theory or law or hypothesis or structural idea. It can be a role, a relation or an equation. It can be a synthesis of data [19]. However, in this paper, a model is defined as "a simplified structuring of reality which presents supposedly significant features or relationships in generalized form. The most successful models possess a high probability of application and a wide range of conditions over which they apply [19]. Figure 1 shows that the Quartet model is highly flexible, for example, a farmer has wide choice of the livestock to rear, fruit types and coffee varieties to plant and in case of bee farming, the type of hive to use.

KRIFS quartet model involves emphasis of integrating four agricultural activities namely: Apiculture, agro-forestry, coffee and at least one type of livestock as shown in Figure 1. Quartet is derived from the important four crops (Olive-Citrus-Vine-Wheat) in the Mediterranean Climate (Dry summer–Subtropics) of Western Europe [2]. This is in line with the application of knowledge learnt from elsewhere to the Ugandan situations. This is in agreement with the Uganda Second National Development Plan (NDPII) that stipulates that the agriculture sector aims to ensure sustainable and market-oriented production, food security and household incomes in the country. It is comprised of three subsectors, namely Crop, Animal and Fisheries Resources (the quartet model dealing with the first two). During the NDPII period, the sector had a target of increasing agricultural exports to USD 4 billion by 2020 from USD 1.3 billion and reducing the number of the labour force in subsistence production from 6 million in 2012/13, majority of who are women to 3 million in 2019/20 [3].

In 2014, KRIFS in conjunction with the Department of Geography, Geo-informatics and Climatic Sciences (DGGCS) and Kamwenge Bee Keepers Co-operative Society (KABECOS) presented an innovative idea to the Consortium for enhancing University Responsiveness to Agribusiness Development ltd (CURAD). The innovative idea was: "Poverty reduction through Integrating Improved Bee, Coffee and Goat farming with Agro-forestry in Kamwenge district (QUARTET)". In the same year, KRIFS in conjunction with the DGGCS, KABECOS and Department of Geography and Environmental Engineering, West Point-New York presented an innovative idea to Global Knowledge Initiative (GKI) an International organization: "Poverty Reduction through Innovative Bee Farming and Processing Hive Products in Kamwenge district, Western Uganda (PRIB-FPHP)".

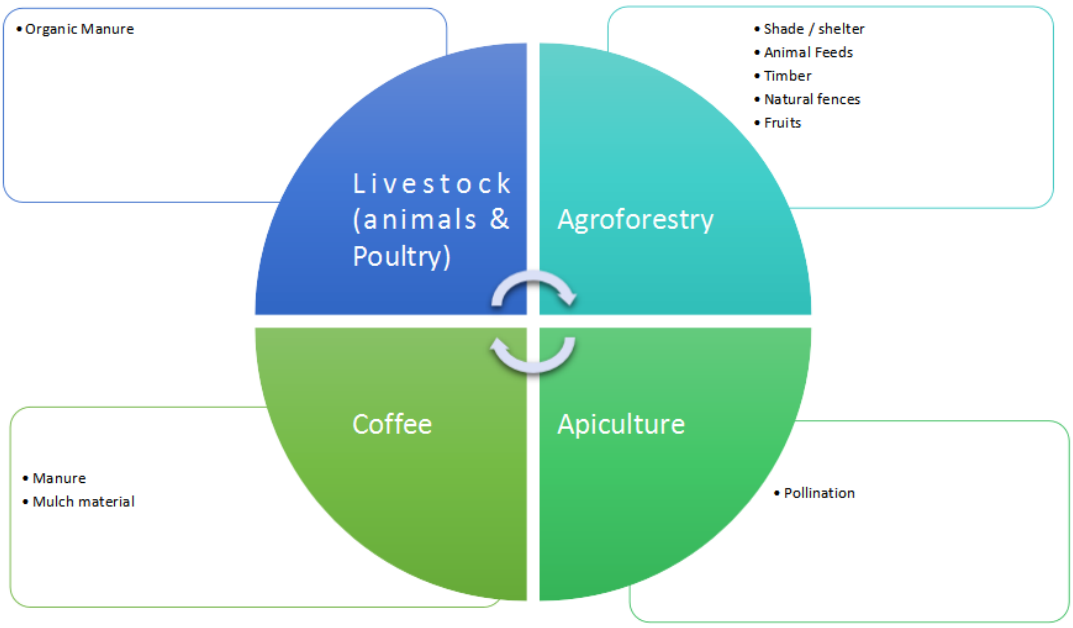

Figure 1. The Representation of the Quartet model

KRIFS and partners was one of the three finalists of the GKI Link Round IV (2014-15). The training that was offered by GKI changed the CBO from the the "Small Scale" (SS) to the "Think Big" (TB) approach.

In 2017, The parternership for Building Resilient Ecosystems and Livelihoods to Climate Change and Disaster Risks (BREAD) a grant project funded by SIDA made it possible to test the QUARTET model. One of the authors won a small grant titled: "Influence of Climate Change Variability on Livelihoods of Bee Farmers in Kamwenge district-Western Uganda" A section for testing the QUARTET model was added to the questionnaire and Focus Group Discussion questions for Ntara sub-county. This provided the survey data for this paper.

JENNI farm is one of the model farms in KRIFS. It is one of the Supper Sites (Field Labarotories). Super sites are centers in different locations of Uganda where the Department of Geography, Geo-informatics and Climatic Sciences of Makerere university use as focal points for research activities. This is in line with Makerere University policy of Community Outreach.

KRIFS encourages sustainable agricultural practices: "Efficient production of safe, high quality agricultural products in a way that protects and improves the natural environment, the social and economic conditions of farmers, their employees and local communities, and safeguards the health and welfare of all farmed species (www.saiplatform.org)" and sustainable development: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

It emphasizes Integrated Farming system: "Whole farm management approach that combines the ecological care of a diverse and healthy environment with economic demands of agriculture to ensure a continuing supply of wholesome, affordable food" (www.seedbuzz.com) or "Concurrent linkages between two or more farming activities within a coordinated framework" This is simplified by KRIFS as "Feed me and I feed you" *"Ndisa nkulise"*.

KRIFS operates efficiently through organising local community in groups at household level referred to as KRIFS Focal Clubs (KFCs). Each KFC is composed of 10 households working for the same cause thus reducing poverty and sustainably conserving the environment.

Jenni farm is one of the leading model farms in KRIFS. Apart from offering free training services, it secures improved plant and animal varieties, market for products and farm inputs.

The KRIFS Quartet model differs from the one used by National Agricultural Advisory Services (NAADS) in that it emphasizes four enterprises rather than the three for the latter. "NAADS operates through farmer groups at village level. The farmer groups in a given sub-county form the farmer forums. Each farmer group prioritizes three enterprises and the advisory service needs. The priority enterprises and advisory service needs are sent to the farmer forum, which determines three priority enterprises in the subcounty. NAADS supports the selected priority enterprises and the required advisory services needed to address the identified constraints and advisory service needs. Following selection of the three enterprises, NAADS provides technologies for demonstration on a member of a farmer group's (or host farmers) field-technology development site (TDS). The host farmer is chosen by fellow members of the group, and private service providers are contracted to carry out the demonstrations and advise farmers at these TDSs" [18].

The major objective of the paper is to illustrate an innovative development model that has been tried in Kitagwenda district by Kyabwanswa Rural Integrated Farming Systems (KRIFS) a local CBO in conjunction with the department of Geography Geo-informatics and Climatic Sciences (DGGCS) of Makerere University. Other objectives include the following: To upraise the values of bee farming in the improvement of livelihoods and emphasize its major link in the proposed quartet model in the district; to establish the proportion of the households that practice the four farming activities as propagated by KRIFS and to show the contribution of KRIFS in harnessing the vast agro-tourism potential in the district.

2. Materials and Methods

2.1 Study Area

Kitagwenda district is located in the south western part of Uganda. It is bordered by Kasese district in the West, Kamwenge in the North, Ibanda in the East and South East and Rubirizi in the South West (Figure 2). According to the Uganda Bureau of Statistics (UBOS), the population increased from 143,786 in 2014 to 178,300 in 2020 depicting a population change of + 3.75 per year (2014-2020) [4]. This is far above the national average of 3.01% per annum for the country between 2002 and 2014 [5]. The population of the district is extremely rural (176,200) 93.8% and only (11,000) 6.2% as compared to the national average of 74.3% and 25.7% respectively.

Altitude of the district range between 1300 to 3800 m above sea level. As a result, temperatures range between 20 and 30 degrees centigrade. The district receives well distributed bimodal annual rainfall (February to April and

September to December) averaging 1200mm throughout the year for most parts. The greatest amount of rainfall is received in the southern parts of the district. The district is endowed with tropical high forests dominated by Kakasi-Kitomi Forest Reserve, woodland, grassland, papyrus reeds/swamp, open water.

2.2 Data Sources and Analysis

The main primary data for this paper were derived from a survey that was conducted in Kamwenge district in January 2017. The current Kitagwenda district was one of the counties of Kamwenge district in 2017. It was curved from Kamwenge district in July 2019. Judgmental (purposive) sampling was used to get select Ntara subcounty for the study. Judgmental sample is the most subjective sampling method. Here, sample elements are selected based on judgment derived from prior experience. Sampling elements are selected based on the interviewer's experience that they are likely to produce the required results [16]. In case of this study, KRIFS headquarters are

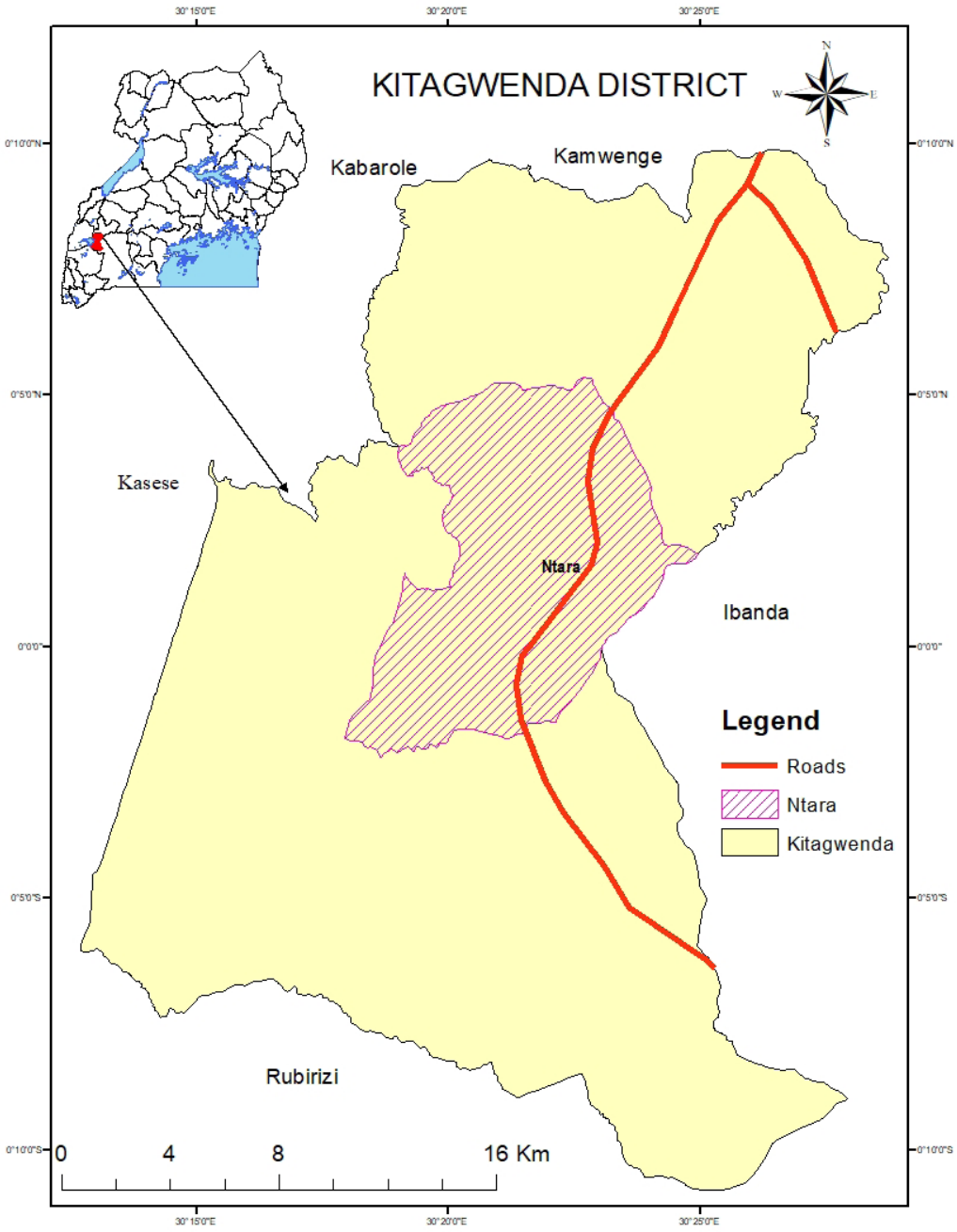

Figure 2. Map showing location of Kitagwenda and neighboring districts

in Ntara sub-county. This made Ntara sub-county the most appropriate. Snowball sampling was used to get respondents. Snowball sampling is non-random sampling method, which is used with the selection of people. This is based on a number of initial contacts that are asked for names and locations of any other people who might fulfill the sampling requirements. In this case, the bee farmers interviewed would help to inform the interviewers the location of the other bee farmers. For every bee farmer interviewed, the nearest neighbor non bee farmer would be selected as a respondent.

A total of 98 respondents from Ntara sub-county of Kitagwenda district who responded to the questions on the quartet model, 69 (70%) bee farmers and 29 (30%) non bee farmers were interviewed. Two Focus Group Discussions (FGDs) and four Key Informants provided additional detailed information. Observations by the authors played a vital role especially in the identification of natural and planted trees. The trees were identified in local names which were later cross checked with English and scientific ones [6]. Agro-tourism data source was a report written by one of the visitors of Jenni farm between 22nd and 25th June 2018. Secondary data included Uganda census results of 2002 and 2014.

Statistical analysis was done on two levels. In the first stage it involved univariate analysis to give the frequency distributions of the variables. This was followed by bivariate analysis using Chi-square. This statistic was used to determine whether there were any significant associations between the dependent variable that is participation of the four activities (Quartet) and independent variables (size of land, income and type of house). Associations were considered significant at $p < 0.05$.

3. The Quartet Model

The livestock (goats, cattle and pigs) feed on conserved, planted and maintained plants. Their excreta are used as organic manure to increase productivity in crops such as maize, beans and cassava which in turn are used to feed the animals. The fruit trees inter-planted with bananas and coffee are also used as feed to the zero-grazed cattle and goats. Mutooma (*Ficus natalensis*) inter-planted with coffee for shade is the most delicious feed for the livestock (Photo 1).

The quartet model is intended to increase production and productivity using improved animal and crop breeds as well as innovative methods of farming. The model is an innovation of four interlinked agricultural enterprises (QUARTET). Bee farming does not require a lot of labour and the hive can produce many products highly demanded for their medicinal and food values. The improved hives will increase production of honey and other products such as pollen, propolis, royal jelly, bee wax and venom. The bees are pollinators, also increase yields of coffee and other crops. Agro-forestry increases the nectar and pollen for the bees by reducing the distance covered by the bees

Photo 1. Goats feeding on Ficus natalensis

in collecting the same raw materials for honey and other hive products. The fruit trees increase production of fruits. The trees also provide shade for the coffee while at the same time increase forage for the zero-graded animals such as goats. The animals supply the highly required organic manure from their urine and droppings thereby increasing yields of coffee and other crops.

Agro-forestry involves inter-planting coffee with trees for provision of shade for the coffee and forage for the zero-grazed animals. Fruit trees that are planted include: Vacados (Persea americana), Mangoes (Mangifera indica), Guavas (Psidium guajava) and Jack fruits (Artocarpus heterophyllus). In addition, Mutooma (Ficus natalensis) and Calliandra which are delicious feeds for goats shall be emphasized. Farmers are encouraged to conserve and propagate indigenous trees such as Musizi (Maesopsis eminii), Murongo (Albizia grandibracteata), Musasa (Sapium elliticum), Mubirizi(Vernonia amygdalina), Munyinya (Acasia gerrardii), Mukunyu (Ficus mucuso), Murama (Combretum molle) and Mwitibale (Blighia unijugata). Grevillea robusta is planted in the boundaries of the farms. These trees are frequently visited by bees for nectar and other products. At the same time, trees to contribute to environmental conservation and improve the micro-climate of the area [6].

It is envisaged that QUARTET innovation will be scaled out to other members in the district and other parts of the country through farmer to farmer extension, tapping into expertise gained by the KRIFS farmers. The proposed engagement is in tandem with Uganda government policies of increasing production and productivity through nucleus farmers in the private sector. It is also meant to support small holder farmers, increase value addition and therefore household income. This concurs with the objective interventions 1 of the Uganda National Development plan II: Increase agricultural production and productivity.

One KI summarized the quartet model as follows: *"It is a life time business that insures old age insurance that is lacking in the country. An old man aged 80 years shall be able to harvest honey and process other hive products, sell coffee and manage to raise high quality animals that shall be feeding from forage from the trees that he planted 20 years ago and sell timber from Musizi and Grevillea".*

Beans, cassava, ground nuts are inter-planted with eucalyptus for a period of two years, five in pine and seven in musizi (*maesopsis eminii)* and gravelia. When the crops are no longer planted, the goats and cattle graze under the trees enjoying the shade and soft grass. The most loved paddocks by the cattle on Jenni farm are those with musizi (*maesopsis eminii*) trees (Photo 2).

The conserved trees and planted ones are used in fencing the paddocks for the cattle and the goats. The dry leaves that drop from the branches of the trees are used as mulch for coffee and other crops. The mature trees are processed into timber for making bee hives and other products (Photo 3).

The goats and cattle use the same paddocks because

Photo 2. Cattle grazing in the musiza paddock

Photo 3. Mature trees from natural forest provide timber for construction of bee hives.

they have different feeding habits. Goats are 90% browsers and 10% grazers while cattle are 90% grazers and 10% browsers. Due to many crops grown, the conserved and planted forests provide forage for the bees. The bees in turn help in pollination of crops and therefore increasing yields. The whistling pine which does not provide timber is one of the most frequently visited trees in the compound.

4. Analysis and Discussion of Results

The results show that out of the 98 members of the households that responded to the question on the quartet model, 42 (43%) participated in all the four activities as observed in Table 1.

Table 1. Participation in the four activities.

Level of Participation	Number	Percent
Participated in four activities	42	42.9
Did not participate in all the four activities	56	57.1
Total	**98**	**100.0**

Source: 2017 survey data

On the other hand, Table 2 shows that out of the 41 respondents of the 56 respondents that were not involved in all the four activities, the majority (71%) were not involved in bee farming. This is not surprising, because previous studies revealed that the biggest proportion (37%) of the respondents were not practicing apiculture because they lacked training that was connected to ignorance and fearing the bees [7]. The second biggest proportion (19%) stressed shortage of land as the main reason. However, it should be noted that with training and provision of protective harvesting gear, the fear of the bees can be solved. With the issue of land, even those with small pieces of land can also carry out bee farming if they have neighbors with big chunks of land or are neighboring protected areas such as National parks and game reserves. One of the KI remarked: "the bees do not respect boundaries of land. They move to where ever there is forage!!!"

Table 2. Activities not engaged in by farmers in the quartet model.

Activities	Number	percent
Bees	29	70.73
Livestock	2	4.88
Agroforestry	2	4.88
Bees & coffee	2	4.88
Bees & agroforestry	2	4.88
Coffee & livestock	2	4.88
Bees &livestock	1	2.4
Bees, coffee & livestock	1	2.4
Total	41	99.93

Source: 2017 survey data

The respondents revealed that they had small pieces

of land since many of them had either inherited it from their parents or had subdivided it to their children leaving each individual with a tinny acreage of land. Participation in the four activities was cross tabulated with size of land, income and type of house. Size of land (p= 0.001) and Income (p = 0.020) are significant. This is because Agroforestry and apiculture need large land size and money to establish. Lack of land and capital were listed as second and third in hindering bee farming as shown in Figure 3.

Table 3. Participation in four activities according to size of land, income and type of house.

Size of land (acres)	Yes	No	Total
1 to 5	13	37	50
6 to 10	15	6	21
11 to 15	4	4	8
Above 15	5	1	6
Total	37	48	85

Chi- square = 16.9, p= 0.001

Annual Income bracket	Yes	No	Total
Less than 720,000/=	25	47	72
2,400,000 to 6,000,000/=	16	9	25
Over 6,000,000	1	0	1
Total	42	56	98

Chi-square = 7.842, p = 0.020

Type of house	Yes	No	Total
Permanent	15	13	28
Semi-permanent	22	42	64
Temporary	0	1	1
Total	37	56	93

Chi- square = 3.664, p = 0.160

Source: 2017 survey data

4.1 Bee Keeping

Bee keeping is one of the most undertakings for poverty alleviation. This fits well in the Uganda government strategies of transforming subsistence to commercial farming and linking agriculture to industry through agro-processing to curb unemployment as enshrined in the National Development Plan (2010-2015). It is one of the projects where funding by Uganda government for the youth is available through the Youth Livelihood Programme (YLP) [8]. However, apiary is not among the eighteen prioritized development commodities under the Parish Development Model (PDM) which is expected to start in the Fiscal year 2021/22. The priority commodity list for the parish model include: Coffee, cotton, cocoa, cassava, tea, vegetable oils/oil palm, maize, rice, sugar cane, fish, diary, beef, bananas, beans, avocado, shea nut and macadamia nuts [16].

Beekeeping or modern apiculture is the art and science of rearing, breeding and managing bee colonies in artificial hives for economic benefits. It has evolved into a farming enterprise that involves the use of sophisticated and artificial techniques to keep bees for bee products such as honey, propolis, wax, pollen, bee venom and royal jelly. It contributes significantly to securing sustainable livelihoods by assisting in transforming vulnerabilities into security [9]. It is an important component of agriculture and rural development in many countries. It provides nutritional, economic and ecological security to rural communities. Beekeeping is a useful means of strengthening livelihoods and has been identified as a viable agricultural practice that could alleviate poverty and sustain rural employment. It causes no disturbance to the natural environment. It creates an economic incentive for rural people to conserve

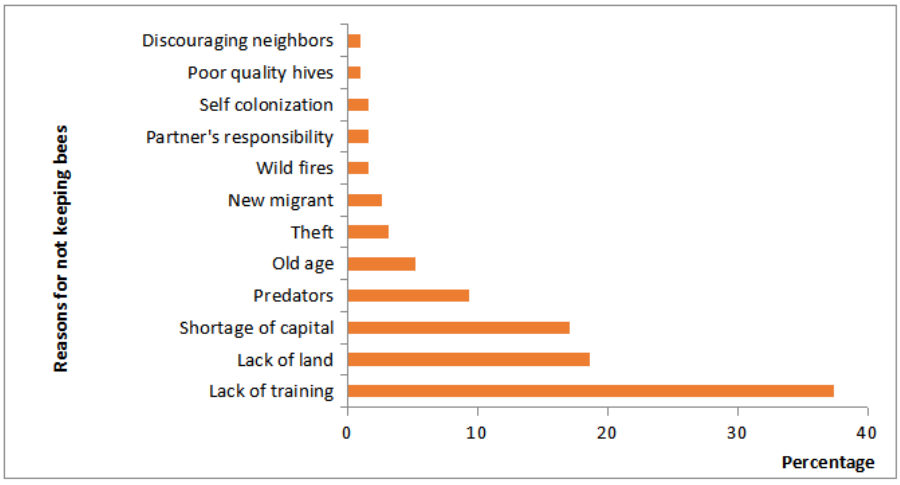

Figure 3. Reasons for not keeping bees.

Source: 2017 survey data

natural vegetation. It is the ultimate environmentally sustainable activity [10]. Improved bee farming would increase production of honey and other products such as pollen, propolis, royal jelly, bee wax and venom that will be processed to add value. Previous studies highlighted that in apiculture sub-sector, the national goal is to enhance the production and marketing of honey and other hive products. Increase in the number of bees, the best pollinators, will further increase yields of crops such as coffee, mangoes maize, beans and other crops [7].

Beekeeping requires minimal start- up investment and generally yields profits within the first year of operation. It contributes significantly to securing sustainable livelihoods by assisting in transforming vulnerabilities into security. It is carried out by small farmers, and it is particularly suitable for under-privileged landless and low income, low resource individuals and groups [11]. Beekeeping is regarded as an activity that complements existing farming systems in Kenya [10]. It is simple and relatively cheap to start, enhance the environment and contribute to biodiversity through the pollinating activity of bees. It provides incentive to conserve natural forests to provide an abundance of excellent bee forage. It is completely sustainable, generates income and requires a very low level of inputs (land, labour, capital and knowledge] in its simplest form. It is therefore an ideal activity for small scale, resource poor farmers. KRIFS carries out training of bee farmers therefore solving the most significant problem of lack of training (Figure 3) and makes improved top bar hives as well as protective harvesting gear which it sells at subsidized prices.

4.2 Coffee

Coffee is the major perennial cash crop in Kitagwenda that was introduced during the colonial period. Bananas have recently become another cash crop although have been regarded as food crops for a very long time (Figure 4).

Coffee in some cases is inter-planted with bananas. Cassava used to be perennial crop but due to climate change and introduction of new varieties, it is now seasonal. Respondents still regard it as perennial. It is also a food and cash crop especially for Rwanda and DRC markets. Coffee seedlings provided by government free of charge for the last 10 years. Beans and Maize are major seasonal food and cash crops that usually inter-planted. Beans are stressed for nitrogen fixing. Millet and groundnuts have reduced in importance due to reduction in soil fertility and increase in population that has reduced the fallow period. Coffee is a popular crop in the district as observed from one of the KIs.

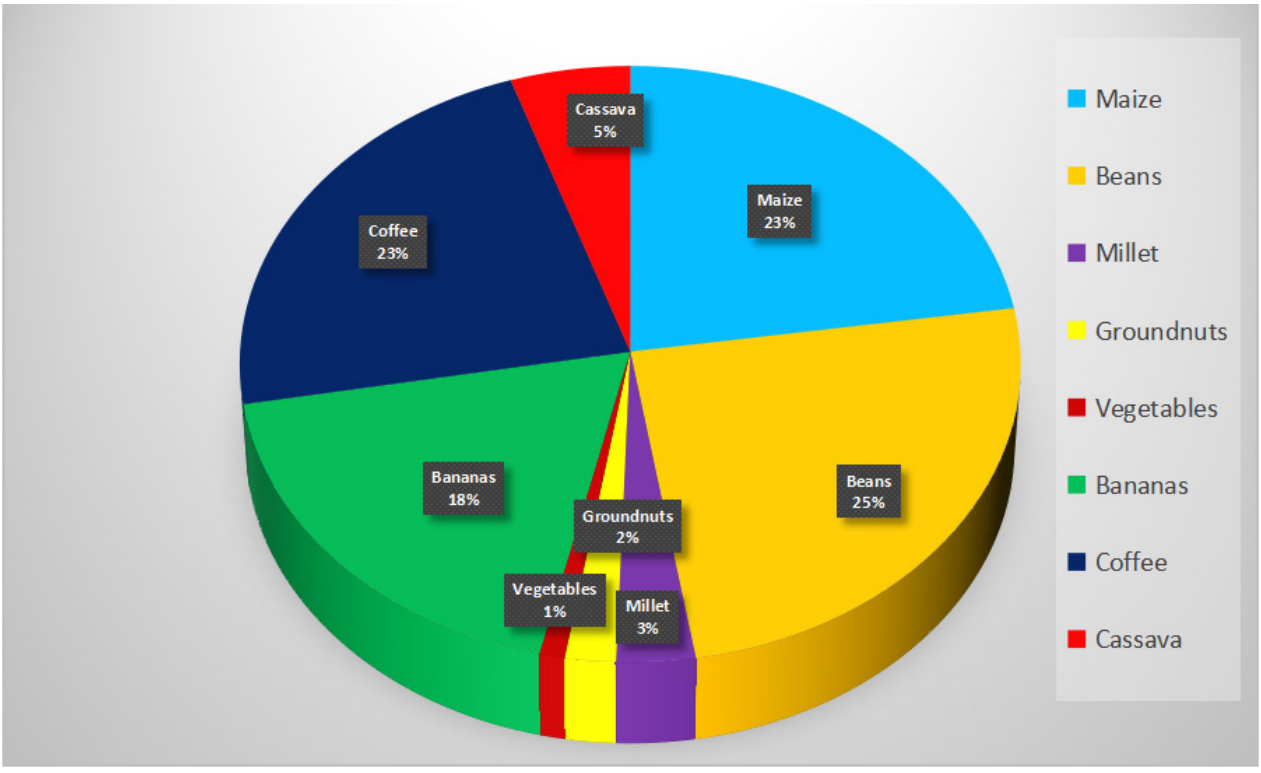

Figure 4. Seasonal and cash crops grown in Kitagwenda

Source: 2017 survey data

"Coffee is a perennial crop. You plant once and you keep enjoying your money for life. It is harvested twice a year. One earns cash twice in a year. The government is also interested in the crop. From one acre of coffee, if well managed, one can earn three million shillings a year"

The government of Uganda has for a long time emphasized coffee growing as evident from the distribution of agricultural inputs using various approaches: public private partnership arrangements, community procurement like under National Agricultural Advisory Services (NAADS), and Ministry of agriculture, animal industry and fisheries (MAAIF) through provision of seedlings; and the private sector and cooperatives. From 2014, Uganda government embarked on the programme of distributing free agricultural inputs (seeds, seedlings, planting materials and breeding stock) to farmers known as Operation Wealth Creation programme (OWC) with the main goal of commercializing agriculture by creating wealth at household level and reducing poverty. The programme uses the army, the Uganda Peoples Defence Forces (UPDF) to distribute and supervise delivery of inputs [15]. KRIFS through Uganda Coffee Development Authority (UCDA) supplied 63,680 coffee seedlings to farmers in Ntara sub-county, Kitagwenda district between November 2016 and February 2020.

4.3 Livestock

More than half of the respondents (54%) kept animals while 46% did not (Table 4).

Table 4. Keeping animals

Animal keeping	Number	Percent
Yes	53	54.1
No	45	45.9
Total	98	100.0

Source: 2017 survey data

Animal keeping is generally regarded as a common venture in Kitagwenda. A KI had this to say:

"How can one regard himself as a head of family when he does not own a goat or chicken? The Batagwenda who were traditional hunters enjoy eating meat. The laws no longer allow people to hunt wild animals for meat. We therefore need to have our own animals for meat. Morevover, animals are essential items in cultural practice of bride price in marriage. These days when, you have animals, you have money"

The most common animals reared in Kitagwenda are goats (30%) followed by chicken (28%), pigs (26%) Small proportions of farmers keep cattle (5%), ducks (5%), sheep (3%) and rabbits (1%) (Table 5).

Table 5. Animals kept

Animals	Responses	
	Number	Percent
Cattle	5	5.4
Goats	28	30.4
Sheep	3	3.3
Pigs	24	26.1
Chicken	26	28.3
Duck	5	5.4
Rabbits	1	1.1
Total	92	100

Source: 2017 survey data

KRIFS has played a big role in the improvement of goat breeds through emphasizing rearing of boer goat breeds in Kitagwenda district. The first buck boer goat was introduced in Jenni farm as early as 1997 and was used to crossbreed with the local mubende goats.

The South African boer goat is one breed that has been specifically selected for high meet production and quality. Introduction of exotic breeds and their use for upgrading indigenous breeds has been widely adopted my farmer communities and organizations as an alternative way of improving the low output of meat and milk among the indigenous goats [20].

4.4 Agro-forestry

Growing of fruit trees is a traditional activity. It is not common to find a homestead without fruit trees. Members of the Focus Group Discussion all agreed that fruit trees are part of homesteads in many parts of Uganda. Table 6 displays the commonly planted trees in the study area.

Table 6. Common varieties of planted trees

Planted Trees	Responses	
	N	Percent
Eucalyptus	19	13.3
Pine	3	2.1
Musiza	4	2.8
Mangoes	31	21.7
Avocadoes	30	21.0
Guavas	23	16.1
Jackfruit	27	18.9
Oranges	1	0.7
Pawpaws	5	3.5
Total	143	100

Source: 2017 survey data

Common trees planted include mangoes *(Mangifera indica*) (22%), avocados (*Persea americana*), (21%), Jackfruit (*Artocarpus heterophyllus*) (19%) and Guava (*Psidium guajava*), (16%). Eucalyptus (13%) is the dominant tree planted mainly for building and firewood. It has of recent become a commercial tree grown on large scale for timber. Other commercial trees for timber include musiza (4%) and pine (3%). In 2008, KRIFS in collaboration with Kamwenge Local Government collected and distributed the first 2000 improved mango seedlings from Kawanda research station paving the way for large scale farming in the area.

The following tree species have been planted by Jenni farm:Mutooma (*Ficus natalesis*), Musizi (*Maesopsis eminii*), Neem (*Azadirachta indica*) Mexican cypress (*Cupressus insitanica*), Whistling pine (*Casuarina equisetifolia*), Muluku (*Sapium ellipticum*), Castor oil plant (*Ricinus communis*), Calliandra (*Calliandra calothyrus*), Podo (*Podocarpus latifolius*), Tipu tree (*Tipuana tipu*) and Ruyenze (*Euphorbia tirucalli*). In addition, Jenni farm has conserved the following other indigenous tree species: Murongo (*Albizia grandibracteata*), Munyinya (*Acacia gerrardii*), Rugando (*Acasia hockii*), Muko (*Erythrina abyssinica*), Murama (*Combretum molle*), Musasa (*Sapium elliticum*), Mubirizi (*Vernonia amygdalina*), Mukunyu (*Ficus mucuso*), Musebeya (*Albizia Versicolor*), Musambya (*Markhamia lutea*), Mulamula (*Dracaena fragnus*), Muhoko (*Diaspyros abyssinica*), Mwatibale (*Blighia unijugata*), Mwongogwenkende (*Tabernaemontana pachysiphon*), Muzigangoma (*Cordia Africana*), Kirundu (*Antiaris toxicaria*) and Palm trees in the wetlands [6].

4.5 Protection and Improvement of the Natural Environment

The wetlands and riverine forests in the valleys have been conserved and preserved. Trees in the rest of the farm are conserved. In farm repairs, branches of trees are used. Cutting a whole tree in farm requires knowledge of the top management. The 200 year old musisa (Olea capensis) with six off-springs is the best example of the conservation of indigenous trees (Photo 4). Of the six off-springs, only one is over 33 years. Before the owners of Jenni farm settled in the area in 1987, the vegetation was burnt twice a year. This could not allow the young *Olea capensis* to grow.

The place which was grassland in 1987 is now covered by crops on top of the hill, beautiful forests and woodland savannah on the slopes and wetlands in the valley bottoms. The wetlands in the valleys have provided a favourable environment for the national bird the Crested Crane to multiply. Crested cranes are strictly monogamous birds that lay their eggs in wetlands.

Photo 4. The oldest musisa (Olea capensis) preserved on Jenni farm

4.6 Agro-tourism

KRIFS through Jenni farm has moved a step further to include special agro-tourism in Kitagwenda district. This is intended to give a special treat to the tourists through four categories. First, tourists visit a number of farm sections of Jenni farm and are involved in daily farm activities. This involves visitor participating in agricultural activities with the household members. For example, if the day is intended for bee farming, the visitors are having to be guided through the stages of hive making, bee trapping, cleaning the apiary, honey harvesting and processing as well as making other hive products. Experiences of one of the tourists on Jenni farm are given below:

"*I must say that Kyabwanswa is a beautiful sprawling woodlot typical of English homesteads as observed from one scene below*: *Standing on the Eastern side of the main Kyabwanswa Hill, one can see a typical equatorial forest in the valley and in the background observe a pine forest on top of a Hill locally called Kinyamugara also part of Jenni farm in the background, as shown in Photo 5* [12]."

Photo 5. Equatorial forest in foreground and pine forest in the background

The activities that stand out are goat rearing, fruit growing, poultry keeping, cattle keeping, growing of all kinds of trees like eucalytus, musizi, pine, gravellier, but to mention a few. Other activities that take credence and are worth mentioning are beekeeping, biogas and use of the swamp to tap water, forming a dam.

All these are enterprises that are handled in a manner that is sustainable and adds value to the entire farming system. The philosophy of having an integrated farming system is clearly brought into light when you begin with the importance of conserving the wetland that provides the water for human and animal life sustenance. It is worth noting that each one of us comes up with an assessment of the entire enterprise. The following priority areas that truly stand out and could be further developed scientifically and research carried out: (1) Geographical engineering that ensures flow of water from the roof to the tank; also referred to as water harvesting. Creation of dams in the wetlands is highly commendable because the wetlands preserved and conserved help the farmer go through the long dry season. (2) The Bio-gas that helps in energy fuel saving. Meals at Kyanbwanswa are cooked using bio-gas. (3) The fruit trees that enrich diet, and help to prevent certain diseases like cancer, etc. (4) The forest cover that ensures a constant cool breeze, supply of timber for various purposes. Natural forests are also conserved. (5) The beekeeping activity with production of honey as well creams for skin beautification as well as healing. 6. Animal husbandry that ensures a constant supply of milk. Poultry that brings in eggs. All this is for sale and home consumption.

All these enterprises are home based and have had a profound effect on improving the household incomes as well transforming lives of people in Kyabwanswa. As far as security is concerned, as there are three strong dogs for that purpose. The meals prepared are delicious. All the food cooked is obtained from the farm. A typical dish for lunch and supper begins with fruit served, then matooke, chicken or beef. For breakfast and the other meals too, honey that is homemade is served on table. Guests are assured of having enough to eat from Kyabwanswa. All kinds of fruits are available like mangoes, jackfruit, strawberries, ovacado, pineapples etc. Therefore a visit to Kyabwamswa will surely leave you fully satisfied, educated, comforted from the stress of life and wishing you would stay longer" [12].

Secondly, tourists undertake landscape viewing using the numerous highlands around Jenni farm and river Mpanga gorge that is endowed with *Cycad* (Photo 6).

The Cycad plant scientifically known as the *Encephalartos villosus*, is an evergreen ornamental plant categorised as either male or female that lives for a long time. The cycad is only 6 km from Jenni farm. Cycad is a pre-historic plant species that from a distance could easily be mistaken for a type of palm tree but on close inspection has no relationship at all to palm trees. Located in Karubuguma

Photo 6. Cycad in Kitagwenda threatened by agricultural activities

I and II villages in Kitagwenda district, western Uganda, is the largest cycad in Uganda [13]. Uganda Tourism Board (UTB) is looking at creating a number of packages aimed at promoting the area to tourists. These include nature hikes, camping, canoeing, zip-lining, rock climbing and the cycad trail, among others. Therefore, promotion of tourism in the area would have a trickle-down effect that would see the local population stop the destructive activities on their lands as they would earn a livelihood from tourism. Other than the cycad plants, the area is home to beautiful sceneries, the presence of waterfalls along river Mpanga and the close proximity to Lake George and several national parks [13]. Cycad Plants, one of the most threatened plants in the wild, are capable of boosting Uganda's tourism if protected, tourism experts have observed. The male plant produces cones filled with pollen, while the female, usually bigger in size, produces seeds. Cycads are usually found in good landscape areas that are well moist, drained and with a mild climate. They are believed to be the oldest seed plants on earth traced from 315 million years ago even before the Jurassic period when dinosaurs flourished [14].

The third stage of tourism organized by Jenni farm, involves visiting other areas of attraction in Fort Portal Tourism City area. These include, Queen Elizabeth National Park, Kibale Forest National Park, Semuliki National Park, Rwenzori National, Katonga Game Reserve and Kakasi-Kitomi Forest Reserve.

5. Conclusions and Recommendations

The quartet model that involves encouraging farmers to grow coffee as the main cash crop, integrated with trees as shade and providing timber, firewood and fruits while rearing bees to pollinate the crops and keeping at least one type of livestock to provide manure and extra income as well as animal protein has been successfully used to increase production and productivity as well as diversification of sources of income and therefore playing a big role model in the reduction of poverty in Kitagwenda district. It is therefore recommended that the model be implemented in the whole of Uganda with adjustments to any four linked items depending on the agro-climatic conditions and preferences of the farmers after careful studies as has been the case in Kitagwenda district. Apiary should be included in the priority commodity list for the parish model. Agro-tourism is yet another economic activity that should be exploited to reduce unemployment and conserve the environment and reduce effects of climate change.

Acknowledgements

Thanks to SIDA through the BREAD project that funded the survey for the primary data collection in 2017. Special thanks go to Uganda Geographical Association (UGA) that funded the authors to attend the 1st International Conference on Geographical Science

for Resilient Communities, Ecosystems and Livelihoods under Global Environmental Change (GORILLA). This paper that was presented in the GORILLA conference held in Kampala Uganda 3rd to 5th December 2020.

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ARTICLE

Gendered Perceptions of Climate Variability and Change among Local Communities Living around Queen Elizabeth National Park in Uganda

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ARTICLE INFO

Article history
Received: 26 October 2021
Revised: 24 September 2021
Accepted: 27 September 2021
Published: 10 October 2021

Keywords:
Gender
Climate change
Perceptions
Local community
National park

ABSTRACT

Climate change affects both men and women which, in turn, shapes their varied and contrasting perceptions of climate variability and change. This paper examined the gendered perceptions of climate variability and change among local communities in Queen Elizabeth National Park in Uganda. The objectives are threefold: - identify climatic shocks faced by the local communities; examine the perceptions of men and women of climate variability and change; and to compare their perceptions with empirical meteorological data. This study employed both qualitative and quantitative methods, with data collected from 215 respondents using survey, interviews and focused group discussions. From the findings, indicators of climate variability and change included reduced flooding events, occurrence of human diseases, increasing crop pests and diseases, dry spells and intensity of rains. There was increasing significant temperatures while rainfall was declining. Both male and female significantly associated with increasing temperatures and reduced flooding events. While climatic shocks affected both males and females, the impact was more pronounced depending on distinct livelihood activities and roles and responsibilities undertaken. The study concluded that people's perceptions of climate change should be taken on by the government and integrated in the national climate programs that support people's livelihoods and survival mechanisms.

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DOI: https://doi.org/10.30564/jgr.v4i4.3637

1. Introduction

Scholarly debates and discourses on climate variability and change have increased in the recent time [1]. Climate variability and change is an environmental phenomenon that has attracted global concern and attention because of its wide ranging adverse effects on the livelihoods of local communities and economies of both developing and developed countries [2,3]. This appears to be the same situation in Uganda where climate variability and change has been identified as a growing impediment to development and resource productivity [4,5]. For instance, livestock death, occurrence of new livestock and crop diseases, reduction of biodiversity, increased deprivation of water and crop failure emanating from climate variability and change characterize many agro-pastoral communities in developing countries in sub-Saharan Africa including Uganda [6,7]. This state of vulnerability to climate shocks is worsened by heavy reliance on climate-dependent resources such as rain-fed agriculture and having low coping and adaptive capacities, coupled with multiple development challenges such as high population increase and poverty that require redress to protect the livelihoods of rural households [8,9]. Protected areas such as national parks and the local communities that live within and on the fringes of the parks are also affected by the changes in climate since they depend on the natural resources therein for their livelihoods [10]. At the same time, such resources, rooted in a highly dynamic ecosystem, are vulnerable to climate variability and change thus affecting the livelihoods of the local communities as well as the park's resources. Such constraints destabilize existing social relations between local communities and conservation goals of protected areas thereby creating contrasting perceptions of climate variability and change [10]. Whereas perceptions cannot be proved scientifically, they provide useful insights into the changes and the ensuing actions for dealing with climate variability and change [11].

In Uganda, protected areas including national parks continue to grapple with climate variability and change as it inhibits productivity and natural regeneration capacities of the resources therein [10,12]. It is evident that climate variability and change continues to disrupt the balance between people, wild life and the environment thereby rekindling conflicts between parks and people [12]. In turn, conservation and management of endangered species and habitats becomes a challenge. For instance, the melting glaciers on mountain Rwenzori in Rwenzori national park have reduced and the glaciers have melted causing floods and landslides in the surrounding areas leading to movement of birds, people and significant reductions in fragile ecosystems and species [13]. Such effects challenge and reverse the progress made towards achieving the sustainable development goals (SDGs) especially reducing poverty (SGD1) and gender inequalities (SDG 5) which affect all the other goals [14,15]. Therefore, to strengthen climate efforts, there is need to understand how men and women perceive climate variability and change.

While several studies indicate the importance of gender in climate studies [16-18], the main argument has been that gender and climate change issues are often treated in isolation [18-20], with limited attempts to bring these two interrelated issues together. A significant body of literature on gender and climate change indicates that both men and women perceive climate variability differently and this is informed by the specific gender roles and tasks to which they are assigned [21,22]. By the very fact that women engage in agriculture as a means to provide for their households, it denotes that any change in the climatic variables either directly or indirectly affects them and their households, and extent of their response is informed by the likely impacts [23,24]. Addressing climate change from a gender perspective ensures that the perceptions of both men and women are given equal weight in planning and decision-making [25]. But the existing gender studies have tended to focus on agrarian settings [10,11,26] and mountainous areas [13,27,28] excluding focus on local communities adjust to and living within the national parks. With a specific focus on communities in and adjacent to Queen Elizabeth national park in Kasese district, this paper first, identifies climatic shocks faced by the local communities. Second, examines the perceptions of men and women of climate variability and change. Third, compares their perception of climate variability and change with empirical meteorological data.

2. Study Area

This study was focused on local communities living in and around Queen Elizabeth National Park (QENP) in Kasese district in western region of Uganda. This park is located between 0^{o} 12'S and 0^{o} 26N and 29^{o} 42'E and 30^{o} 18'E (Figure 1). The human population density surrounding the park was estimated to be 107 persons per km^2 and district population of 702, 029 [29]. The major economic activities are subsistence farming (growing of crops and livestock farming), fish farming, salt mining around lake Katwe and Kasenyi, bee keeping or forestry (tree growing) [29]. The park's ecosystem comprises savanna and grassland, wetland, lake and riverine [4]. The region normally experiences a bi-modal rainfall regime with the first beginning in March and ending in late May (MAM) and the second season beginning in September and ending in November (SON) with mean annual rainfall of 1250 mm and mean annual temperature

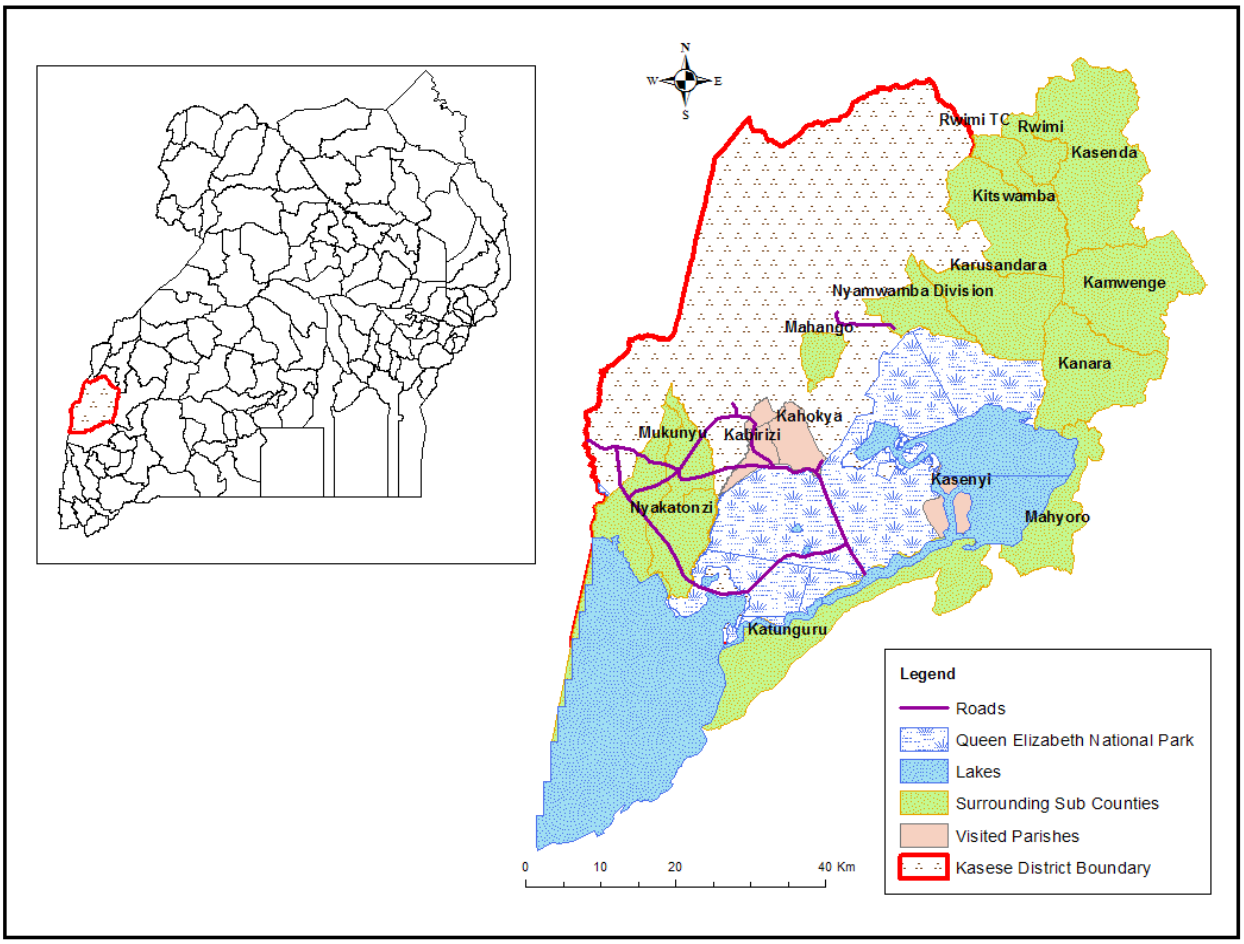

Figure 1. Map of Queen Elizabeth National Park showing the study sites.

of 22-25°C [30]. The rainfall varies due to its location along the equator and annual migration of the Inter tropical Convergence Zone [4,30].

3. Materials and Methods

3.1 Selection of Respondents-Household Surveys

The respondents were purposively selected from communities in and around Kasenyi, Katunguru, Lake Katwe and Kahokya parishes on assumption that all the households in each respective parish were involved in the same economic activities. However, the economic planner indicated that there are three dominant activities cross the study area as shown in Table 1 below. These are farming, salt mining and fishing. Since the number of participants in each of this activity was not well known, the sample size was derived by computing the minimum sample size required for accuracy in estimating proportions by considering the standard normal deviation set at 95 confidence level (1.96), percentage picking a choice or response (50%=0.5) and the confidence interval (0.05=±5) [Mensah, 2014]. The formula is:

$$n = \frac{z^2 (p)(1-p)}{c^2}$$

Where:

z= standard normal deviation set at 95% confidence level

p=percentage picking a choice o response

c=confidence interval

Although a total of 250 respondents were purposively sampled from the four parishes with the guidance from the community officer. 215 copies of the questionnaires were filled and returned representing 86% response rate.

Table 1. Selected respondents

Parish	Village	Dominant economic activity	Sample
Kasenyi	Mwalo	Salt Mining	29
Lake Katwe	Katwe	Salt Mining	30
Katunguru	Kasubi	Fishing	51
Kahokya	Kikorongo	Farming	105
Total			**215**

3.2 Data Collection

Both primary and secondary sources of data were used in this study to understand gendered perceptions of climate variability and change and how the rainfall and temperature trends related with perceptions of men and women.

Primary data

A designed and pre-tested open semi-structured questionnaire supported by an interview guide was used to solicit information on climatic shocks faced by the local communities and perceptions of men and women regarding climate variability and change. The pretesting was meant to confirm the reliability and validity of the questionnaire before administering it to the communities. In addition, six focused group discussions (FGDs) comprising an average of 16 persons (an almost equal representation of male and female) of different age categories were conducted in the selected communities to validate the information from the questionnaire survey. The focused group respondents, who were selected with guidance of the local council chairpersons, dwelt on climatic shocks, perceptions of climate variability and the most affected social group by climatic changes. Seven key informant interviews were conducted with local village and parish leaders (3), Sub-county Community Development officer (1), District Environmental Officer (1), District Fisheries Officer (1) and officials from Katwe Information Centre (KIC). The information collected included climatic shocks faced by the local communities, observed changes in the community as well as cross validating the information provided by respondents during focus group discussions.

Secondary data

To understand both rainfall and temperature trends at seasonal and annual scales, historical daily rainfall and temperature data for the period 1981-2016 were obtained from the Uganda National Meteorology Authority (UNMA) and quality controlled using the recommended World Meteorological Organization (WMO) guidelines.

3.3 Data Analysis

Primary and Secondary data analysis

The questionnaire responses from the household survey were coded and results entered into Statistical Package for Social Scientists (SPSS) to create a data file that generated descriptive statistics in the form of graphs, tables and chi square test for significance which were presented for discussion. Qualitative data from focused group discussions and interviews responses were transcribed, sorted and synthesized through a qualitative coding process and clustered into themes and later presented as narratives. To perform seasonal and annual rainfall and temperature trends, the daily rainfall and temperature data were analyzed using simple linear regression analysis with graphical methods (i.e a line graph) to illustrate the temporal trends of the time series of rainfall and temperature accordingly. Regression was used method was used because only weather data at weather station level (point data) was available. Additionally, linear regression is a popular parametric method recommended for trend analysis of climatic variables [31]. Other formats such as gridded data for the study area were not available where other methods such as spatial maps would have been used. This study considers the simple linear model equation below:

$$\hat{y}_i = a + bx_i$$

Where $i = 1,2,\Lambda\ ,n$

x is a known with precision independent variable, b is the slope of the line and a is the y-intercept.

4. Results

4.1 Demographic Characteristics of the Respondents

Table 2 shows the demographic characteristics of the 215 households interviewed. Of the respondents, 61% were males and 39% were females. Majority of respondents are engaged in farming (49%) (Crop production & livestock rearing), salt mining (27%) and fishing (24%). This finding agrees to the traditional nature of livelihoods in rural areas. Traditionally, rural livelihoods are based on crop production and rearing of livestock as the dominant sources of livelihoods though supported by other economic activities [29]. About 90% of the respondents were below 60 years which were within the productive employment age of active service while those above 60 years were meant to be retired from active labour. From the survey, 68% were married compared to the 17% that were single, while 6% widowed and 9% were divorced. Nearly half of the respondents (53%) had primary education, who are expected to understand the study problem while only 15% had tertiary education though the levels of education were unevenly distributed. Various reasons can be used to explain the variations in education attainment. However, poverty which leads to early marriages and its resultant effects was cited by the respondents in the focused group discussions as the greatest causal factor. The average household size was 6

persons while the majority of households (51%) had 1 to 5 persons. The findings suggest that there are still some larger households in the rural area. The reason behind this is that house size has a significant influence on household adaptation to climate change as proved by several researches [32,33].

Table 2. Demographic Characteristics of respondents

Parameter	Category	% response
Sex	Male	61
	Female	39
Age	18-35	39
	36-59	51
	60 years and above	10
Marital status	Married	68
	Single	17
	Divorced/separated	9
	Widowed	6
Education level	Non-formal	12
	Primary	53
	Secondary	20
	Tertiary and above	15
Household size	1-5 people	54
	6-10 people	33
	More than 11	13
Livelihood Activity	Farming	49
	Salt mining	27
	Fishing	24

4.2 Empirical Evidence on the Basis of Meteorological Data

Rainfall and temperature data were analysis to determine the trends in the values at both seasonal and annual scales. This was meant to compare whether the empirical data capture the trends as reported by the community members from the household survey and focus group discussions.

4.2.1 Rainfall Trends

Results for March April May (MAM) rainfall season indicated noticeable periodic variations in the rainfall amounts with a positive trend (gradient=0.632) though the increase in MAM rainfall was not significant since R^2 was very low (0.64%). On the other hand, September October November (SON) rainfall season results depicted more increase in rainfall amount compared to the MAM season with a positive trend (gradient=1.2) and R^2 (3.34%) though not statistically significant. On an annual basis, it is observed that there was an increase in rainfall amount from 1981 to 2016 with (gradient=2.20) though the increase was not significant given R^2 (2.8%) was low (Figure 2). This implies that the increment in amount of rainfall received is relatively small to create an impact.

4.2.2 Temperature Trends

Overall, there was a significant increase in the annual temperature trends (Maximum, Mean and Minimum temperatures) (Figure 3a-3c) in the study area for the period 1981-2016 more especially with the minimum temperatures. This means that the warm climate is likely to have significant effect on occurrence of climate extreme events such as drought.

4.3 Climatic Shocks Faced by the Local Communities

In this study, changes in biophysical environment were considered shocks since they affected agriculture, salt mining and fishing. Although there are seven variables of weather (temperature, precipitation, cloudy (type and cover), wind (speed and direction), humidity and air pressure, Government agencies such as Uganda National Meteorological Authority (UNMA) emphasizes rainfall and temperature and their manifestation as the most important variables in the field of climate sciences to help trace extent and magnitude of climate variability and change [34]. Therefore, the study concentrated on rainfall and temperature because the study area is highly dependent on rain-fed agriculture and so these variables helped explain various socioeconomic problems. Thus climatic shocks faced by the community are presented in Figure 4.

Across the livelihood activities, the study findings revealed that reduced flooding events, occurrence of human diseases, increasing crop pests and diseases, increasing dry spells, and increasing intensity of rains were the most noteworthy climatic shocks across the livelihood activities. However, reduced flooding events (35%) and occurrence of human diseases (28%) was outstanding among salt miners while increasing crop pests and diseases (32%) and increasing dry spells (26%) was outstanding among the farmers. Likewise, increasing intensity of rains was outstanding among fisher folks. The above responses were confirmed by the focused group discussions and key informant interviews conducted. For instance, salt miners observed that 1986 and 1994 were the most noted years where their salt pans were flooded leading to major reduction in salt extraction and

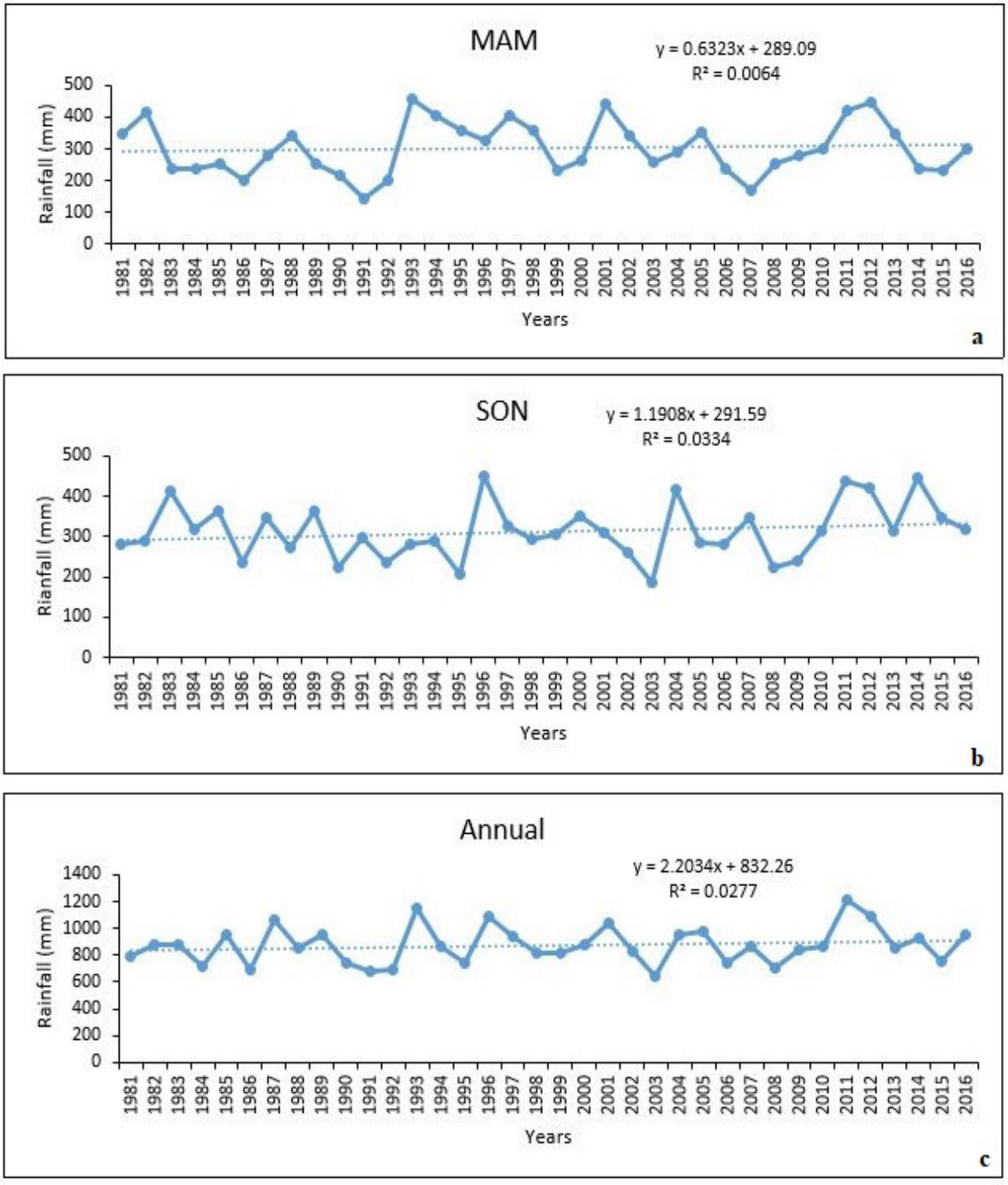

Figure 2. a. MAM seasonal rainfall for Kasese from 1981-2016. b. SON seasonal rainfall for Kasese from 1981-2016. c. Annual rainfall for Kasese for the period 1981-2016.

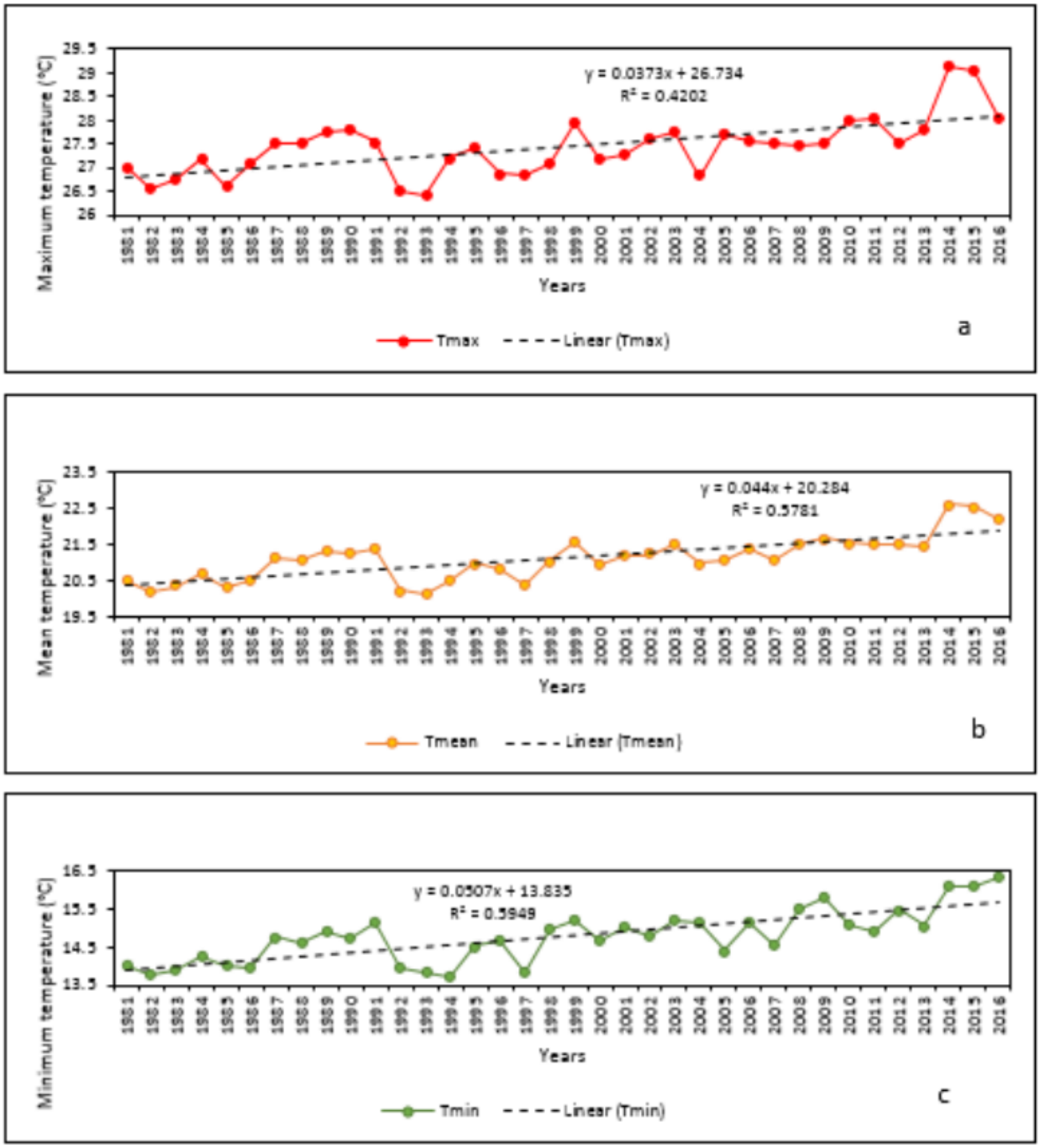

Figure 3. Temperature trends for Kasese district from 1981-2016

production. Furthermore, outbreak of water borne diseases like cholera and bilharzia were common as well severe skin irritations due to constant contact with water. On the other hand, farmers revealed that it was common for crops to be scorched due to the increasing dry spells and as a results crop yields harvested were reduced. The fisher folks complained of increasing intensity of rains.

4.4 Gendered Perceptions and Knowledge of Climate Variability and Change

4.4.1 Gendered Understanding of Climate Variability and Change

Climate change is a complex phenomenon that is perceived differently by males and females based on

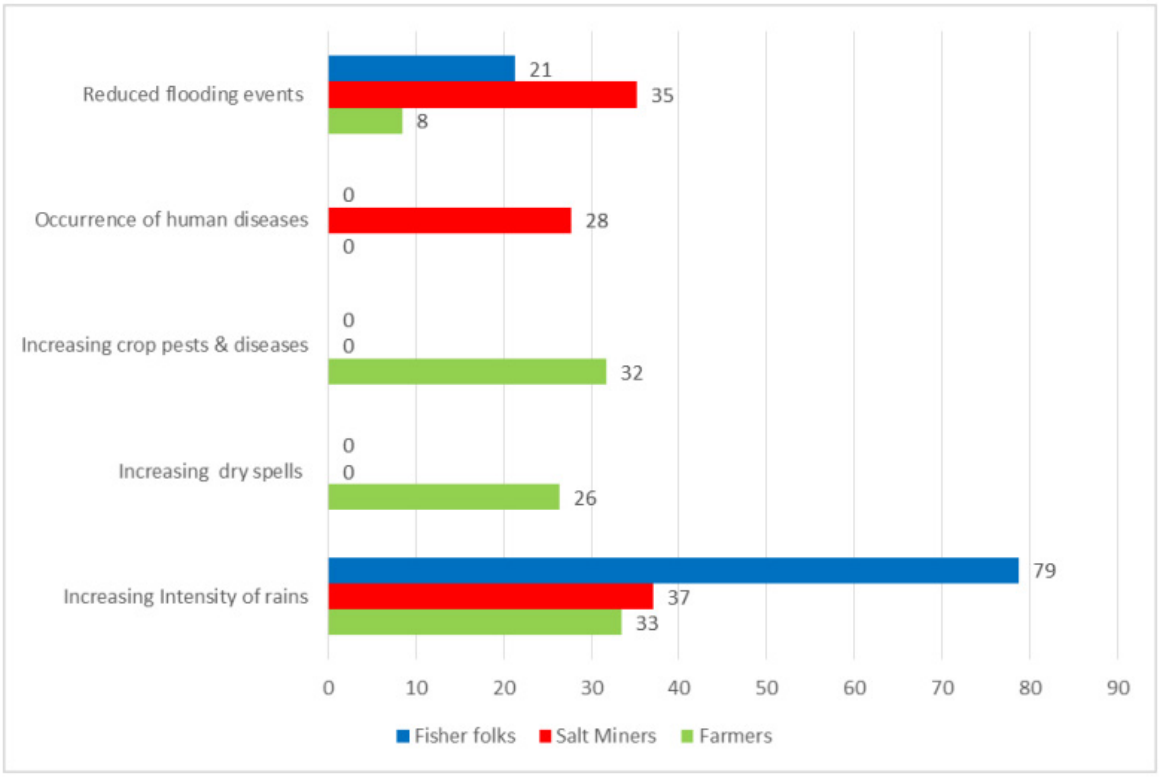

Figure 4. Community Climatic Shocks

associated events, roles and responsibilities. Respondents were asked about their perceptions of climatic shocks over the last 10 years and how these had evolved over time. Both male and female respondents mainly perceived climate change in terms of increasing dry spells, increasing temperatures, increasing intensity of rains and reduced flooding events (Table 3). However, a significant association was noted by both males and females with increasing temperature which affected the growth of crops and reduced flooding events.

4.4.2 Most Affected Social Group across the Livelihood Activities.

From the survey results obtained, the shocks affected both males and females (Figure 5). The males were more affected by increasing dry spells (30%) and increasing intensity of rains (30%) while females were more affected by increasing temperatures (21%). On the other hand, however, group discussions revealed that females were more affected by climatic changes compared to males. For instance, discussions among the fisher folks in Katunguru

Table 3. Gendered perceptions of climatic changes based on livelihood activity (% response)

Climate change indicator	Sex of respondent	Farming	Salt mining	Fishing	Statistics		
					X_2	df	P-Value
Increasing dry spells	Male	28	31	33	2.764	2	0.251
	Female	27	30	33			
Increasing temperature	Male	28	7	2	95.133	2	0.000****
	Female	27	11	0	55.711	2	0.000****
Increasing intensity of rains	Male	28	32	32	0.771	2	0.680
	Female	27	30	33			
Reduced flooding events	Male	15	31	32	38.776	2	0.000****
	Female	18	29	33	11.283	2	0.004****

**** P< 0.005

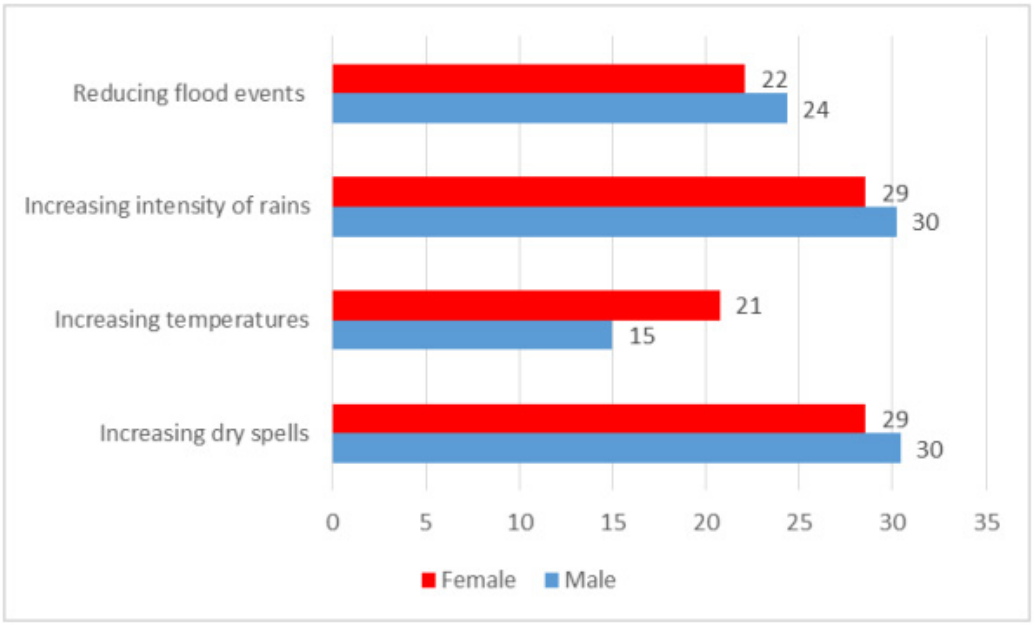

Figure 5. Most affected social group

parish revealed that women were the most affected by climate variability and change due to land use restrictions accorded to national parks and limited livelihood alternatives. While male fisher folks temporarily shifted to salt mining or informal activities including local drivers for tourists, mechanics, and motorcycle taxis. Similarly, farmers agreed that women were most affected because they depended on rain fed agriculture and so any variations in climate resulted into poor crop production.

4.4.3 Gendered perception on causes of climate variability/change.

Climate variability and change causes were categorized into 5 options; human causes, natural causes, human and natural causes, climate change does not occur and no sufficient evidence to support climate change claim, and assigned 5-likert scale where; Strongly Agree, Agree, Undecided, Disagree and Strongly Disagree responses signified the level of agreement of their perception would fetch and thereafter, mean score (WMS) was computed and ranked accordingly (Table 4). The results showed that both male and female perceived climate change to be caused by both human and natural factors (70.7%) because they scored the highest weighted mean score of 4.66 and ranked 1st. This suggested that climate change was understood by respondents as human own doing and some part of natural occurrence. However, with the indication of more human activities, respondents perceived more of human activities (74.9%) to be causing climate change than natural causes (66.0%). Secondly, climate change was perceived to be caused by natural causes with weighted mean score of 4.52 implying that, second to human activities, the ecological environment was equally depreciating leading to increase in climatic

Table 4. Gendered perception on causes of climate variability/change

	Level of agreement (Frequency (%)							
Attitudinal Statement	**SA**	**A**	**U**	**D**	**SD**	**Mean**	**Rank**	**Decision**
Climate Change is caused by human activities	161(74.9)	38(17.7)	14(6.5)	0(0)	2(1)	4.65	2nd	Agree
Climate Change is caused by natural factors	142(66.0)	43(20.0)	29(13.5)	1(0.5)	0(0)	4.52	3rd	Agree
Climate change is caused by both human and natural factors	152(70.7)	54(25.1)	8(3.7)	1(0.5)	0(0)	4.66	1st	Agree
Climate change is not occurring	2(0.9)	0(0)	7(3.3)	180(83.7)	26(12.1)	1.94	4th	Disagree
There is no sufficient evidence to support climate change claim	1.0(0)	10(0)	7(3.3)	3(1.4)	205(95.3)	1.08	5th	Disagree

change conditions with 66.0% of the respondents strongly agreeing it was equally causing climate change. The fourth and fifth perceptions were disregarded by the respondents because majority disagreed (83.71%) and strongly disagreed (95.3%) respectively with the statements that climate change was not occurring and there was no sufficient evidence to back that claim.

4.4.4 Gendered Perceptions of Seasonal Changes.

Rainfall and temperature were noted by both male and female to have changed across the three livelihood activities. For that, with improvements from the author, seasonal calendars were derived from the focused group discussions (FDGs) in respect of each livelihood activity (Table 5). According to the salt miners, March-April and September -October were the wet months, therefore, carried out fishing and business during the rainy seasons as an alternate livelihood. The rest of the months (May, June, July, August, November, December, January and February) were considered dry so extracted salt.

Similarly, the fisher folks shared the same sentiments of seasonal variability and emphasized March-April as the wet months. However, fishing and business was carried out throughout the year since fishing was less affected by the seasonal variations. Both male and female farmers noted two farming seasons (March and August-September) with unpredictable and reduced rainfall which resulted into increased dry seasons. Additionally, the farmers agreed that March was the new planting season for food crops.

Table 5. Seasonal Calendar

Livelihoods	Seasonal activities	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Salt Miners	Extraction of salt, Fishing and Business												
Fisher folks	Fishing Business												
	Land preparation (Digging)												
	Planting												
	Weeding												
Farmers	Harvesting												
	Processing (Drying)												
	Storage												
	Marketing												

5. Discussion

Overall, the findings of the household survey, focus group discussions as well as rainfall and temperature data showed observable climatic changes in the study area. Other studies undertaken in Uganda similarly revealed that the country was experiencing climate variability and change which has marked effects on food availability and on the income of agriculture-dependent households [35-39]. Empirical evidence from secondary data (1981-2016) showed that although increasing rainfall trends were observed for the March to May (MAM) and September to November (SON) seasons and annual rainfall, the trends were insignificant. Likewise, findings by Mwaura & Okoboi [37] and Kisauzi *et al.,* [40] indicated that a decline in rainfall received in Uganda and the trend was not statistically significant. Furthermore, monthly values of rainfall indicated a shift in the rainy seasons which Cook, & Vizy [5] attributed to the solar heating maxima in the equinox season. The decrease in rainfall especially during the MAM results in significantly drier conditions which are not optimal for crop production [41].

On average, temperatures have been increasing significantly especially minimum temperatures. According to Nimusiima [8], increase in temperatures lead to increased evapotranspiration and hence water stress for crops and animals while studies by Kaggwa [42] indicated that increased temperatures in Kasese district were responsible for increased floods where the ice cap on mountain Rwenzori had melted. Other studies that perceived temperatures to be increasing included Bomuhangi [43] in the Mt. Elgon Eastern Uganda and Nsubugua & Rautenbach [44] for the whole of Uganda.

More so, respondents identified reduced flooding events, occurrence of human diseases, increasing crop pests and diseases, increasing dry spells and increasing intensity of rains as major climatic shocks faced in the area. These are in agreement with other study findings reported in the Benguela marine areas [45]; Central Africa [46]; rural Bangladesh [47]; Western Uganda [48], areas adjacent to Kidepo Valley and Mt. Elgon National Park, across agro-ecological zones [9] as well as the cattle corridor [8] and Teso sub region [40]. With regards to understanding climate variability and change, both male and female respondents perceived climate change in terms of reduced flooding events, occurrence of human diseases, increasing crop pests and diseases, increasing dry spells and increasing intensity of rains (Table 3). However, a significant association was noted by both males and females with increasing temperature which affected the growth of crops and reduced flooding events. This can be justified by the direct negative effect increasing temperatures have on agricultural productivity and fish availability. These finding were similar to studies by [27,41,49,50]. Although studies by Merino [51] and Narloch [52] argue that projected fish demands can be achieved despite the changing climate, Timmers [53] indicated that fish were also vulnerable to climate change. In contrast, salt formation thrives better with higher temperatures intercepted with a few rains. A study conducted by Kasedde [54] revealed that increased pond solution layer temperature increased the evaporation flux hence leading to increased salt production rate.

Results also indicated that climatic shocks affected both male and female across the livelihood activities. However, males were more affected by increasing dry spells and increasing intensity of rains while females were most affected by increasing temperatures. Studies by Ngigi *et al.,* [55] showed that men were affected by increasing intensities of rains while Owusu, *et al.,* [56]; Twyman *et al.,* [57] revealed women to be affected by heat waves caused by high temperatures. The difference in perceptions could be due to the distinct livelihood activities, roles and responsibilities that are undertaken by men and women in society [27,55,58]. For instance, group discussions revealed that women were into climate sensitive activities such as agriculture and salt mining and had limited livelihood alternatives [59-62]. As such any slight variations in climatic parameters affected their earnings and the impact trickled down at household level. This has been supported by studies from [63-65].

Generally, human and natural factors were considered as major causes of climate variability and change. However, human activities were perceived to be the major causes of changes in climatic conditions. Kisauzi's study [40] in Teso sub region Eastern Uganda, reported human activities such as tree cutting/destruction of vegetation as a major cause of climate variability and change. Gendered perceptions on understanding of climate change was linked to changes in rainfall and temperature. Both farmers and fish folks perceived the seasons to have changed. In light of the climatic changes, March had become the new planting season for food crops while August-February for cash crops such as cotton among the farmers. This justified the change in planting season (early planting) as a coping strategy to climate change. On the other hand, fisher folks pointed out March as a dry month. Using the MAM seasonal rainfall outlook, onset was expected around Mid-April till late May to early June [66]. More so, the same report indicated that Kasese district has experienced isolated light rains since 2014 with April as the peak of steady rains [66]. The reason for

the contradictions would be based on temporary shifts in livelihood activities which were carried out in different seasons.

6. Conclusions

The study concluded that climatic changes were observed in the study area. The increment in rainfall received has no impact while the significant increase in temperatures was likely to have significant effect on occurrence of climate extreme events such as increasing dry spells. The most notable indicators of climate variability and change included reduced flooding events, occurrence of human diseases, increasing crop pests and diseases, increasing dry spells and increasing intensity of rains. Both male and female significantly associated with increasing temperatures and reduced flooding events. While climatic shocks affected both males and females, the impact was more pronounced depending on distinct livelihood activities and roles and responsibilities undertaken. Both male and female agreed that climate change was majorly caused by human activities and natural occurrence. Overall, people's perceptions of climate change should not be disregarded but taken on by the government and integrated in the national climate programs that support people's livelihoods and survival mechanisms.

Conflict of Interest

The authors have not declared any conflict of interest.

Acknowledgments

This research was made possible by funding from BREAD-SIDA project. Special thanks to my team who worked tirelessly in collecting all the useful information.

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ARTICLE

Culture Dynamics across the World Today: Tourism and the Palette of Imagination

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ARTICLE INFO

Article history
Received: 28 July 2021
Revised: 4 September 2021
Accepted: 7 September2021
Published Online: 21 October 2021

Keywords:
Cultural selection/Cultural production
Liquid modernity
Liquid tourism
Polycultural vision
Tourism power
Bauman

ABSTRACT

In general, this manuscript critiques the contemporary dynamisms of the formation/deformation of the cultural sphere under the increased mobilisations of globalization. In particular, it inspects the symphysis [❑ SYMPHYSIS] between 'tourism' and 'culture', where the latter stands as an immense portmanteau phenomenon embracing many different things (under the vicissitudes of globalisation/glocalisation) across the protean realms of race, gender, entertainment, consumerism, meaning-making, et cetera. Critiquing Jamal and Robinson's recent attempt at panoramic coverage of the geography of tourism/tourism studies), it argues that tourism is regularly implicated in cultural practices relating to power-exercises in/across society. Then, in synthesising Bauman's vision of contemporary society as that moving from seemingly well-ordered stabilities to a geographic realm where change is the-only-permanence and uncertainty the-only-certainty, the manuscript generates five lead propositions calling for 'plural knowability', viz., for a deeper/richer palette-of-imagination on the teeming multiplicities and throbbing provisionalities of culture as it emerges/unfolds or otherwise gets recast under the destabilising 'nomadic logics' of our time. In viewing culture as a vehicle of both 'impermanence' and 'seduction' nowadays, the paper notes how in so many places and spaces, individuals are less inclined to be engaged locally/regionally/nationally as culture — partly through the volatile iterability of travel/tourism — has become an ever-widening polylogue.

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LEGEND: Citations from *The Sage Handbook of Tourism Studies* (Jamal and Robinson 2009) are shown as ▲ in this manuscript (as in ▲ Mavrič and Urry 2009)
Terms explained in **the Appendix** are shown as ❑ in this manuscript, where they first occur (as in enunciations [❑ ENUNCIATION])

DOI: https://doi.org/10.30564/jgr.v4i4.3488

1. Introduction to the Geography of Tourism vis-a-vis the Cultural Sphere: Cultural Production and Cultural Selection under Globalization, Today

"Human beings, like the higher types of animals — everything above the oyster in fact — are made for locomotion and action"

[Attributed to Robert Park: American sociologist of geography and migration]

In recent decades commentators on modernity and globalisation have saluted 'tourism' as a vital international phenomenon which plays a very strong part in how we humans reimagine the world and our own part in it. Tourism is increasingly seen to be not just a mundane and leisure-related matter of vicarious travel but a cardinal activity in the global social and political relations of our time. Variously, observers of modernity, globalisation, and cultural change point out that tourism — a significant organising instrument or force of spatial awareness — plays a large role in problematising 'received' or 'historicist' accounts of who we each are [1,2], and thereby serves as a vehicle of fast social and political transformation in and through the newly emerging ethnoscapes, ideoscapes [❑ IDEOSCAPES], mediascapes, technoscapes, and financescapes of our era [3]. Indeed, Featherstone [4] — drawing from Deleuze and Guattari [5] — maintains that tourism is a if not the leading organ and means of expression by and through which so many of us take on board and further new nomadic identificatory logics [❑ NOMADIC LOGICS] about being and becoming. To Featherstone (a sociologist of the geography of global culture and consumer culture), it is critical that we therefore explore the power of travel and tourism in the global formation and deformation of the cultural sphere and in the conceivable fragmentations and dislocations of our increasingly locomotive age.

Such esteemed analysts of the international temper of *the 'microcosmic' practice and aspiration* [6] of our turn-of-the millennium time suggest that tourism is not just a small-fry and humdrum 'spare moments' activity, but is an important culture-selecting and culture-producing machine which helps many new, decalibrated or recalibrated, political and cultural institutions rise 'connectively' and 'internationally' to supersede many of the received national institutions which had grown to prominence over the previous two to three centuries and more. The sustained treatise of these commentators on modernity and globalisation — while far from being fully in agreement on particular time/space matters of homogeneity/heterogeneity [7] — have come to recognise tourism as a powerful industry and apparatus by and through which 'the global' increasingly and reciprocally informs 'the regional' and 'the local', thereby transforming (or, rather, helping transfigure) inherited ideas about 'nationalism' and 'national allegiance'.

This critique here in *The Journal of Geographical Research* is predicated on the understanding that it is crucial that tourism studies thinkers and practitioners pay rich respect to the microcosmic matters raised and/or expounded by such theorists of globalisation/glocalisation (see [8] on *glocalisation*, ipso facto, and [9] on the complexity of geo/techno-central processes of today). A number of substantive research questions come to mind regarding the function of tourism in these large society-shaping and culture-conditioning transformations: Geographically, what role does tourism play in the so called triumph of 'the spatial' over 'the temporal' [10,11]? How is tourism involved in the new activisms of emergent populations under the so called postcolonial moment [12,13]? How is tourism imbricated in the recent revolution and late expansion of 'creole cultures' [14,15]? Where has tourism been instrumental in the production and/or articulation of hyperreal worlds [16,17]? In which particular places and spaces has tourism brought about — or has significantly helped bring about — the demise of the nation-state [18,19]? For which communities or groups has tourism been a paramount player in the successful international vocalisation of either cherished-but-long-subjugated or emergent-and-newly-fortifying counter-knowledges on the national and international stage [20,21]?

What these analysts of globalisation and glocalisation are telling (or reminding!) scholars in geography/geopolitics (as well as in tourism studies, itself) is that tourism plays a significant part in the cultural and the psychic economy of places, and in what Luke [22] calls the *neo-world* orders and Braidotti [23] terms the affirmative politics of today's richly-connected communities across the world. In this light, Anderson's [24] previously identified 'world order' of imagined communities is nowadays conjoined by — and often replaced or destroyed by — fresh forms of hyperabstracted 'virtual communities' [25]. In this neo-world of highly abstracted virtual places, new fantasies of time fast transmogrify received constructions of 'history', new fantasies of space fast transmogrify received constructions of 'reality', and new fantasies of image and information fast transmogrify received constructions of 'the social'. And tourism is substantively active and vibrant in these neo-world games of projection, propagation, and proliferation or in what Bhabha [26] might term these sometimes spiritous,

sometimes inebriate, and sometimes potent *fantasmatics* [❑ FANTASMATICS] about being and becoming. [For a brief account of 'fantasmatics' translated to tourism and related fields of public culture/public heritage/public nature, see Name of Author Removed [112] and Name of Authors Removed [113] and Kuon [27] for an application of thoughtlines on fantasmatics in Cambodia). The power of tourism has long been identified as a useful instrument in the universalisation of the world, and otherwise of the multiculturalism of metropolitan/cosmopolitan places, but under Luke's neo-world of virtual and hyperabstracted realities, tourism clearly is seen to have potent projective and declarative agency in what Pieterse [28] and Escobar [29] would call the fresh combinative but not-so-predictable blendings of *interculturalism*.

What the spreading hyperrealism of Baudrillard, the neo-worlds of Luke, and the intercultural amalgamation of Pieterse all suggest is that to many of us in many situations around the world, 'hyperrealism' is distinctly more real than 'realism' and decidedly more acute in its ramifications (see [30] on hyperreality). Rising numbers of us — as we venture to different places and to distant spaces — are not drawn so much via the pure equivalence of the represented world but to the concocted presentation of increasingly formulated and/or increasingly fabricated sites and scenes. What nowadays appears to progressively register with us — in the judgement at Baudrillard, Luke, and Pieterse — is not so much the genuine and durable correspondence of things with a decently/properly authenticated local inheritance, but the generative power of an object or subject (be it a visionary image, a designated destination, a themed drawcard, a dreamlike scene, or an otherwise aspirational scenario). The generative fantasmatics of projected culture — the generative enunciations [❑ ENUNCIATION] of place and space — are increasingly becoming hallucinatory and infectious, and we are tending (if Baudrillard's views on hyperreality are supportable) to be rather less concerned about whether longstanding views about cultural inheritance and of local being have been contaminated or defiled in some way. In all of this new projectivity in geography and geopolitics of and about culture, the neo-systems of place-declaration and space-declaration are much more pliable and pliant than the more resolute/adamantine cultural forms of yesteryear, particularly where transnational capital has moved in upon local and international forms of culture to steep the world with its own preferred sorts of novel or procreated commodities [31,32].

In the view of Featherstone and Lash (1995, p.9) "whereas the traditional world-order was *theo-dictive* [❑ THEODICTION], and the 'man-made' social order of the new world order [of modernity is/was] *juris-dictive* [❑ JURISDICTION], the 'micro-molecular' codes of the neo-world orders are *polydictive* [❑ POLYDICTION] ... that is [composed of] virtual communities [articulated through] not just finance and commerce but gender, ethnicity, and ecology". To them, what now counts under this polydictive realm is how these fantasmatic forms of culture (and these virtual places and spaces) are iconically symbolised. Such classificatory matters of identification and moral order are often contentious, however, such as occurs with, for instance, with the large controversies which exist these days as to whether Islamism in its various hues (and its diverse differences of claimed contiguity with early Islam [33]), of 'political Islam', 'radical Islam', 'activist Islam', is principally a religious faith or otherwise a political order [34].

Nonetheless, the gender groups, the ethnic population, the ecological bodies, the transnational corporations, and whatever else, are all learning the capacity to decode effective iconic/symbolic/graphic messages which project virtual-community-specific or virtual-group-particular entreaties. And so, in the knowledge economy of the early twenty-first century across the world, polydictive forms of cultural capital are variously narrowcast if the messaging is exclusive, or broadcast if the messaging is designed for a more catholic audience or an external and diffuse market. Such is often the more open-ended kinds of declarative communication about culture (and place and space) of our neo-times, and such are the poetics and the politics of the projectivity about culture of the polydictive moment [35,36]. The static categories of our longstanding identifications about culture, heritage, and nature are thereby tending to be overlapped or overshadowed by these fruitive dynamics of the mythopoetics [❑ MYTHOPOETICS/MYTHOPOESIS] and mythopolitics [❑ MYTHOPOLITICS] of the seemingly polydictive moment [37]. The increasingly prevalent neo-forms of imagined culture and of virtual communities are tending to generate many fresh sorts of magnetic and vigorous (but sometimes fleeting or impermanent) forms of individuation and subjectivity [38,39]. And many of these declarations of identity and aspiration are not so bounded and contained (as of yesteryear) as refreshed/restored/investigated kinds of 'difference' are being targeted nowadays. And where critical theorists of the Frankfurt School and of structuralist inclinations might have taken this polydictism and its seeming disregard for stable identification as a manifestation of cultural rot, we are learning to appreciate (after Bhabha, Cixous, Deleuze, Derrida, Foucault, Hall, Haraway, Irigaray, and others) the

resonance of ambiguous selfish and enigmatic existence [40]. Such are the emergent and less-bounded 'neo' styles of society where each population group or sizeable community finds itself escalatingly under challenge both internally and externally [41,42,44]). Perhaps the late condition of these heady matters of identity-poesis/identity-politics is best summarised by Butler [45]:

> *… identifications [nowadays increasingly] belong to the imaginary; they are phantasmatic efforts of alignment, loyalty, ambiguous and cross-corporeal cohabitations, they unsettle the I … the very formulation of the I. Identifications are never … finally made; they are [subject to] the volatile logic of iterability. They are that which is constantly marshalled, … retrenched, contested, and, on occasion, compelled to give way.*

And there we have it for the practitioners of geography and *the thinkers on geopolitics: the volatile logic of iterability* [46,47] [❑ ITERABILITY — THE VOLATILE LOGIC OF ITERABILITY]. Since iterability is the very stuff of tourism, it is crucial that those who think and work in tourism/travel take these equivocacies of cultural identity and these indeterminacies of being and becoming very seriously. But are those who work on travel and tourism programmes and packages conceptually geared up so to do? [[114] on the resident power-logics in the discourse in and of tourism.] Is current schooling in tourism studies equipping travel/tourism researchers and practitioners with enough deep insight into these malleable, mercurial, and messy matters of cultural identification? Or is the field just muddling through on lukewarm forms of polydictive interpretation?

2. Background: The Interface between Tourism and Culture

Having provided some introductory comments on the general contours of cultural production and cultural selection today under imperatives of globalisation and glocalisation [❑ GLOCALISATION], it is now opportune to make some more telling background observations on the interface that 'tourism' conceivably has with 'culture', ipso facto. The points registered in this background section are principally taken from what many social science theorists who work on projects and developments in the arena of travel and tourism (i.e., in the domain of tourism studies/tourism management) consider to be the most up to date and comprehensive exposition of the current health of research in the domain. The magnus opus is *The Sage Handbook of Tourism Studies* [48] which — if two back-cover testimonies may be acceptable! — "[provides] the strongest overviews... [in terms of] range of topics, depth of analysis and distinction of its contributors, [where] nothing is comparable" [49], and which "[in terms of] breadth of vision and sweep of accounts is remarkable... [thereby providing] clear statements [or] major studies, and... new examples, approaches and ideas to rethink the familiar" [50].

In inspecting the thirty-nine chapters of the Jamal and Robinson compendium, one finds that *The Handbook* editors do in fact claim that many of the handbook authors did indeed pay *critical research attention* to "the intricate interrelationships within and between various [culturo-political] systems, spaces, and patterns of consumption, in addition [to addressing culturo-political] modes of production" [51]. Thus, *The Sage Handbook* presents tourism as a phenomenon which has a multilayered complexity: "one of the great paradoxes of tourism is the apparent disjuncture between the simple pleasures and enjoyment experienced by the tourist, and the complex web of structures, arrangements, relationships and histories which are brought together to produce these intensive moments of [leisure] experience" [52]. The following synthesis of leading reflections from the handbook contributors no doubt assisted the editors of *The Sage Handbook* (i.e., Jamal and Robinson) to make the summary judgement that approaches to understanding tourism (as part of much more complex and wide ranging cultural phenomena) thereby require the erstwhile and excessively dominant 'acts of measurement' to be pointedly supplemented by a panoply of 'acts of critico-interpretive assessment'.

To Franklin [53] "there is now a plurality of departure points… [rather than the hackneyed and contained former] search for a singular account of, or explanation for, tourism", and in his judgment "a more generous and open-minded view of tourism [and its culturo-political effects] was one of the characteristics of the new wave [of theorists of the touristic world order such as Franklin and Crang [54]; Tribe [55]; Picken [56], Alteljevic, Morgan, & Pritchard et al., [57]; Hollinshead, [58]". Moreover, in deploying — in particular Fullagar [59] and Edensor [60] — Franklin importantly recognises that tourism studies "is not predominantly a semiotic field of [mirrored] representations, but [is] also crucially [an arena] of enactment, performance and agency ... [and in] clearly new research inspired by Deleuze and Guattari, has become interested in the distribution and dispersal of [culturo-political] forms of action in which humans and nonhumans have affect [❑ AFFECT] and agency, and [thereby generating nowadays] accounts not merely of being but of becoming" [61]; see Anderson and Harrison

[62], Bissel and Gorman-Murray [63], Smith [64], and Buda [65] on matters of 'affect'). Wood [66] also registers the new modes of inspection of 'affect' and 'agency' in tourism studies, and celebrates the recent view of Higgins-Desbiolles [67] that, in tourism studies, *tourism* has itself for too long been "the forgotten power...as a social force", while Mavrič and Urry [68] — borrowing from both Franklin and Crang [69] and Franklin [70] — make a similar point that the predominant 'structural' and 'motivational' accounts of tourism of recent decades "leave little room for understanding tourism as a significant modality through which transitional modern [cultural and mobile] life is organised". The point is further adumbrated in *The Handbook* by Smith [71] who indeed suggests that tourism is a modern industrial form which is not only clearly associated with but *dependent upon* the promotion of the particular cultural understandings and their related forms of individualism of the contemporary age, and to that end he cites Urry (the lauded sociologist of geographic and psychic mobility), notably the latter's well-referenced statement that "acting as a tourist is one of the defining characteristics of being modern" [72].

The multiplicity of interfaces that tourism seemingly has with 'culture is — after studied inspection — a pungent feature of *The Handbook*. Calling upon Arellano [73], Mavrič and Urry [74] maintain that tourism is the commonplace mobilization of cultural meanings and of related 'imagination' to the extent that tourists themselves serve as not only active interpreters but also as performers of imagined contours of place around the world. Yet Robinson and Jamal [75] themselves warn that it is important to register "whose constructs [of cultural meaning and being] are allowed [to flower] when [particular built or intangible visions of nature or heritage are on show]". All too regularly the cultural worldviews that are peddled in and through tourism across the world are anchored only in European traditions: they (Robinson and Jamal) ruminate as to whether "[the tourism industry of] the developed world [can] accept a system of tourism [interpretation and projection] that is rooted in different sets of values, needs, wants and aesthetic preferences which is different [to those grounding Euro-roots]?" [76]. In these respects, for a critique of Eurocentric privilege [❑ EUROCENTRISM] and 'its' colonial matrix of power, refer to Mignolo and Walsh [77].

Accordingly, Jamal and Robinson conclude their magnus opus by calling for research approaches in and across tourism studies which move beyond the governing *analysis* of *static frames* of yesteryear, and for the much more frequent adoption of approaches which pry into the culturo-political connectivities of tourism in order to derive deeper accounts which can sequentially trace the linkages and the overlaps that tourism has with the globalities and glocalities of our age and to the longitudinal and cumulative changes of cultural phenomenon that are in process today. The clamour of *The Handbook* is thus a loud and specific one — amongst other lead necessities — for the cultivation of directed research agendas into the multiple and varied dynamic interface tourism has with the cultural transpositions and the local/regional/national transnational boundary movements of each and every continent. [This very matter of the intersectionalities [❑ INTERSECTIONALITY] and the entanglements of tourism are currently being investigated within a special issue of *Tourism, Culture and Communication*: refer to Lapointe and Muldoon [78].

This 'multiple and varied' dynamic interface which tourism has with culture is now highlighted in Table 1, drawn from the contributors to Jamal and Robinson [79]. In providing the table, the aim here is not — given the space limitations within this journal — to be comprehensive, but rather to be broadly indicative of the ordinary everyplace/everyday degree to which tourism rubs up against cultural issues. In the table, therefore, a fast selection has been made of twenty-eight of the thirty-nine chapters which, prima facie, discuss aspects of tourism which have a very strong interface or imbroglio with cultural matters. Again, it should be stated that the table is only meant to be suggestive, for concerns over, general cultural issues like 'authenticity' or sub-issues like 'emergent authenticity' [❑ EMERGENT AUTHENTICITY] are only cited here for one of the listed chapters, whereas they actually might crop up in a litany of them. Indeed, the table has been composed only after a first and second inspection of each of the chapters by the authors of this 'Palette of Imagination' [❑ PALETTE OF IMAGINATION] critique here in *The Journal of Geographical Research*, and an inquisitive reader of the Jamal and Robinson work may indeed point out that many (or all?) of the other eleven chapters in *The Handbook* also reveal that tourism is indeed routinely and intricately entwined with 'matters of culture' across the continents.

These simple caveats acknowledged, the heuristic content of Table 1 strongly implies that tourism is far from being a discrete or an isolated/independent with its own contained life-forces. While only three of the thirty eight contributors to Jamal and Robinson — namely Crouch [80], Long and Robinson [81], and Hollinshead [82] — actually use the word 'culture' in their chapter headings, it is safe to suggest that cultural forces are either manifest in all of the twenty eight chapters listed (or even in all of the thirty-nine chapters published?), and

Table 1. The commonplace interface of tourism with "culture": some indicative cultural prominences in Jamal and Robinson

KEY: ▪ = Contributory Author • = *Chapter Coverage* ♦ = **Engagement of Tourism in / with culture**
_____
▪ = Jamal & Robinson • = *CH.1= Evolution of Tourism* ♦ = **Culture and other flows**
▪ = Leite & Graham • = *CH.3= Anthropology in / of Tourism* ♦ = **Engagements in / of imagination**
▪ = Franklin • = *CH.4= Sociology of Tourism* ♦ = **The orderings of tourism: matters-of-control and 'becoming'**
▪ = Crouch • = *CH.5= Dynamics of Cultural Studies* ♦ = **Transformative practice in culture**
▪ = Long & Robinson • = *CH.6= Popular Culture and Media* ♦ = **Represented worlds**
▪ = Telfer • = *CH.9= Development Studies* ♦ = **Dependency / development / eurocentrism**
▪ = Richter • = *CH.11= Power and Politics* ♦ = **Privatisation / politicization**
▪ = Holden • = *CH. 12= Natural Resources* ♦ = **Cultural / instrumental use of nature**
▪ = Evans • = *CH.13= Strategy Business Perspectives* ♦ = **Heterogeneity of experience**
▪ = Sharpley • = *CH.14= Religion and Spirituality* ♦ = **Traditionality / communitas**
▪ = Wearing & Ponting • = *CH.15= Volunteer Tourism* ♦ = **Commodification**
▪ = Hollinshead • = *CH.16= Theme Parks / Consumer Aesthetics* [❑ CONSUMER AESTHETICS] ♦ = **Symbolism / representation / normalcy**
▪ = Mugerauer • = *CH.17= Architecture and Urban Planning* ♦ = **Segregated space / distributive justice**
▪ = Orbaşli & Woodward • = *CH.18= Heritage Conservation* ♦ = **Authenticity of experience**
▪ = Mbaiwa & Stronza • = *CH.19= Sustainable Tourism / Developing Countries* ♦ = **Cultural production**
▪ = Rettie, Clevenger, & Ford • = *CH.22= Conservation / National Parks* ♦ = **Marginalisation / Indigenous pop's**
▪ = Quinn • = *CH.27= Festivals / Events* ♦ = **Politics of identity**
▪ = Tucker & Akama • = *CH.28= Postcolonialism* ♦ = **Embedded hegemony / Colonial discourse**
▪ = Seaton • = *CH.29 = Thananatourism* ♦ = **Subjectivity (regarding Dark Tourism)**
▪ = Edensor • = *CH.30= Performance* ♦ = **Performativity / Individual reflexivity in of culture**
▪ = Gretzel & Fesenmaier • = *CH.31= Technology Information* ♦ = **Cultural consumption**
▪ = Debbage & Gallaway • = *CH.32= Global Business Operations* ♦ = **Globalisation / global production**
▪ = Wood • = *CH.33= International Policy / Neoliberalism* ♦ = **Hyperglobalism / cultural transition**
▪ = Smith • = *CH.34= Ethics* ♦ = **Modernity and ethics / cultural rights**
▪ = Aitchison • = *CH.35= Gender* ♦ = **Gender and power relations**
▪ = Mavrič & Urry • = *CH.36= New Mobilities* ♦ = **Nomadic metaphysics** [❑ NOMADIC METAPHYSICS]
▪ = Phipps • = *CH.37= Languaging* ♦ = **Interculturalism**
▪ = Jennings • = *CH.38= Methodologies and Methods* ♦ = **Marginalisation / Indigenous worldviews / axiologies**

Source: The above 28 chapters are taken from the 39 contributions in Jamal & Robinson [110].

each of them are pregnant with cultural traditions, cultural flows, cultural scapes, cultural imperatives, or cultural transitions of at least one kind or another. It appears that tourism is not only governed by cultural exigencies here, there, and everywhere, but as a declarative industry it also serves as one of the leading projective/inscriptive channels through which the culture of a place or space is signposted. It seems that wherever tourism is planned, developed, programmed, packaged, or mooted, *cultural implications* or at least *cultural considerations* are the immense 'elephant in the room'! And that signposting is not only commonly issued EXTERNALLY to the wider world but via 'the wilful nostalgia' [83] [❑ WILFUL NOSTALGIA] predilections of governing powerbrokers within the given host territory (who might want to remind or encourage local citizens just what is *the right sort* of local/inherited culture to uphold, there). Not all the strategic communication about the preciousness of 'culture' in the projections and promotions of 'culture' in the tourism industry is indeed targeted upon visiting travellers, therefore: locals/residents/immigrants have to be properly guided towards 'decent citizenship' [❑ DECENT CITIZENSHIP] there, too [84,85]. While the right sort of selected and produced culture has to be experienced by visitors, it importantly has to be enacted and celebrated by the incumbent locals, too. In this respect the governorship of wilful nostalgia thereby generally — but not always — acts as a socially conservative force [86,87] where a pragmatics of prescribed exclusivity rules [88,89], and where, for instance, ethnic minorities have often been effectively given only the heartless/pitiless choice to assimilate or perish. These are indeed important matters of geographic and cultural perception. Under such evangelising missions, the purpose of the promoted heritage tourism of a place is to spread the local/regional/national 'gospel' there in imbricated and cumulative

fashion, and thus prevent the inhabitants of the said territory from forgetting whom they really ought to be, 'there'.

3. Focus on the Conceivable Uncoupling of the Cultural from the Social: The Power of "Liquid Culture"/"Liquid Tourism"

So far in this conceivable reformation and deformation of the cultural sphere, an attempt has been made to situate tourism in the dynamics of cultural and cultural selection, and the strong interface between 'tourism' and 'culture' has been registered. It is now useful to reveal how that interface (or that juxtaposition and mix of relationships) has perhaps intensified during the most recent of decades. In this respect, the scrutiny of Zygmunt Bauman — the Professor Emeritus at the University of Leeds in England (until he passed on in 2017) — is germane, notably per medium his recent work *Culture in a Liquid Modern World*. In this text, Bauman [90] notes how the meaning of culture has been significantly nuanced at our turn of century moment. As a sociologist, he suggests that, for the last two hundred years or more, 'culture' had been regarded as that agent of and for 'change' through which the population of a place/territory/nation could be 'educated' by the leading individuals and institutions of the given society. Accordingly, to him, the function of 'culture' was to serve as both a repository and a communicant for what was locally deemed to be the best of human thought and creativity. But in late years — under what he labels the contemporary *liquid modern world* [❑ LIQUID MODERNITY] — culture has lost much of that missionary or evangelistic role and has become attenuated or reduced to being a force of seduction and allurement. In these respects, see Salazar [91] and Bauman [92], himself, on our incremental existence within 'societies of consumption', and refer also to Picard's [93] Bauman-informed treatment of La Réunion in terms of how the Indian Ocean destination is turned into an alluring place of touristic consumption.

To Bauman — who first published his unfolding ideas on *liquid modernity* in his eponymous work a couple of decades ago [94] — 'culture' is no longer that phenomenon (that mix of phenomena) through which a resident society is proselytised or enlightened, but it is that representational force through which they (and others) are tempted and beguiled. By this assessment, the aim in the new reconditioning and deployment of culture is not so much to satisfy existing societal or community needs but it is to seductively create ever new 'needs' without regard to whether current communal requirements and exigencies are durably fulfilled or national needs satisfied: see Bauman [95] here, on the recent incapacity of 'nations' to deliver on their supposedly-longstanding but commonly utopian promises of old. Thus, to Bauman, 'culture' has now become a bazaar-like emporium these days, where all sorts of 'fresh' and 'desirable' inducements are on display, and where new intriguing or exhilarating 'wares' (i.e., allurements and commodities) are added temptingly on a daily/weekly 'drop-down-menu' basis.

To Bauman, culture is tantamount to being a vehicle being driven here, there, and everywhere by the vigorous new forces of globalisation, migration, and the intensifying admixture of blended or blending populations around the world. Table 2 has thus been drawn up to distil some of these leading 'liquid modern' imperatives which have occasioned the change of paradigm of recognition about what culture is and does in each place.

In the table, the globalising process (as interpreted by Bauman) is no longer a relatively stable and constant 'fortress' which guides individuals in the developed world (and, increasingly, beyond it) to the right sort of salvation, it has become a *lebenswelt* — a new realm of experiences — where the public edifice/the public ground of yesteryear has broken up and where ways of life have lost/are losing their own distinctive 'gravity' to float in suspension bumping uncertainly yet sometimes magnetically into each other. Table 2 has thereby been composed in the effort to capture his Baumanic vision of the incrementally anchor-free *perpetuum mobile* [96] [❑ PERPETUUM MOBILE] of cultures as they now each exist in a constant state of flux. To Bauman, this fluidity and mutability for 'culture' is the rule under the globalising moment, and it begets a normative vacuum which affects greater freedom for the taking of corporate initiatives and for the expression of individual idiosyncratic actions (which are less culture-bound in terms of old/traditional meanings of and for 'culture' and 'society') [97].

The *perpetuum mobile* of liquid modernity' is thereby the existing shape and condition of footloose modernity as it is transformed from its old 'solid' state to the fluidities of the postmodern/late modern/hyper-modern moment where the social conservative 'correct'/'attest ed'/'beauteous' cultural traditions of yesteryear are no longer so secure. As Table 2 registers, Bauman's liquid modernity is a more dynamic realm where the old socially conservative storylines of "the naturalness of belonging" (i.e., of *preferred* and *institutionalised* local sameness) [98] are swept away and as new liquefied versions of identity, national unity and citizen loyalty emerge. By this judgment, culture thus is no longer something which is reliably correspondent with the divisions and

Table 2. Culture as impermance – culture as seduction: the changing role of culture under the geography of liquid modernity

THE FATE OF 'CULTURE' UNDER GLOBALISATION AND THE INTERMINGLING OF POPULATIONS, ACCORDING TO BAUMAN
1 = Under the globalisations of our contemporary age ***the scale of population movements is vast*** and keeps on growing, generating a global growth of ethnic diasporas and new protean sorts of cultural loyalty (p. 38 - 43).
2 = Under the globalising imperatives of liquid modernity, the world distribution of capital and information becomes exterritorial (i.e; external to every place) and governments have had to cede control over economic and cultural processes to 'market forces' which tend to be unfettered by political control (p. 79). Consonantly 'culture' today tends to be much less frequently a matter of 'propositions', 'prohibitions', and 'norms' but ***a matter of 'offers'*** within the consumer-orientated market place (p. 13) – ***a means of seduction.***
3 = Under the globalisations of our contemporary age, 'culture' has tended to lose much of its erstwhile localising/regionalising/nationalising *missionary role,* and ***individuals are inclined to be much less engaged*** locally/regionally/nationally (p. 55). Several questions are consequently posed upon each individual in terms of the degree to which his/her cultural identity is incipiently and unbreakably bound up with his/her place of habitation and physical neighbourhood (p. 36).
4 = Under the globalising imperatives of liquid modernity, the old/established right of nations to self-determination is slowly evaporating (p. 99), and the identity-guaranteed sovereignities of nation-states has corroded (p. 71). Consonantly, nations are turning from being territorially-cohesive-bodies into evermore mobile and ***spatially dispersed associations of spiritually allied units*** (p. 72).
5 = Under the globalisations of our contemporary age, 'culture' is not so frequently found to be the messianic force by and through which (under high nationalism) it had been enlightening thereby converting, reflecting, perfecting local/national citizens (p. 97), but has becoming ***a perpetually widening polylogue*** (p. 116) [❑ POLYLOGUE].
6 = Under the globalising imperatives of liquid modernity, ways of life have tended to drift in varied and not necessarily coordinated directions, where cultural relations have become rather less 'vertical' and more commonly 'horizontal' (p. 37). As old certainties and loyalties are accordingly swept away, people are prone to seeking ***new belongings/new cultural identity storylines*** which are decidedly different from the old narratives built on an assured naturalness of historical belonging (p. 81).
7 = Under the globalisations of our contemporary age, people increasingly have had to become accustomed to ***living in close proximity with strangers*** (p. 37)., and thereby cheek-by-jowl everyday with 'cultural differences' (p. 36). In the past, individuals in emergent ethnic minorities might commonly have had to renounce or hide their separate cultural identity, or otherwise have had it 'taken away'/'subjugated' by force (p. 75).
8 = Under the globalising imperatives of liquid modernity, the so-called modern condition of cultural life loses its old solidities and dissolves into a litany of molten or limpid forms (p. 11). None of these emergent and flowing/running cultural forms is generally able to maintain its shape or condition for long, and ***local/national life becomes increasingly dissolved and impermanent*** (p. 12).
9 = Under the globalising actions of our contemporary age, the molten and limpid forms of social life which emerge and flow exist as ***cultural mutations which find their own unpredictable level*** in and across societies (p. 88). Their respective life-courses tend to be vicissitudinous, and most tend to be definitive, fixed, irrevocable (p. 88), having blurred boundaries with other cultural forms (p. 90).
10 = Under the globalising imperatives of liquid modernity, cultural value/cultural importance is often something bestowed via the imprimatur of a promoted or heralded 'event' [❑ EVENTS] (p. 112). In this fashion, such events are prone to be loudly-projected/multimedia attention-makers, but they are '***one-off' or 'short-lived' culture-generating/behaviour-stimulating spectaculars*** orchestrated in harmony with a perceived resonance with the supposed or the claimed spirit of the times (p. 113). Such culture-creating events are designed for maximal impact, yet instant obsolescence, and tend to avoid the obligation of long term investment (p. 113).

Source: Synthesised from Bauman [111]. All citations are from this work, commissioned by the National Audiovisual Institute for the European Cultural Congress [Wroclaw: Poland].

stratifications of 'geographic society', and under liquid modernity, it is the turnover-oriented consumer market that increasingly calls the tune with "its surplus of offerings [allied to the] rapid ageing and [the pre-planned] untimely withering of their [particular selected and projected] seductive power [99].

Clearly, *Culture in a Liquid Modern World* is a work which speaks readily to the condition of the 'European' (or rather, of the Western/cosmopolitan/urban-industrial)

inheritances in our time, and indeed it was conceived as a publication commissioned by the National Audiovisual Institute for the European Culture Congress (of September 2011 in Wroclaw, Poland). But Europe — now more "a mosaic of diasporas (or...an agglomeration of overlapping and criss-crossing ethnic archipelagos [rather than a strong and distinct patchwork of nation-states])" according to Bauman [100] — serves as an important lesson on the peregrinations of 'culture' nowadays. It is Europe, with its large diversity of peoples, languages, and inheritances where the strange/the foreign/the Other is inevitably one's immediate neighbour, and where that proximity with proposed 'difference' constantly gives opportunity for individuals to witness and learn from many varied 'others'. In this light, 'Europe' can thereby serve as a docent for the world where individuals, now relatively free of the old social conservatism of definitive state control, are freshly locked in an intimate interaction with 'the adjacent other'. And it is Europe where the cultural polylogue can thereby widen and spread at pace [101], as it has increasingly done over the last eight to nine years of intensified migration from Africa and the Middle east to Europe since *Culture in a Liquid Modern World* was indeed published by Polity Press.

While the pressing liquid modern exigencies — as captured in Table 2 — are *not* exclusively situated in tourism (itself) in this particular work by Bauman, the globalising imperatives and the corporate seductions identified by him may be seen to have considerable import for the broader geographic field of tourism studies. If to Bauman [102] — reflecting upon Kundera [103] — the old socially conservative mission of 'art' was to educate and remind people what was important in the given place, what ought not be forgotten 'there', and thereby what ought properly and continuously to be celebrated 'there' *through mighty art*, then it is not much of a stretch to suggest that this people-making declarative function has been one of the proper duties of the projective realm of *mighty tourism*, itself. And later, to Bauman [104] — reflecting upon McLuhan — if (under the reductive promiscuities of liquid modernity) art "is anything that you can get away with", then again it is not unreasonable to maintain that the interpretive repertoires of tourism have been considerably 'opened up'/'bastardised' in like unchaste fashion — depending upon your own positionality in each act of projective place-making, of course. Accordingly, in our scissile (brittle/fracturable/separable) times, the projections and interpretations of *mighty tourism* are 'anything you can enticingly get away with' whatever the geographic/geopolitical scenarios one operates in! Yet while Finley [105] has critiqued the force of the arts (per *art power* [❑ ART POWER]) in the everyday operations of global cultural politics [❑ CULTURAL POLITICS], we still lack an equivalent succinct explication of the force of tourism (per *tourism power*) on the imagination/disimagination/reimagination of populations and places.

But while Bauman did not explicitly refer to the general arena or the industry of 'tourism' in *Culture in a Liquid Modern World*, he did hold forth there on the matter of special 'event promotion', which he deemed to be a declarative but intensively seductive activity which is used by various agencies under the liquidities of the contemporary age to bestow added value or an imprimatur upon a place, a people, or a cultural phenomenon. To him — drawing from Steiner — events are wonderful things for the liquid developer/the liquid management body to put on, for (as Table 2 reveals) they are relatively risk-free attractions which can offer fast credibility and/or immediate prestige yet which "avoid the plague of any long term investment" [106]. To him, the operational merit of 'events', per se, lies in their liquid malleable form and in their fleeting life, and each place/each destination is nowadays engaged rather fashionably in the gradually development of its own "cemetery of [fleeting] cultural events" [107] of one ephemeral kind and short-lived other. And there we have it: 'event development' (ergo, *tourism management* as the nimble-footed but rather frivolous funereal business of our time!!).

Bauman's insights on the historical peregrinations of the concept of 'culture' and on the transitory identifications of the *liquid now* certainly — if implicitly — give those who work on travel/tourism projects much for reflexive rumination about in terms of the consequences of *mighty tourism*. Each researcher or practitioner in the geography/geopolitics of place and space can weigh up his/her own strength as a seducer in and through culture, as [115] have mulled over in their scrutiny of Bauman's critique of the industrial cultural 'devilry' that the new diet of 'events' interminably cultivates here, there, and almost everywhere in the urban-industrial/cosmopolitan/'West'. And, as Braidotti (the cultural studies/feminist commentator on nomadic logic) reminds us, while the death of culture may be a or the "painful event par excellence", it can also serve as the ongoing process that inscribes new cultural forms and new energising possibilities for the geographic present [108].

4. Summary of the Conceivable Fragmentation and Dislocation of Culture: From the Liquidities of Bauman to the Fluidities of Deleuze

This manuscript on the dynamic imbroglios tourism

Table 3. The geography of tourism and polycultural vision: the call for a broader/richer palette of imagination regarding the volatile logic of iterability

■ **PROPOSITION 1 = VISIONS OF CULTURE NOT AS ESSENTIALISED OBJECTS BUT AS ONGOING PROCESSES**

Considerable gains can be made tourism studies by viewing culture not as a fixed or essentialised set of objects but as an ever-dynamic realm of processes. Tourism studies researchers are thereby encouraged to move *beyond static frames of reference* about 'culture' to view the agency and authority of tourism in ongoing practices of cultural production and cultural celebration. In guarding against the essentialisation of singular accounts of culture/history/nature, researchers should beware of their own possible role in the reification [❑ REIFICATION] of a given society, and should be alive to the possibility that local culture is peregrinating (under the conceivable liquid modernity of globalisation/ glocalisation) away from/beyond inherited or state or unquestioned visions of and about that place or space.

■ **PROPOSITION 2 = VISIONS OF A MORE PROVISIONAL GLOBAL ORDER**

Considerable advantages can accrue to tourism studies researchers who are open to a more contingent and less-authoritative view of and about the global order of things. While much of the representational repertoire of tourism has tended to reflect static and socially conservative identifications of place and space where the lead projections of tourism are consanguine with dominant 'wilful nostalgia' accounts (and often evangelical views of inheritance and belonging), the volatile logic of global iterability today — and the conceivable cultural promiscuities of liquid modernity (?) — may demand that, in the given place or space, hailed identifications are heterogeneous today, and that a range of *ambiguous/double/hybrid identities* now significantly populates it. Accordingly, old/established/contained outlooks on culture may need to be replaced by multiple interpretations, or rather by a polycultural vision over locally held identities.

■ **PROPOSITION 3 = VISIONS OF PLURAL KNOWABILITY**

Considerable benefit — in terms of equity and creative opportunity — can result for governing bodies in tourism management and development who are alive to (become aware of) the hegemonic understandings they uphold in their day-by-day/quotidian acts of projection and promotion. Commonly, local/regional/national organisations in charge of tourism tend to collaboratively dovetail their representational and development activities with the symbolic/significatory practices of other inscriptive industries (such as the industries of film, the arts, and the media) — sometimes consciously, sometimes unconsciously — to universalise highly restrictive versions of place and space. And, accordingly, the Western-dominated tourism industry has been regularly chastised over recent years for — at local and not just international levels — for being restrictively anchored in *eurocentric* meanings.

■ **PROPOSITION 4 = VISIONS OVER CULTURAL POESIS AS WELL AS OVER CULTURAL POLITICS**

Considerable dividend is ensuing for researchers in other social science fields (which have a large mandate for matters of culture) who have turned their disciplinary attention or their field-activity observations towards *ethnoaesthetic* [❑ ETHNOAESTHETIC] meanings. It was has become a working mantra of many such investigators of the ethnoaesthetic contours of populations that real-world problems can only be effectively attended to/solved once the difficulty is viewed in terms of the governing forms of communal knowledge that exist 'there'. The range of social science curricula that reach into these new grounds of understanding about aesthetic value (thereby augmenting the coverage of 'cultural politics' with the coverage of 'cultural poetics) is steadily increasing, and can/ should be much more pointedly and readily oriented towards tourism, too (?).

■ **PROPOSITION 5 = THE WORLDMAKING POWER AND COMPASS OF TOURISM IN THE GEOPOLITICS OF ITERATION**

Higgins-Desbiolles maintains that tourism is a forgotten social force. But perhaps it never has been understood (academically) as a social force! Perhaps Higgins-Desbiolles should have said *culturo-political force* in lieu of social force? Yet perhaps, too, tourism never has been widely understood (academically) as a culturo-political force! Jamal and Robinson have — in their field-leading magnus opus — called for much more critical inspection of the everyday authority and reach of tourism within and across cultures. Perhaps the new wave of social theories (which Franklin maintains has come to the fore in international tourism studies) are already mounting research agendas into the power and compass of tourism that can longitudinally and latitudinally assail the liquid modern seductions which Bauman suggests are so redolent within all of the other creative/inscriptive/performative industries, and which are likely to be just as redolent in and through tourism?

has today with culture under what Bauman styles as the uncertainties and impermanences of our liquid modern times now concludes with Table 3, which provides five summary propositions on what (after Bauman) geographers of travel and tourism can do/ought-to-do to conceivably improve their awareness of who might be doing what to whom else, when, and where via the new seductions of 'culture'. In calling upon researchers of nomadic logic and iteration to reflexively cultivate a broader and richer (i.e., more informed/better monitored) palette of imagination about the potentialities but also the perfidities of culture, Table 3 asks the collective field of tourism studies researchers and practitioners in and across the field:

● to view culture not so much as a fixed field of mandrake 'objects' [❑ MANDRAKE OBJECTS] divorced from their social/psychic/political connectivities, but as a dynamic realm of ongoing protean 'processes';

● to examine the cultural geography of the world not only in terms of its supposedly solid and presumably well-ordered stabilities, but admit the increasing prevalence of not-so-predictable 'liquid forms of being and becoming' [❑ BECOMING];

● to inspect the world via more versatile forms of discernment which reflexively address the *changing panoply of cultural logics* that is needed to gauge the plural voices which increasingly inhabit our local places and spaces today (especially in Europe), and thereby build up their own powers of 'critical multilogicality' [❑ CRITICAL MULTILOGICALITY] (i.e., 'plural knowability' [❑ PLURAL KNOWABILITY]) about found culture(s);

● to identify what is happening in each place in the arena of cultural tourism in 'the cultural poesis' [❑ CULTURAL POESIS] of things (i.e., in the dynamic cultural aesthetics of changing tastes and behaviours) and not just in 'the cultural politics' of things;

● to stay vigilant to which particular 'worldmaking aspirations' [❑ WORLDMAKING] are being honoured and normalised/naturalised in everyday fashion across the continents through the exercise of the cultural poesis and the cultural politics of tourism, and which are otherwise being coterminously silenced/suppressed/ignored.

Such are some of the key enhanced awarenesses that are conceivably obligated on the researchers and practitioners of tourism in these fast-changing days where "the Other is [increasingly] one's neighbour and where each is constantly called upon to learn from everyone else" [109]. And these matters of liquid modernity and not-so-predictable cultural identity and practice are being examined in a follow-up article — viz., in a companion article on the nomadic logic of travel/tourism by [116]. In this succeeding paper, the French philosopher Deleuze (amongst others) will be harnessed to shed further light on the pressing need for multiple visions/multiple interpretations to resist the reductionism and the reifications brought about by the imposition of overly-fixed forms of culture-making, people-making, and place-making as acts of iteration and identity-making are examined. In this succeeding 'companion paper' on cultural being and cultural meaning today, the interpretive focal point on and about the meaning and significance of culture, ipso facto, is shifted just a few degrees to accentuate Bauman's ideas on *the liquidities* of modernity (from this paper here in *The Journal of Geographical Research*) towards the in-many-senses parallel Deleuzian intelligences on *the fluidities* of becoming, after Deleuze and Guattari. Let Bauman and Deleuze importantly yet respectively both provide a little more chromaticity cum ruddiness to the international and local palette of imagination about culture in and across the geography of travel and tourism and its volatile logics of iterability.

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Appendix

GLOSSARY OF TERMS ON THE DYNAMICS OF CULTURE:
CONCEPTS USED WITHIN THIS MANUSCRIPT

- **AFFECT ...**

is that which has a significant influence on or alteration in something. For Spinoza, affect comprised 'the affectations' by which a body's power-to-act is raised or lowered, and the turn-to-affect constitutes a shift away from conventional rationality and human agency. For Deleuze and Guattari, affect is decidedly different from 'the emotions', and describes the pre-personal intensive and embodied experiences an individual encounters or is subject to.

- **ART POWER ...**

Is the broad effects of the craft and/or performance of art on seeing and understanding and on lived cultural/social/psychic life. For Groys, 'art' has its own power in the world, and is so frequently a force in global politics today on account of what it produces (i.e., includes/excludes).

- **BECOMING ...**

generally consists of aspirations and actions which hopefully empower a group/community/population to positively advance towards some differently-desired (changed) identity or some fresh/cherished (preferred) state-of-being. For Deleuze, 'becoming' is an unpredictable/happenstance process which generates new ways of being where the involved people/things/ideas are removed from their original function or widely-known characterisation.

- **CONSUMER AESTHETICS ...**

are actions taken in a marketplace in terms of the design and development of products/services in order to address the known or assumed cultural proclivities and sensory values of particular target groups/consuming populations; they do not necessarily relate to standard 'natural beauty' definitions of aesthetics and thereby tend to be non-art/non-nature experiences.

- **CRITICAL MULTILOGICALITY ...**

is the engaged capacity of researchers and/or practitioners to respect in highly-relevant ways the different between-group and within-group cultural and spiritual/psychic/other values found to exist 'there', and to faithfully interpret how those doxa (cultural warrants) are changing vis-à-vis local/regional/national imperatives. Those who critically probe multilogical scenarios tend to reflect in painstaking fashion the dynamic 'multicultural collage' of living today within a specific territory or via particular fluid currents of being/becoming.

- **CULTURAL POESIS ...**

comprises understandings which seriously address the vital and dynamic values/aesthetics/predilections of particular groups/communities and which respect both the related long-run cultural traditions and the contemporary transitions of those people. For Deleuze and Guattari, those who inspect cultural poesis do not so much look for the meaning of 'culture' but for the influence of outside/other 'events' upon culture.

- **CULTURAL POLITICS ...**

comprise understandings which seriously map the inherited and the now-dynamic structures-of-power/vehicles-of-influence of particular cultural groups/communities in terms of both found internal mobilisations and traced external relationships. Those who inspect cultural politics explore the ways in which cultural attitudes/opinions/beliefs (especially in the media and the arts) mould society and condition politics.

- **DECENT CITIZENSHIP ...**

consists of those behaviours/activities/aspirations which a found interest group or institution seeks to normalise across the citizenry of a wider cultural group or society in order to advance specific hailed versions of the past, the present, the future. Consonantly, 'decent citizens' are those individuals who conform to a politically-naturalised set of outlooks over important population-confirming inheritances/practices/events.

- **EMERGENT AUTHENTICITY ...**

is the legitimacy that is bestowed on specific objects/activities/events that have somehow lately become important and which significantly mirror long-established/already-honoured notions of cultural distinctiveness or en groupe propriety. Such unfolding authenticity tends to be learned activity that pertains to a current (or a then current) 'lived-world'/'real-world'.

- **ENUNCIATION ...**

is the power of a cultural group or community to speak up for itself and claim its own sought rights and declare its own identity(ies) especially where that body has been notably subjugated/suppressed in the past (where vital 'corrected' articulations of being/becoming are now therefore required). Effective enunciation demands clear and definite affirmative speech, and for Bhabha (these days) it is important to monitor the vital psychics of enunciation involved for those many restless populations which are caught up in difficult 'ambiguous'/'hybrid' (Third Space) postcolonial/neo-colonial settings.

- **ETHNOAESTHETICS ...**

stands as understanding which substantively relates to the long-valued and the changing preferences/practices/aesthetics of particular ethnie and which pays noted attention to remote or muted populations which have been misrepresented or poorly-interpreted in recent years. In this manuscript, the role of imagination is addressed vis-à-vis the capacity of researchers/practitioners in tourism studies and related projective fields to faithfully/relevantly perceive the held sensibilities of the world's different/distant//discriminated host populations (and their revered spaces) across the world.

- **EUROCENTRISM ...**

constitutes orientations to the world which predominantly favour Western (notably 'European') mind-sets and which advantage (perhaps) 'white'/'North-Atlantic'/'Anglo-American' views of history, contemporaneity, and culture at the sorry expense mainly of other (i.e., othered) non-European/remote-from-Europe/'Indigenous' populations. Eurocentric views tend to privilege values such as individualism, dualistic thinking, command-over-nature, and hierarchical decision-taking.

- **EVENTS**

In the specific contexts of this manuscript, events are those Baumanic (largely-corporate) celebrations of culture which are put on by recreation/hospitality/tourism bodies and other projective organisations which exhibit shortlived (often heavily commodified) interpretations of place and space, where limited regard is paid to concerns of bona fide (local) authenticity.

- **FANTASMATICS ...**

comprise the ways in which the world is seen and versioned by a distinct group or institution notably in terms of the cherished myths, legends, and super-narratives it cherishes. The storylines which are peddled (in often contested fashion) tend to be pointedly aspirational (and frequently 'corrective' vis-à-vis a past misrepresentation), and are inclined to be supported by a spectrum of carefully-designed educational activities, controlled declarative events, and promotional programmes.

- **GLOCALISATION ...**

stands as a verdict on contemporary developments across the continents (over recent decades for some, over several centuries for others) where the places in the world (and the populations of the world) are becoming 'more thoroughly connected' and in many senses 'similar' — as, indeed, under *globalisation*) but where there are crucial and distinct *local* flavourings/nuances/adaptations to that supposed incremental uniformity.

- **IDEOSCAPES ...**

are those interpretations of global change (predominantly associated with Appadurai) which concern how national and regional populations today are increasingly being deterritorialised with regard to the dominant narratives/storylines/ideas 'there' in like fashion to the manner in which local states are losing controlling influence over matters of finance (*financescapes*), technology (*technoscapes*), media (*mediascapes*), et cetera, as techno-corporate bodies increase their often external pull over the linked-economy and the expressed-culture of places.

- **INTERSECTIONALITY ...**

refers to the manner in which social factors such as ethnicity, gender, education, and location are seen to be interdependent and overlapping for particular populations thereby deepening or multiplying forms of advantage/disadavantage or accumulation/ discrimination for them. The term is normally used where a group of individuals or sub-population are handicapped in such interleaved ways and placed or forced through such inter-feeding circumstances into a *minor* class.

- **ITERABILITY — THE VOLATILE LOGIC OF ITERABILITY**

Iterability refers to notions of belonging (commonly associated with Butler) where cherished outlooks on matters of being and becoming are uncertainly and ambiguously realigned as specific individuals/groups fast become more nomadic in their loosened ties to historic-place and traditional-space and more connected instead (at dizzying/capricious speed) to what had previously been the culture and lifestyle of former strangers or distant-others.

- **JURISDICTION ...**

is the constitutional authority/right/power an institution or interest group has to rule on the law, and it is normally exercised in sovereign fashion subject to certain prescribed limits. State jurisdiction refers to the agency of the nation/province/body-politic to hear all civil and criminal matters which crop-up within its territories. It tends to contrast with other received world-orders which often have theodictive (religious or spiritual) origins or orientations.

- **LIQUID MODERNITY ...**

is Bauman's term for late modernity and describes the manners in which global societies today function as extended-developments of modernity rather than as spinoff-features of postmodernity, per se. Bauman's metaphoric concept pivots upon the speedy changes he sees in relationships/identities/economics and on the fluid mobilities of the increasingly unstable and uncertain contemporary era. He sees international tourism as a prime influencer (or carrier) of such liquid modern impulses.

- **MANDRAKE OBJECTS ...**

are, *in this manuscript*, those reified objects/entities (and even subjects!) that are presumed to be distinct/lasting/always-there phenomena and which are assumed-to-be a natural or normalised part of a local cultural sphere or an en groupe fantasmatics. In a metaphoric (hallucinatory) sense — named after the plant the magical/poisonous nightshade (mandrake plant) *genus Mandragora*, which is often likened to be 'human' in form — their conceptualised immateriality is thus substituted by an actual/manifest reality. In a wider sense, everyday/banal *objectification* is the degrading of someone to the status of an ordinary or elemental object, or of the essentialisation of an idea-in-currency to that of a mere concrete form. Such reification across or down to an absolute thing is felt (by knowing others) to be illogical and weak reasoning.

- **MYTHOPOETICS/MYTHOPOESIS ...**

Is that domain of understanding of/about a culture based on scrutiny of the aesthetic form of held storylines/narratives and hailed legends/fantasies 'there'. While most of the inspected myths are assumed (locally) to be traditional/longstanding, some may actually be (unsuspectingly/under-suspectingly) recent in origin or influence. Those who inspect mythopoesis probe for how such myths are made vis-à-vis what they explain and how (locally/emically) the future ought cosmologically/hegemonically to be seen 'there'. Tourism is increasingly felt to be a vital means for communication about the explanatory power of 'other'/'distant'/'alien' mythopoetic narratives.

- **MYTHOPOLITICS ...**

is the demesne of understanding of/about culture in terms of the power of found storylines/narratives 'there' both in the contested internal authority of those legends/fictions within that people/society and the degree of reach they have out to or across from other populations. These days, in the so called rational West, much mythopolitics concerns the increasing rejection of predominant dualistic cognitions of humanity and nature — as *the Anthropocene* is increasingly rejected politically on grounds of sustainability for *the Symbiocene* (i.e., the coming age of companionship/ mutual benefit) — since such old/long-run humanistic explanations of life poorly describe the embeddedness of humans in broader and interdependent earthly/planetary webs of life. In contrast, many of the world's

long-held Indigenous narratives have axiomatically already been orientated towards such wider reciprocal relationships. Tourism is increasingly felt to be a vital means of communication about the place and force of such mythopolitical explications.

- **NOMADIC LOGICS ...**

are the outlooks on the world and interpretations about the history, contemporaneity, and future of populations that are absorbed (and spread further by) individuals, interest groups, and institutions as they increasingly move from place to place (physically or relationally), especially where they (the individuals/interest groups/institutions) become open to a shifting but protean mix of other/previously-foreign/formerly-alien understandings.

- **NOMADIC METAPHYSICS ...**

are the often-deep thought-lines or often-acute philosophies about life that mobile populations are exposed to as they move fluidly around the world. In Bauman's view, such global travellers can fast become growingly subject to speculations about living that emanate from the distant others/strangers they encounter-in-flux. To him, many of these fresh cognitions prove to be exhilaratingly lasting, but others are airy and only ephemeral in adoption or force.

- **PALETTE OF IMAGINATION**

In this manuscript, the palette of imagination is that quality of understanding a researcher or practitioner has regarding the cultures and cosmologies he/she is engaged with or otherwise has to confront. The term describes the fact that it is incumbent upon those who operate in global contexts across the continents to often become demonstrably sensitive to all manner of often difficult-to-grasp different inheritances-of-being and aspirations-of-becoming. Some of these 'new sense' cognitions challenge both the sensitivity of their approaches in novel-to-them environments and the creditability of their creative powers of communication.

- **PERPETUUM MOBILE**

For Bauman, culture is a medium or even a pawn which is propelled right, left, and centre by the energetic and effervescent vigour of globalisation and migration as the peoples of the world are stirred up under the pressures of liquid modernity. To him, these admixing forces constitute a contemporary *perpetuum mobile* 'agency' which keeps cultures in an uncertain state-of-flux increasingly free of the inherited pursuits cum traditional proclivities of populations/places and which instead (nowadays) inventively sustains nomadic individuals in open and receptive outlooks towards fresh trajectories of experience.

- **PLURAL KNOWABILITY ...**

is the capacity of researchers/practitioners in tourism/ tourism studies — and in other inscriptive/declarative fields — to cultivate a rich discursive cartography of and about different (multiple) peoples in their own various places/spaces based on emic (rather than etic) understandings in each respective 'there'. Plural knowability, as a reified cognitive/communicative craft, tends to recognise the need of the observer to compensate for his/her conceivable past institutionalised or personal sins of othering about remote or subjugated populations and it thereby helps cultivate a teeming multiplicity of honest-to-self (cum new-sense) differentially-contextualised profiles of identity. Hence plural knowability depends upon informed and skilled differentiality, in lieu of the hackneyed projection of sterile/molonologic (i.e., poorly represented) accounts-of-being for or about outsider/poorly-articulated peoples.

- **POLYLOGUE**

Generally, a polylogue is a speech projected *to* several persons or groups. In this manuscript, the term is taken to mean the ability of researchers/practitioners to have informed and situated dialogue with several groups or populations about 'their' respective cultural habits, identities, and preferences. Omniscient individuals working on such cultural predilections in tourism/tourism studies — and related representational/projective fields — thereby are largely those painstaking individuals whose tested sensibilities enable them to have rich and relevant exchanges with different peoples via fittingly-selected reflexive channels of communication.

- **POLYDICTION**

In this paper, polydiction is the capability of a researcher/practitioner in tourism/tourism studies — and related declarative fields — to engage with the different populations of the world under global modernity (viz., under Bauman's liquid modernity) and accordingly have appropriate but varied dialogue with distinct groups/institutions. In its purest form, those who engage in such forms of polydictive articulation today tend to recognise the distended placelessness of those peoples/interest groups both between and beyond traditional-to-them (or previously-represented-about-them) places/spaces, but also the restlessness which they may exhibit in their nomadic positions of cultural and territorial flux.

- **REIFICATION ...**

is the act of signifying or characterising an abstract entity as an actual/concrete 'thing', especially where a notion or image is assumed to have definitive corporeal existence. In this article, a heavily reified culture is one which is predominantly/exclusively/limitedly seen as a solid or adamantine set of fixed/unchanging traditions and practices where noumenon (abstract notions) are accordingly *thingified* (restrictively objectified) 'there'.

- **SYMPHYSIS**

In physiology, symphysis is (for instance) a joint where the body of a bone conjoins that of another, and where they 'operate

together' anatomically. In this manuscript, the term is used to represent how 'tourism' is an entity which is strongly fused with culture in terms of the selection and production of exhibited activities/behaviours/events, and where (under Bauman's conditions of liquid modernity in particular) cultural forms are significantly de- and re-articulated on an ongoing basis through tourism (and through related nomadic forces of globalisation).

- **THEODICTION ...**

is the narrative of and about the world in terms of God's omnipotence, or that of some other ultimate spirituality. Historically, theodictive understandings were proclaimed against the presence of evil, but under the new-world-orders of globalisation certain new almost-theodictive polarities are emerging — in a chequered cacophony — which speak beyond (but sometimes still-within) the so called rational/instrumental jurisdictions of nations/states.

- **WILFUL NOSTALGIA**

Nostalgia has recently become a notable subject in cultural theory as researchers explore the juxtapositions between the established traditions of places and the unfolding transitionalities.'there'. Wilful nostalgia is that sentimental longing not so much for the received past but — politically — for a preferred/resignified/realigned interpretation of that past that reflects the outlook (or rather the 'inlook'!) of an strongly-positioned interest group today: it is thus a biased/doctored/normalised version of yesteryear and its supposedly-given inheritances.

- **WORLDMAKING ...**

is Goodman's term (in the realm of the arts and aesthetics) for the manner by which specific visions of being and becoming are normalised by an interest group/organisation/corporation for a particular population or place. Hollinshead has adapted the concept to describe the processes by which certain versions of the past/present/future/whatever are naturalised in everyday fashion through the representational agency and declarative reach of tourism/public culture/public heritage. He argues that worldmaking is not just an act-of-privilege of the elite but an inherent/intrinsic and constantly-engaged-in (consciously or unconsciously) mundane participatory activity of all of us. Indulging in worldmaking is thereby like breathing: if one is alive, one participates in its often-unsuspected/often-undersuspected games of preference, precedence, and power, be it in large/loud declarations or otherwise in mundane/everyday ways.

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ARTICLE

Road Network Analysis with GIS and GRASS-GIS: A Probabilistic Approach

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ARTICLE INFO

Article history
Received: 24 September 2021
Revised:21 October 2021
Accepted: 26 October 2021
Published Online: 31 October 2021

Keywords:
Road network analysis
GIS
GRASS GIS
Probabilistic approach
Irregular tessellation

ABSTRACT

In this paper we show how it can be useful to the probability of intersections in the determination of a classification rule for raster conversions in Geographical Information System (GIS) and GRASS GIS for the Road Network Analysis (RNA). We use a geometric probabilities approach for irregular path considering these results for transportation planning operations. We study two particular problems with irregular tessellations, in order to have a situation more realistic respect to map GIS and considering also the maximum value of probability to narrow the range of possible probability values.

1. Introduction

In the last years GIS represents the most fascinating tool for the transportation planning. That is the one most capable of performing the functions of collector between the available application potential and the numerous relational connections between the various branches of knowledge. These tools are technologically adequate to integrate knowledge from multiple sources and at the same time able to create totally transversal environments at a collaborative level.

The analysis methodologies associated with their use have completely changed the strategic decision-making processes both in the organizational and scientific fields.

In summary, they can be defined as IT tools of a matrix, which allows the organization, storage and management of a large amount of mostly qualitative and quantitative data to create digital cartography, produce possible

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DOI: https://doi.org/10.30564/jgr.v4i4.3759

simulations and support planning processes for various reference levels. They are also tools characterized by the specific peculiarity of loading different overlapping information layers (overlays) within their system, realized through appropriately created adequately criteria.

The potential and the various functions to which they must fulfill with very rapid timing and high levels of absolute precision consecrate their role as a key element in the application processes.

Within a GIS software there are peculiar features that serve to perform a multiplicity of spatial analyzes based on geographical and statistical skills. The main fields of application are: the added value they determine in the field of representation and analysis, both overall and in detail, of the demographic-settlement and socio-economic data, allowing the identification of homogeneous territorial areas or with discontinuous distributions; allow to obtain fundamental elements relating to the analysis of the geophysical and anthropic components of an area for the possible management and planning of emergencies related to earthquakes and volcanic eruptions; the elaboration of statistical-cartographic models to determine the evolution of hydrogeological risks and territorial exposures to fires; in the tourism sector they determine the assessments of the overall offer as well as that for individual contexts in terms of endowments in order to determine possible specific characterizations and territorial vocations; even in urban planning studies they find their place by providing analysis on several levels and meticulous analysis on all the components that persist in a given area, providing elements of importance to better understand the different phenomena and plan new implementation phases.

2. Preliminaires and Context

A particular case of intersection occurs when one of the features is a cell in a regular lattice, and the other is a straight line or area because for short lines, the probability of intersecting a single cell boundary is useful and for long lines, the expected number of cells intersected with the standard deviation, is useful. In the case of cell-area intersection, either the probability of boundary intersection or the probability of overlapping the middle point of a cell may be important. Probabilities for lines are dependent upon both feature size and Sharpe relative to cell size.

An important operation on data stored is the calculation of distance between two points. In fact, if we do not consider the projection distortion, the operation is trivial when the positions are in the same zone. However, the calculation becomes more complex when the points are in different zones. When the zones have different projection, the task of calculating between-zone distances may be even more onerous. For this situation, it is useful to compute the probability that two locations separated by a distance d are in the same zone. This probability, as a function of d, may be practically employed to calculate the expected time to compute the distance operation. This valuable became very important for real implementations when the number of operations to be performed is very large. A common GIS application is the conversion of vector landcover maps to a raster database. A variety of potential encoding rules exist; here the encoding rule chooses the class occupying the central point of each raster cell. Of course, there is a tradeoff between precision and data volume; coarse cell resolution leads to smaller and more tractable datasets at the cost of information loss. To what degree can this loss be estimated in advance of the procedure? For example, what is the probability that a landcover patch of a specific size is captured by raster encoding at a specific cell resolution? This is a specific case of a more general problem: the probability that a spatial feature will intersect at least one central point of a tile in a regular tessellation. Foreknowledge of such probabilities may be employed to identify ideal cell sizes for the application. Solution for these sorts of problems appear in recent GIS literature [11], but their mathematical underpinnings are identifiable in texts of geometric probability [9,10,13,16]. In fact, integral geometry provides instruments and methods to solve problems of this kind and there exists an active research area working in this direction [12,15]. In general, Earth and its features are located and evolve in 3D space and time. However, for most applications a projection of geospatial data to a flat plane is sufficient; therefore, two-dimensional representation of geographical features (with data georeferenced by their horizontal coordinates) is the most common. GIS provides the most comprehensive support for 2D data. Recently a new Geographic Information System, commonly referred to as GRASS GIS [4], is developing; it is used for data management processing, graphics production, spatial modeling. Recent versions of GRASS GIS include a 3D raster model for volume data. In view of these new recent developments the study of the statistics of intersections in the three-dimensional case becomes a powerful instrument for eventual encoding rules for 3D raster data model. In [2] the authors illustrated the solution given by [8] and they show that such solution is a special case of a more general result of integral geometry, given by [6] Stoka and Duma extended the results of [6] to the three-dimensional case applying the solution determinate [7] for 2D raster conversion is extended for the analogue problem in 3D case. In fact, starting from [12] and [15], which had great

importance for these studies, between the late nineties and the beginning of the present century, the Stoka research team made a significant contribution to the development of research of geometric probabilities. In [5] and [16] the authors introduced in the Buffon-Laplace type problems so-called obstacles. In [1] they studied a Buffon Needle problem for an irregular lattice determining the maximum value probability, i.e. managing to reduce the usual probability range.

3. Probabilistic Approach

The variations of the classic Buffon's Needle problem are of particular interest. In this variation we consider a tile $\mathcal{R}(a,b,\alpha)$ composed by irregular fundamental cells C_0 represented as in Figure 1.

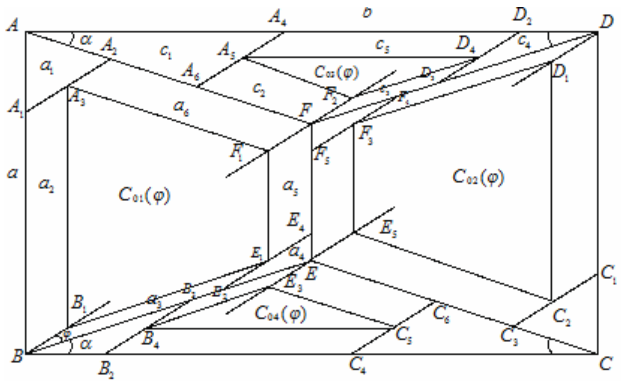

Figure 1. Fundamental cell with segment limited position

where $\alpha \in \left]0,\frac{\pi}{4}\right]$ is an angle and $a > btg\alpha$.

Denoting by *M1* and with *M2* the set of all segments *s* that their center in C_{01} and C_{03}. Denote likewise by *N1* and *N2* the set of all segment *s* completely contained in C_{01} and C_{03}. We compute the the intersection probability between the sides of the cell and the segments by [16]:

$$P = \frac{\mu(N_1)+\mu(N_3)}{\mu(M_1)+\mu(M_3)}, \tag{1}$$

where μ denote the Lebesgue measure in the Euclidean plane.

To compute the above measures, we use the Poincaré kinematic measure [12]: $dK = dx \wedge dy \wedge d\varphi$, where *x, y* are the coordinates of the point *0* and φ the angle of *s*. By Figure1, $0 \le \varphi \le \frac{\pi}{2} - \alpha$, and we have

$$\mu(M_1) = \int_0^{\frac{\pi}{2}-\alpha} d\varphi \iint_{\{(x,y)\in C_{01}\}} dxdy = \int_0^{\frac{\pi}{2}-\alpha} (areaC_{01})$$

$$d\varphi = \left(\frac{\pi}{2} - \alpha\right) areaC_{01},$$

$$\mu(M_3) = \int_0^{\frac{\pi}{2}-\alpha} d\varphi \iint_{\{(x,y)\in C_{03}\}} dxdy = \int_0^{\frac{\pi}{2}-\alpha} (areaC_{03})$$

$$d\varphi = \left(\frac{\pi}{2} - \alpha\right) areaC_{03},$$

$$\mu(M_1) + \mu(M_3) = \left(\frac{\pi}{2} - \alpha\right)\frac{ab}{2}, \tag{2}$$

and

$$\mu(N_1) = \int_0^{\frac{\pi}{2}-\alpha} d\varphi \iint_{\{(x,y)\in \widehat{C}_{01}\}} dxdy = \int_0^{\frac{\pi}{2}-\alpha} \left[area\widehat{C}_{01}\right.$$

$$\left.(\varphi)\right]d\varphi, \tag{3}$$

$$\mu(N_3) = \int_0^{\frac{\pi}{2}-\alpha} d\varphi \iint_{\{(x,y)\in \widehat{C}_{03}\}} dxdy = \int_0^{\frac{\pi}{2}-\alpha} \left[area\widehat{C}_{03}\right.$$

$$\left.(\varphi)\right]d\varphi. \tag{4}$$

Integrating relations (3) and (4) and substituting in (1) we obtain

$$P = 1 - \frac{4}{(\pi-2\alpha)ab}\left\{al(1-sin\alpha) - \frac{bl}{2}(1-sin\alpha+3cos\alpha) - \right.$$

$$\left.\frac{l^2}{2}\left[cos2\alpha + \left(\frac{\pi}{2}-\alpha\right)(1+ctg\alpha)\right]\right\}. \tag{5}$$

Denoting with

$$f(\alpha) = \frac{2al(1-sin\alpha)-bl(1-sin\alpha+3cos\alpha)-l^2\left[cos2\alpha+\left(\frac{\pi}{2}-\alpha\right)(1+ctg\alpha)\right]}{\pi-2\alpha},$$

we can write

$$P = 1 - \frac{2}{ab}f(\alpha). \tag{6}$$

We prove that there exist a system values for α, a, b, l for which the probability *P* is maximum. In fact, for $\alpha = \frac{\pi}{4}$ is easy to verify that $f'(\alpha) = 0$ and $f''(\alpha) > 0$ then the probability *P* is maximum.

For our considered lattice we have:

Example 1. What is the probability that the body test is missed during a 2D conversion to raster?

Theorem 1. The probability P_{int} that a random segment *s* of fixed lenght *l*, fulfilling the relation $l < \frac{a}{2}$, uniformly distributed in a bounded region of the plane, intersects a side of the lattice $\mathcal{R}(a)$ is:

$$P = \frac{4}{(\pi-2\alpha)ab}\left\{al(1-sin\alpha) - \frac{bl}{2}(1-sin\alpha+3cos\alpha) - \right.$$

$$\left.\frac{l^2}{2}\left[cos2\alpha + \left(\frac{\pi}{2}-\alpha\right)(1+ctg\alpha)\right]\right\}.$$

Corollary 1. For $\alpha = \frac{\pi}{4}$, by (6) we have that $0 \le P_{int} \le \frac{2}{ab}f(\alpha)$.

Figure 2 represents trip distance respect to the probability that the trip crosses a cell boundary.

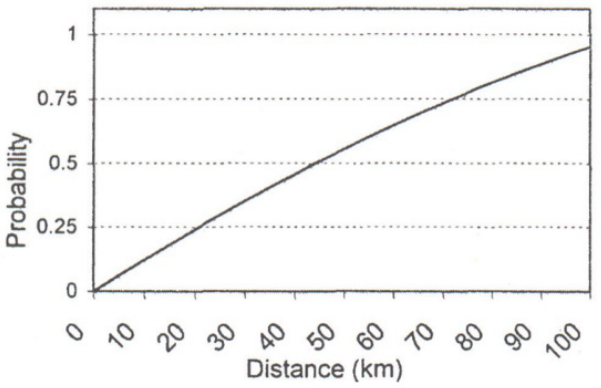

Figure 2. Probability of two points a given distance apart falling in different UK National Grid zones

4. Geometric Probabilities for Rectangle

We consider a tile $\mathcal{R}(a,\alpha,\beta)$ composed by an irregular fundamental cell $C_0 = C_{01} \cup C_{02}$ represented in the Figure 3 where α *and* β are angles with $\frac{\pi}{4} < \alpha \leq \frac{\pi}{3}$ and $\beta \leq \alpha$:

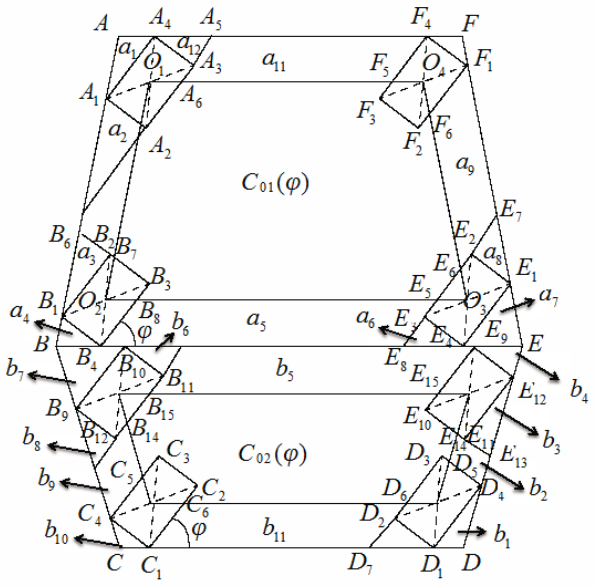

Figure 3. Fundamental cell with segment limited position

In the same way of the section 2, we have:

Example 2. What is the probability that the body test rectangle is missed during a 2D conversion to raster?

Theorem 2. The probability P_{int} that a random rectangle *r* of side *a* and *b*, uniformly distributed in a bounded region of the plane, intersects a side of the lattice $\mathcal{R}(a,\alpha,\beta)$ is:

$$P_{int} = \frac{1}{3a^2(\alpha tan\alpha + \beta tan\beta)}\left\{al\left[6 - 4cos\alpha - 4cos\beta + \frac{1}{cos\alpha} + \frac{1}{cos\beta}\right)\right] -$$

$$(2sin\alpha + 2\,sin\beta - \frac{l^2}{2}[sin\alpha(sin\alpha + cos\alpha) + sin\beta$$

$$(sin\beta + cos\beta) - \alpha cot\alpha - \beta cot\beta] -$$

$$\frac{m^2}{2}(sin^2\alpha + sin^2\beta) - \alpha cot\alpha - \beta cot\beta\Big\}. \quad (7)$$

For $m=0$ the rectangle *r* became a segment of lenght *l* and we wind the probability determined in [1].

5. Conclusions

In this paper we highlight even more the relevance of geometric probabilities for RNA applications.

The GIS and GRASS-GIS application is the conversion of vector landcover maps to a raster database.

In order to estimate the number of maps required to analyze an area of interest and to determine the probability of "missing" converting vector data to raster grids in a transportation planning problems, in this paper we studied a probabilistic approach for the road network analysis with GIS and GRASS-GIS. For some fundamental GIS operations, the mathematical approach showed descriptive, with little or no notion whether observed quantities or relationships are significant. Respect to the previous studies of other authors, we consider two new aspects, in fact we introduce an irregular lattice also considering the maximum value of probability obtaining situation and results more realistic.

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REVIEW

Old Geographical Materialities. Recover the Past and the Heritage in the Present of Pheripherical European Rural Spaces: A Research Proposal

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ARTICLE INFO

Article history
Received: 29 September 2021
Revised:25 October 2021
Accepted: 27 October 2021
Published Online: 31 October 2021

Keywords:
Past
Heritage
Present
Geography
Materialities

ABSTRACT

The past has had a minor consideration in geographic studies the transformation of rural areas, usually dominated by socioeconomic analysis. Incorporating the old and in many cases, the materialities of the past through a reconsideration of heritage to the future of rural space requires an adequate conceptualization and reconsideration of rural materialities and especially of popular housing. In this way, it is intended to decentralize the human and functionalist point of view to give a life of their own to rural cultural and natural materialities in the context of more-than-human-geographies. The renewed study of heritage and the historical past acquires a notable value in the present and future of rural areas through: (1) the interpretation of dissymmetrical realities where the old confronts new activities; (2) for adequate and realistic management of rural heritage and the processes of selective recovery of heritage in certain historical places.

1. Introduction

Returning in summer to the most unpopulated areas of Europe is a joy for the soul and the heart of those who investigate in rural areas. Many houses are open, and many people pass placidly and calmly through the narrow streets. This movement expresses and recounts in a daily way in the summer months, the seasonal cycle of many unpopulated areas and specifically of the most depopulated Spain, as it constitutes an ephemeral way a meeting place for those who resisted and never left when everyone did, those who returned a few years after emigrating flooded by longing for their place, those who never stopped returning for the summer to reconnect with their origins and loved ones and those who were already born in other larger and more urban places but were

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DOI: https://doi.org/10.30564/jgr.v4i4.3787

always tied to family origins. This is made possible by the recovery of popular heritage in rural areas.

The preservation of the family home or its rehabilitation has constituted a silent transfer of urban income to rural origins, not yet adequately quantified. Many families have pledged their savings to preserve, restore, or even acquire a home in rural origins. They are not second homes, they are family homes where the periodic annual reunion of reconstituted rural communities takes place within the framework of material realities rehabilitated and raised again, in many cases after being lost.

Now that the European Commission has established a long-term vision in 2040 for a new flourishing of rural areas and especially of unpopulated areas [1], it is possible to favor a quiet change from the most unpopulated rural spaces. This is the most appropriate vision for a country of territorial imbalances of the magnitude expressed by Spain. For now, in countries with serious imbalances, progress is required in the principle of spatial positionality established in successive national-territorial strategies. To achieve territorial equality, it is necessary to start with the rebalancing of rural areas. In this strategy, it is necessary to take into account the value of past and heritage and articulate the precise processes to incorporate them into the present and the future.

The purpose of this contribution is to suggest a series of geographical considerations that serve as a frame of reference to incorporate past and heritage into the processes of change in European rural areas and especially in southern spaces. The processes of rural change have different speeds in Europe, but are more delayed in the peripheral areas of the continent and in each country. In these remote areas, it is possible to investigate the relevance that the recovery of rural materials can acquire especially rural houses. Research in these remote rural areas has usually focused on their social dimension, obscuring the role of the material setting.

2. The Reconstructed Materialities

Geographical studies on rural change processes have usually had a social perspective, focused on the one hand on the loss of traditional populations and the introduction of new populations and the other on the analysis of new realities and social conflicts between locals and newcomers who arrived. The analytical dimension of the current rural geography has positioned his studies in the present, forgetting some interesting dimensions of the past in explaining the current processes of rural transformation. The renewed role of heritage and traditional landscape are some of the dimensions that it is possible to incorporate from the past [2]. This allows positioning the studies in the material realities of the past in the micro-processes of rural transformation and from a broader dimension to position in the cultural and natural materiality the study usually centered on the human or from the human. In this context, rural reconstruction processes of built and non-built heritage and rural environments can be established [3]. Giving affection, symbolism, and a life of its own to rural heritage contributes to decentralizing and adopting an alternative point of view or at least different from the human soul and the utilitarian vision for the people, agencies, and institutions of the rural (popular) heritage. From this perspective, it is possible to question the possibilities and the new role of old material realities in new contexts. Also, on the role of old traditional communities and new materialities, for example in energy contexts- or new technologies in old communities in form of dissymmetrical realities old in new or new in old in a continuous process of insistent eruptions of the past in the rural spaces of the present [4].

3. Management Styles of the Past

There may be different styles to manage the past in the present. This suggests giving a relevant role to the scale of historical past from small to national in a vertical dimension. It is also possible to manage the spatial scales from a horizontal view: central-marginal, marginal-central, and marginal-marginal according to the relative value of the location of the (heritage in) place. Indeed, the micro and macro value of heritage in place / out of place is relevant. The place encounters would add places with location and local histories of their own. Consequently recover the (power of) past not a sample material scenario or scenic of new things or it is not only heritage and (active) culture but is a force for the future with three broad dimensions: the new value of rural place, tourism (as example of economic activity) and new populations.

Heritage is a spatial phenomenon [5], with several dimensions: (1) Location, not all heritages is associated with specific places and are built from people and non-human elements. (2) Distribution, not all places has the same heritage or the same notoriety. (3) Scale, the place is possible to analyze within a hierarchy of spatial scales, from local to international. A particular heritage can have a variable function and vision on each scale. Heritage can acquire value from the local to the global. The very management of heritage sites obeys politics with spatial scales where global ideals of conservation and traditional and particular interests of rural communities compete [6].

4. The Reconstituted Historical Place

The place is related to the past through the relevance

of the place and its originality. This contributes to their differentiation. The past is a key component of selectivity (re)colonization through material manifestations: popular houses and monuments or through the event or historical literature. There is always a differentiated or relative value of place context in each time of history. For example, in countries with a historical process of repopulation, there is a notorious value of political and military borders, with two dimensions intrinsic value and positional value. It is possible to argue an academic transition from history to heritage in the reconstruction process of the new rural heritage sites [4]. In many rural areas there has been a process of destruction, revival, and reconstitution, with multiple simultaneous processes of loss and conflict of historical heritage in its two natural and cultural dimensions.

At present, it is possible to argue emergent relational communities of interests in historical places. More than local communities based on the extra local value of local rural historical places (emblematic national or regional value). The village suggests notable and multiple differences in the history but selected images and associations persist in the present [7].

A characteristic is the relevant play of old and new heritage and landscapes in the constitution of contemporary new functions of old landscapes. In the present time exists differentiated visions of histories of rural change are based on old and new materialities. In this context it is possible to make a new history of depopulation and restructuring in rural areas based on materialities: rural houses and emblematic artifacts and landscapes. Materiality, memory, time, politics, place, and heritage have a remarkable and continuous intersection [4]. It is possible to establish material memories of the past in place as an object of rural heritage. The past is not a pre-condition to produce of heritage [5]. Time is central in the interpretation of heritage, but heritage is viewed and interpreted from the present. Heritage is a present-centered process [8]. If the present society and people make the heritage, the heritage needs to manage for contemporary purposes. Heritage must be viewed within the cultural and material context of a particular time [8]. The history of heritage is a history of the present or a historical succession of narratives of successive presents [8]. Is a process with notable continuities in the time. For this reason it is possible to conceptualize heritage through the idea of representation [5]. In this way, heritage becomes a commodity subject, and is possible the coexistence and conflict between different views of heritage in the present.

Heritage has remarkable relevance in the identity of the place. Conceptualizing heritage as meaning or representation rather than an artifact or object suggests social conflicts for different positions, interests and views of individuals or social groups [5]. The importance of identity as bounded by place and the use of heritage is a notable source of contestation. The past in the present is a heterogeneous, fluid, and malleable relation, with flows of heterogeneous materials [9].

There is a selective nostalgia for times and places of the past [10], which makes it possible to connect the past time with the present landscape in a qualified way. The past acquires meaning in the present landscape. The material past of a place affects the everyday life of local populations. The past is cumulative in the rural setting and contributes to making the scene more complex. Multiple individual pasts give plurality to the collective past of the rural community. Each separate individual makes his moral history [7]. The moral development of a community suggests a kind of physical or spiritual renewal.

5. Recover (loss) Materialities

5.1 Recover the Material Lost of Rural Decay and the Emergence of New Materialities

'We speak of vulnerable places and things needing protection, conservation, and preservation' [4]. Currently, there is a crisis of accumulation in heritage practice which suggests alternatives to material conservation in the context of a great material rural change. As Desilvey [4] argues, the first thing is to recognize the historic value that is granted to each place in the way to post-production, for later to reserve repair and adequate maintenance. In certain places, the ruin has affected the aesthetic value; while in others natural processes have returned the place to a stage before the managed landscape [11]. Decay is associated with logic of loss or with the logic of rebirth and renewal [4]. 'The continuous accretion of the tangible past is counterbalanced by its continuous loss' [10]. Heritage is a process that refers to heritage practices in the present in the context of transitions in the experience of space and place [12]. Thus, heritage is produced by people according to their current concerns and experiences. Consequently, it varies with the passing of the present time in the form of a changeable social process. If heritage is produced in the present, its relationship with the past has a clear temporality and spatial experience [12]. Micro-spaces emerge from the key social discourses and material constitutions of given assemblages of power [9].

It is necessary to distinguish between an elite or institutionalized memory –the authorized or hegemonic heritage discourse [8] and the memory of ordinary

people associated with everyday life. Old sites must be integrated within the context of political agendas and wider conceptions of present popular memory. Heritage is a permanent subjective and cultural process, where identities are created and answered, at different scales [12]. Oral histories reflect aspects of landscape heritage by offering alternative narratives [13]. In this sense, the rural place is produced and consumed through multiple and contrasted paths by non-expert voices from below. But, local and popular interpretations suggest a more democratic and inclusive management heritage agenda. It also allows us to notice the moral dimension of the landscape, its plurality, and its social value to integrate it into the practice of conserving the heritage site. The lost period is also a lost period of county life. As Matless [3] suggests, in each loss and recovery process there is a particular morality of settlement. The reconstruction of a place allows making a new visible community [3]. People and new materiality produce a new material and visible community. Social change produces new material and visible communities.

5.2 Recover the Material Past and Traditional Heritage for the New Future

Heritage has a present-centered and future-orientated relationship with the past [12,8,6] in form of a process. The term 'heritage' is used to refer to the complex practices and policies that structure our relationship with past material [4]. There is a macropolitics of heritage around institutional practices associated with the preservation and a micro-politics that emerges from the management of specific places, adopting an intimate distance [4]. The valuation of past material does not necessarily encompass accumulation and preservation, since invocations to natural processes or managed decline may appear in institutional agendas [4]. The recovery of the historical conditions of a place allows the emergence of new trajectories. The conservation and preservation of natural and cultural heritage are always associated with the future [14]. Heritage is a non-renewable resource [15] and can have various levels of rarity. It is possible to suggest material resistances or heritage survivals of past rural environments. At the edges there are many survivals precarious communities in visible form of dispersed settlements or close villages [7]. The community to survive has had to change in its dimensions even as imagined (future) or memories (past) of place. Heritage analysis has been oriented to adopt integrated approaches to examine the politics of loss in both cultural and natural heritage sites [15]. Landscape memory of cultural and natural heritage sites is a key factor in recovering the past after a period of loss and disturbance [11]. We constantly reform historical material sites or scenes as much as our memories. Cultural prejudices affect preservation and destruction. The past is continuously selectively viewed, altered, and preserved in the present. Reconstruction of past scenes can also create new ones [10]. The reconstruction of rural houses are a particular example traditionally associated with the interests of the 'fashionable folk' [16]. More recently, the purchase and rehabilitation of traditional houses to use them for recreational amenities has been a notable way of investing money in the new urban middle class. The rehabilitation and use of traditional rural housing, one of the main components of rural heritage, is a prestigious factor in contemporary Western societies.

Heritage allows associating heterogeneous human and non-human realities and actors and assembling different management practices and politics to design different strategies for the future [17]. These heterogeneous properties of heritage are assembled in the present to qualify the particular future of the place. There is a process of heritage experiences in the present in the context of the heritage site [18]. This is manifested encounter between an exclusive and inclusive sense of identity and belonging [19].

5.3 Particular Histories of the Management of Decay and Institutional Histories of Decay and Recover

Material systems encompass multiple unique trajectories and stories of change and transformation. The memories associated with the heritage forms may be popular or elite, consensual or contested, but the association between 'material persistence and memorial function goes largely unquestioned' in the geographical discipline [4]. Protection in heritage contexts does not refer only to material realities or objects. It also presents a subjective dimension linked to the encounter between different social memories and materialities. There is a particular and singular association to each heritage site between materiality, memory, and subjectivity. Materiality is not a fixed entity but establishes a dynamic relationship with other entities. Some different paths and processes allow creatively configuring the preservation process in a creative way in permanent more-than-human dialogue [14]. All loss material recovery processes operate on-site and off-site in the form of dynamic and particular associations that generate a diversity of styles. There is a group or individual heritage concerning the social behavior of individuals [5]. The positive and negative views of heritage sites change in the form of stories that reflect a variety of local communities and organizational structures. In other words, there is a notable acceptance of the inevitability of

change as a permanent process situated in the present.

6. Conclusions

Usually, the analytical nature of geographic research has obscured some areas of work that can acquire considerable relevance in a re-evaluation of the transformation processes of rural spaces that encompass stages of decline, change and new emergence. The reconsideration of materiality and rural heritage as the starting point of rural spaces allows the usual socio-economic point of view that dominates modern rural geographical studies to be decentred.

It is about providing an alternative perspective based on materiality and natural and cultural heritage that allows reinterpreting the evolution of rural spaces, especially in the most remote and unpopulated areas where the transformation processes have been more acute. In this context 'curated decay' [4] has a notable relevance in the reinterpretation of the dynamics of rural spaces based on the management of materiality.

Rural materiality is mainly based on a re-emergence of popular housing and concern for other accessory buildings or old rural roads. It has a popular dimension associated with the dimension of the rural place. It is about giving life or it's voice to the rural heritage that allows decentralizing the utilitarian point of view that usually dominates its study. Through the more-than-human geographies, it is possible to reevaluate the rural natural and cultural heritage of remote rural areas and incorporate it with a life of its own into a global reinterpretation of rural transformation processes.

Currently, it is about investigating in geography about global transformation processes and their different faces in each place. In this proposal we focus on European spaces, but there are other areas where the relevance of materiality is different, such as those of new colonization such as the United States or in spaces with unique dynamics such as the Far East or even Latin America, where materiality acquires another relevance associated with regional dynamics.

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ARTICLE

Using Landsat Images to Determine Water Storing Capacity in Mediterranean Environments

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ARTICLE INFO

Article history
Received: 28 September 2021
Revised: 26 October 2021
Accepted: 29 October 2021
Published Online: 31 October 2021

Keywords:
Climate change
Decision-making tools
GIS
Reservoir
Water storage

ABSTRACT

Reservoirs play an important role in water management and are key elements for water supply. Monitoring is needed in order to guarantee the quantity and quality of stored water. However, this task is sometimes not easy. The objective of this study was to develop a procedure for predicting volume of stored water with remote sensing in water bodies under Mediterranean climate conditions. To achieve this objective, multispectral Landsat 7 and 8 images (NASA) were analyzed for the following five reservoirs: La Serena, La Pedrera, Beniarrés, Cubillas and Negratín (Spain). Reservoirs water surface was computed with the spectral angle mapper (SAM) algorithm. After that, cross-validation regression models were computed in order to assess the capability of water surface estimations to predict stored water in each of the reservoirs. The statistical models were trained with Landsat 7 images and were validated by using Landsat 8 images. Our results suggest a good capability of water volume prediction from free satellite imagery derived from surface water estimations. Combining free remote sensing images and open source GIS algorithms can be a very useful tool for water management and an integrated and efficient way to control water storage, especially in low accessible sites.

1. Introduction

Reservoirs are a very important tool for water management, especially in semi-arid areas [1]. They facilitate water supply in scarcity periods, flood control, hydroelectric power generation and other uses [2]. In arid and semi-arid areas, with water scarcity and irregular precipitation, an efficient use of water resources is one of the greatest challenges for managers [3], especially considering the climate change projections where a decrease in available water resources is expected [4,5]. In Spain, there has been a significant increase in water demand mainly to the

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DOI: https://doi.org/10.30564/jgr.v4i4.3780

growth in population, above all in the coastal areas due to tourism. Likewise, the irrigated area, mainly in the South, has increased in the past decades. Increased population, irrigation and energy generation are the main causes of the regulation of river flows. In fact, Spain is the EU country with the largest irrigated area [6]. Therefore, there is a water stress caused by a situation of lack of water resources and a high extraction rate [7]. As a result, most of the rivers are regulated by dams, which negatively affect fluvial dynamics such as sediment transport, alteration in the runoff balance, and aquifers recharge. Spain is the European country with the largest number of dams (more than 1,200 dams with total water stored capacity of 56,000 hm^3) [8] and with a large supply network. However, all of these infrastructures entail a very high maintenance cost. Despite this, according to a report carried out by SEOPAN (Spanish Association of Construction Companies and Concessionaires of Infrastructures), Spain is the country of the EU that less economic investment dedicates to the water infrastructures maintenance and improvement (nowadays, it is investing 60% less than in 2007) [9]. According to data from the Ministry for the Ecological Transition [10], in March 2019, the Spanish water reserve rose up to 58.1% of the total capacity, and in March of 2021 this was close to 63.1%. The sum of the consequences of climate change and the aging of infrastructures, can lead to an alarming situation with important losses of this valuable resource and the storage capacity.

There are different techniques to estimate the water reserve and the storing capacity. In Spain, the most commonly used equipment to measure the water level in reservoirs are pressure methods (hydrostatic collection, pneumatic capture, etc.), since they have high precision and stability [11] in addition to the traditional limnimetric method. However, the use of this type of sensors could suppose a cost in the maintenance and the time dedicated (i.e. inspections and technical visits), especially for smaller and/or dispersed reservoirs in the territory. Even more, one of the problems in the water reserve temporal series data is the deficiency of homogeneity in the values due to changes in the gauging stations over time [12]. In developing countries, it could be difficult for the availability and the continue maintenance of these tools to measure the water stored.

Remote sensing is a tool that can be very useful to study the water quantity and quality over time, especially when direct observation or validation in situ is not possible [1,13]. It offers the possibility of assessing current and monitoring future water demands in order to better allocate limited water resources with integrated management systems [14]. Satellite images can provide us with an overview of the resource spatiotemporal dynamics and incorporate it into management measures [15,16]. Even more, the free availability of Landsat images can help to control and manage water and produce models to estimate the future scenarios of water storage and demand [17].

Despite the possibility of cloud cover [18,19] the images obtained from the Landsat ETM and ETM+ sensors present a medium spatial and temporal resolution [20] that allow to map variations of the surface of the dammed water. There are some researchers who used different remote sensing products to assess, estimate and monitor, and develop methodologies in order to obtain data series [21-24] that help in the management of water resources, even in developing countries [25,26].

Considering the facilities of acquiring remote sensing images and the possibilities offered by free Geographic Information Systems (GIS) for modelling and predicting future sceneries, the combination of both could be useful for water management and decision makers [27-31].

The purpose of this study was to assess the potential use of remote sensing images to estimate storage capacity in different reservoirs by using open source tools and establishing a quick method to estimate the volume of water stored, that can be integrated into an automatic or semiautomatic management system.

2. Materials and Methods

Five reservoirs with different sizes (and water storing capacity) were selected in this study (Figure 1) combining Landsat images and hydrological studies [32]. These reservoirs are located in the climatic Mediterranean area of Spain: La Pedrera and Beniarrés, both in the province of Alicante, Cubillas and Negratín in the province of Granada and La Serena in the province of Badajoz. The annual average rainfall of all areas is between 300-500 mm and the annual average temperature range from 14ºC to 16°C [33].

Characteristics of each reservoir, such as surface and maximum capacity are summarized in Table 1. La Serena reservoir (38°55'49.4"N 5°13'36.1"W) is located at the confluence of the Zújar river and the Guadalemar river in the Guadiana river basin. It was built in 1990 over a large part of the old Zújar Reservoir. Annual average precipitation values are around 550.40 mm, and frequent droughts periods during summer months. The main uses are mainly irrigation, but also water supply and hydroelectric power generation [34].

La Pedrera reservoir (38°01'05.9"N 0°51'56.9"W) was built to use it as a regulator in the distribution of water

from the Tajo-Segura transfer to the Campo de Cartagena in 1985. It is located on the Rambla de Alcoriza, in the Segura watershed. This area is characterized by low and irregular rainfall (around 300 mm, mainly in April and October), and high temperature. La Pedrera reservoir is a key element which is part of a natural and man-made environment cataloged as a Protected Landscape of Sierra Escalona and its surroundings. Moreover, this area is classified as a Special Protection Area (SPA) for Birds and Site of Community Importance (SCI) [35,36].

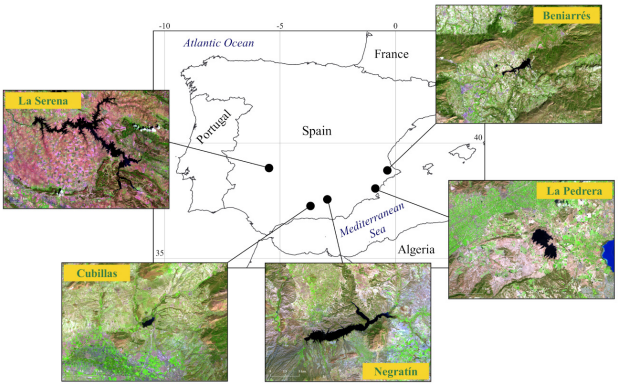


Figure 1. Location of the studied reservoirs. False color composites of each study area are shown.

Source: Landsat 8 OLI RGB:5.6.2

Beniarrés reservoir (38°48'21.2"N 0°21'52.2"W) is located on the Serpis river and it was built in 1958 mainly for agricultural irrigation, but fishing is also allowed. Annual average precipitation is about 650 mm. The reservoir is surrounded by two SCI's: Sierra de la Safor and Valls de la Marina, both with a great endemic vegetation representation [37,38].

Cubillas reservoir (37°16'37.0"N 3°40'13.6"W) was built in 1956 on the Cubillas river and it is not only used for irrigation but also as a bathing area. The Cubillas watershed average rainfall values are around 600 mm, with dry hot summers. It is located close to Sierra de Huétor Natural Park [39].

Negratín reservoir (37°17'19.03"N 3°39'44.66" W) was built in December of 1984 on the Guadiana Menor river and currently is the third biggest reservoir in Andalusia (Spain). The main uses are irrigation and electric generation, but also has a great social component for sailing, fishing or bathing [40]. It is situated 100 kilometers northeast of the Cubillas reservoir.

To describe material and methods employed in this research, a flowchart with the sequence of data sources and analyses is provided (Figure 2).

Table 1. Main characteristics of the study reservoirs. Source: Spanish Yearbook of the Water Gauging Information System [40].

Reservoir	Surface (ha)	Maximum storage capacity (hm^3)
La Serena	13,708.3	3,219
La Pedrera	1,226.9	246
Beniarrés	224.3	27
Cubillas	184.6	21
Negratín	2,016.8	567

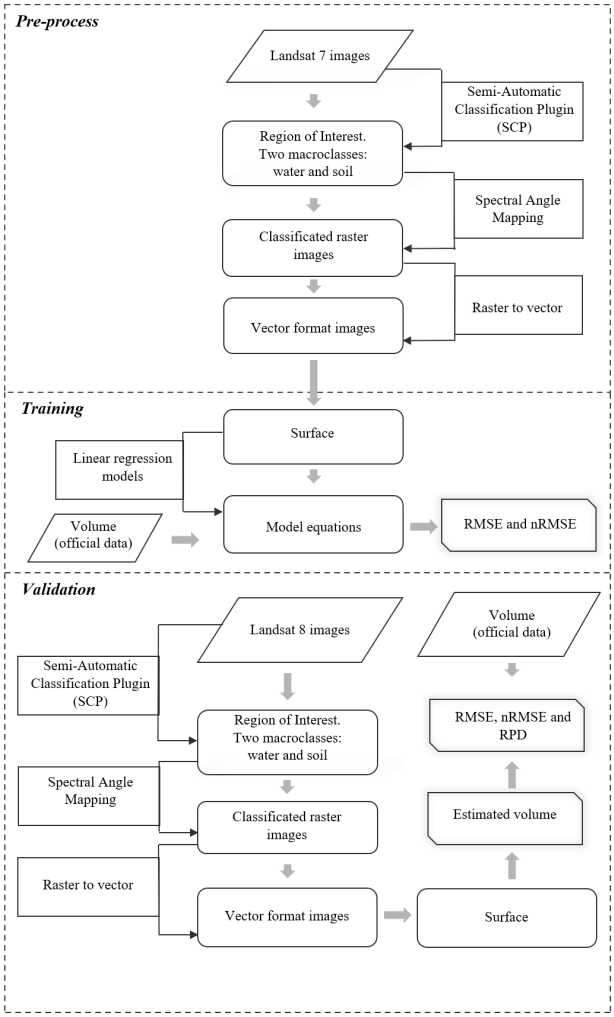


Figure 2. Flow chart of the process: 1) Pre-processing of Landsat 7 images with QGIS and the SCP plugin, 2) Training model, 3) Validation process with Landsat 8.

2.1 Hydrological Data

Water storage data proceeded from the web tool State Monitoring Networks and Hydrological Information [41] owned firstly by the Ministry of Agriculture and Fisheries, Food and Environment (MAPAMA), nowadays by the Ministry of Ecological Transition and Demographic Challenge (MITECO), with information about outlet flow,

reservoir water level, and water storage.

Daily values of water level variation for each reservoir were obtained from the monitoring control stations network. These data do not consider evaporation losses. Reservoir water volume data used for each reservoir were from the same dates when the remote sensing images were obtained. This information is publicly available and facilitated the production of water storage time series.

The Official Gauging Stations Network has been in operation since the hydrological year 1911-1912, so there may be some variations in the data homogeneity, due to changes and improvements in the measurement systems used over the years. Gauging stations are part of the continental water masses monitoring program.

2.2 Remote Sensing Data

Multispectral Landsat images were processes in this study (336 images). Landsat 7 ETM+ (Level-2) images acquired from the U.S. Geological Survey-Earth Explorer Geodatabase [42], corresponding with dates between October 1999 and May 2003, were employed in the first stage of this study. Although the main limitation was cloud cover, the number of cloud free (under 10%) images used for each dam were the following: 28 images for La Serena, 85 for La Pedrera, 43 for Beniarrés, 35 for Cubillas and 62 for Negratín.

Additionally, a set of images acquired between April 2013 and December 2015 by the Landsat 8 Operational Land Imager (OLI) (Level-2) were use in the second stage of the study. A total of 17 images for La Serena, 14 for La Pedrera, 16 for Beniarrés, 15 for Cubillas and 21 for Negratín were used.

Landsat images have been widely used in numerous studies around the world for the observation and monitoring changes and processes in water masses, mainly due to the image's availability from the 1970s to the present day.

2.3 Image Processing

Firstly, the images were bounded by using a buffer created from the geographical data files (shapefiles) of the reservoirs (maximum surface). This geographical database was obtained from the open source spatial data infrastructure of the different Hydrographic Confederations of the rivers: Guadiana [34], Segura [35], Júcar [37] and Guadalquivir [39].

A supervised classification approach was employed to calculate the water surface of each Landsat image [43]. For each one, the algorithm was trained with sets of pixels belonging to the following categories "water" or "upland". In this study, we focused on delimiting the area corresponding to the water surface, associated with the thematic class "water". The Spectral Angle Mapper algorithm (SAM) [44,45] was employed for mapping surface water extent. The algorithm calculates the similarities between the spectral signatures of the training image and the spectral signatures of the pixels of the image as vectors in an equal dimension to the number of bands (bands 1, 2, 3, 4, 5, 7 for Landsat 7 and bands 2, 3, 4, 5, 6, 7 for Landsat 8). The SAM equation is the following (Equation 1):

$$(x, y) = \cos^{-1}\left(\frac{\sum_{i=1}^{n} x_i y_i}{\left(\sqrt{\sum_{i=1}^{n} x_i^2}\right)^{\frac{1}{2}}\left(\sqrt{\sum_{i=1}^{n} y_i^2}\right)^{\frac{1}{2}}}\right) \quad (1)$$

where n is the number of bands in the image, x is the spectral signature vector of a pixel image, y is the spectral signature vector of the training area. Therefore, a pixel belongs to the class having the lower angle (Equation 2):

$$x \in C_k \Leftrightarrow \theta(x, y_k) < \theta(x, y_j) \forall k \neq j \quad (2)$$

where Ck is the k coverage class, yk is the k class spectral signature, and yj is the j class spectral signature.

Digital image processing analyses were performed with the QGIS vs. 3.4 "Madeira" open source Geographical Information System [46] and the Semi-Automatic Classification Plugin (SCP) [47].

2.4 Statistical Analyses

Descriptive statistics of estimated surface water and officially registered water volume were compared for each reservoir. After that, a statistical modeling approach for predicting water volume from remote sensing surface water estimation was done.

Least square regression models were computed to predict water volume from the obtained surface water maps. In order to develop a cross-validation modeling approach, Landsat 7 images were used for training and Landsat 8 images were for independent validation. In this sense, 75% of the images were employed for training and 25% for independent validation.

The training stage implied the development of regression models between surface water estimations and official water volume. Then, regression coefficients were used to compute the estimated water volume in the validation stage and compared with measured water volume. A set of statistical measurements were used to assess the accuracy of both modeling stages. Firstly, Pearson correlation coefficient (R^2) was calculated to explain how much variation in the dependent variable y (volume) is explained by x (surface) variable. Then, the adjustment of the estimation model was evaluated by using the Root Mean Square Error (RMSE) and

Normalized Root Mean Square (nRMSE) [48,49]. RMSE compares a predicted value and an observed value (Equation 3).

$$RMSE = \sqrt{\frac{\sum (M-E)^2}{n}} \quad (3)$$

where M = measure value, E = estimated value, and n = number of samples used for prediction. The smaller a RMSE value is, the closer the predicted and observed values are. Due to reservoirs have different dimensions, the nRMSE was calculated in order to provide a practical comparison among regression models for reservoirs with different spatial scales. This measurement was computed as a normalization of the RMSE respect to the range of the response variable (Equation 4).

$$nRMSE\ (\%) = \frac{RMSE}{range} \cdot 100 \quad (4)$$

Finally, the robustness of the predictions in the validation stage were evaluated with the Residual Predictive Deviation (RPD) that is computed as the standard deviation (σ) of observed values divided by the Root Mean Square Error or Prediction (RMSEP) as shown in Equation 5.

$$RPD = \frac{\sigma}{RMSEP} \quad (5)$$

To interpret the results of the RPD statistics, Cheng et al. [50] proposed that successful models should have RPD values higher that 2, moderately successful models have RPD values in the range 1.4 to 2, and unsuccessful models have lower values. All statistical analyses were developed with the R programming language [51] in the RStudio (https://www.rstudio.com/) integrated development environment.

3. Results

During all the studied period, reservoirs exhibited large stored water fluctuations. Average water volume of La Serena was 2369.9 hm^3 (74% of its maximum capacity), 83.9 hm^3 for la Pedrera (34% of its maximum capacity), 11.1 hm^3 for Beniarrés (41% of its maximum capacity), 15.8 hm^3 for Cubillas (75% of its maximum capacity) and 388.1 hm^3 for Negratín (68% of its maximum capacity). Those water bodies with a lower value than the maximum capacity correspond to reservoirs with greater seasonal variability, measured by their coefficient of variation. In fact, significant negative correlation between both variables (R=-0.94; p-value<0.05) was obtained. It denotes the high variability of the water surface, especially in drier Southeast of Spain.

Training stage implied the development of regression models among the estimated water surface of each reservoir from Landsat 7 images and the officially measured stored water data (Figure 3). In these five cases, we reported R^2 values over 0.9.

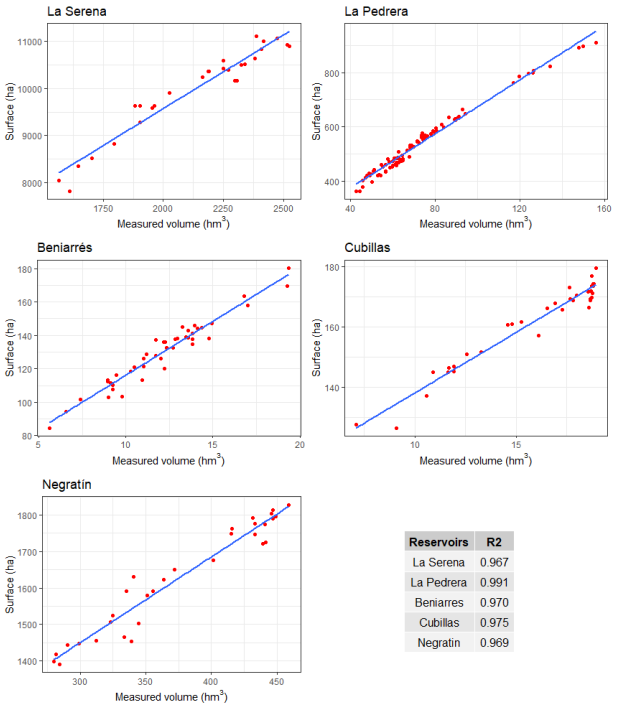


Figure 3. Linear regression between water surface and water storage in the five reservoirs (note: R2 means R^2).

In order to increase the knowledge about the performance of the regression models, RMSE and nRMSE were computed along with the Pearson correlation coefficient (Table 2). Lower RMSE values indicate a better fit of the models, and the lower values were obtained for Beniarrés (RMSE = 0.713) and Cubillas (RMSE = 0.742) reservoirs. These results should be analysed carefully because this statistic is scale-dependent. To avoid this problem, RMSE was normalized with the range of the predicted variable, thus obtaining the nRMSE. A more coherent comparison of the model was possible with the nRMSE and its values were about 20-25% except for La Pedrera, that was notably lower (nRMSE = 13.4%). All of them show adequate results of the model adjustment [50].

Table 2. Cross-validation results. Estimation of water volume from remote sensing surface water.

	Training			Validation			
Reservoir	**R^2**	**RMSE**	**nRMSE**	**R^2**	**RMSE**	**nRMSE**	**RPD**
La Serena	0.967	72.352	25.0%	0.939	37.408	33.2%	3.01
La Pedrera	0.991	3.288	13.4%	0.991	3.926	12.7%	7.90
Beniarrés	0.970	0.713	24.0%	0.973	1.018	22.3%	4.49
Cubillas	0.975	0.742	21.7%	0.990	0.378	13.7%	7.32
Negratín	0.969	14.721	24.2%	0.930	11.644	35.8%	2.79

Validation of the previous regression models was

developed with an independent Landsat 8 repository of images. Coefficients of the training stage were employed to predict water volume from estimated water surface. Then, water storage predictions were compared with officially measured water volume [52].

4. Discussion

Our results suggest that this methodology used for estimating surface water was robust enough (Table 2 and Figure 4), even at highly variable water bodies (human consumption, irrigation…) such as our studied reservoirs. Pearson correlation coefficients were always high ($R^2 > 0.9$) and RMSE and nRMSE were similar to those obtained in the training stage. La Pedrera (nRMSE = 12.7%) and Cubillas (nRMSE = 13.7%) reservoirs reported the better results for those statistics.

The predictive capability of regression models was evaluated with the residual predictive deviation (RPD) statistics. All the models reported RPD values higher than 2. That is a threshold commonly employed to identify model that could bring successful predictions of selected variables.

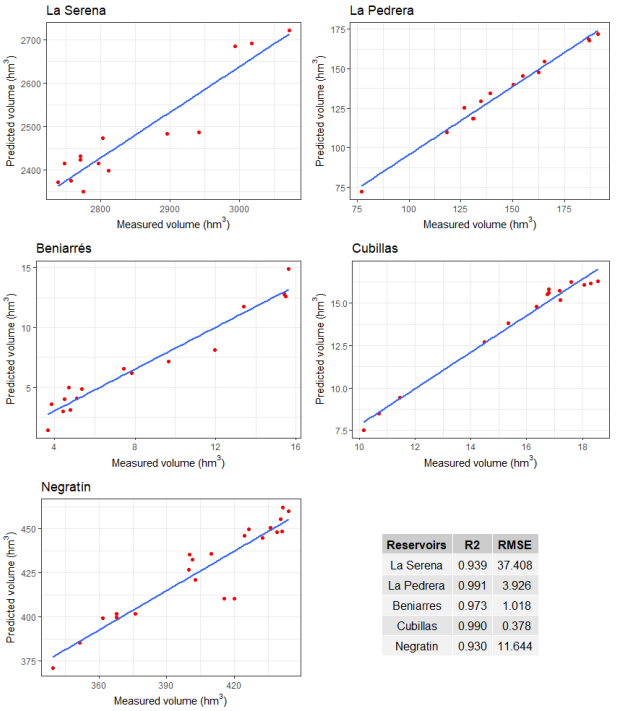
The use of temporal series of images to study and monitoring hydrologic dynamics in arid and semi-arid areas is becoming of great interest due to the increasing pressure on the water resources [53,54]. In addition, predictions of climate change cause growing concern about the efficiently management of resources.

In this study, according to the results obtained, the relationship between the water surface of the reservoirs and the stored water presents a good adjustment although some values of nRMSE were relatively low. Values of RPD over 2 indicate a successful prediction with maximum values for La Pedrera and Cubillas.

The complex sinuosity of the shore of the reservoirs and the existence of vegetation that covers the borders could affect the delimitation of the water surface by using automatic classification tools.

Despite the usually clouds coverage presented in these areas, there are a large number of images available to obtain good prediction models for water storage. However, there may be changes in the storage capacity due to structural, operational level modifications or sedimentation processes [55,56]. Knowing these, managers could quickly re-estimate the available water and use this methodology efficiently.

The information provided from this study could be useful when trying to estimate the available volume mainly in those areas where reservoirs monitoring has a complex accessibility, cost and time-consuming [17,52]. This information could be integrated into semiautomatic or automatic decision-making tools and big data management and can help to study the effects of the climate change and predict future sceneries to determine water availability.



Reservoirs	R2	RMSE
La Serena	0.939	37.408
La Pedrera	0.991	3.926
Beniarres	0.973	1.018
Cubillas	0.990	0.378
Negratin	0.930	11.644

Figure 4. Comparison between measured and predicted volume obtained from validation in Landsat 8 images (note: R2 means R^2).

5. Conclusions

The relationship between area and water stored obtained in this study presents a good adjustment with high R^2 values and great RCP values, mainly in two reservoirs: La Pedrera and Cubillas. The study indicates the possibility of incorporating this methodology into management systems as an auxiliary tool to control water reservoirs. One of the main advantages of using remote sensing is the availability of images to create temporal series with water storage data in a quick and less costly way by using an open source Geographic Information System and free download images such as Landsat. This can help to take decisions and create strategies to predict different future scenarios.

This methodology has the aim of facilitating the implementation of an essay tool and method to manage water resources with a minimum cost, based on the use of free sources and open software.

Another advantage may be that this type of methodology can be easily automated. It is possible to create plugins and run personalize applications. For instance, using a programming language, a script can be created to

automate the process of obtaining update images, processing and calculating the water surface. To manage and analyse large volumes of information, as well as adjust and customize the methodology, this type of tools is very efficient and suitable. In this sense, this would be the first step for an automated management of big data and control data of a wide variety of reservoirs in order to establish regional or national strategies for water supply, hydroelectrical energy production and irrigation water availability.

Funding

This research received no external funding.

Data Availability Statement

Data obtained for the reservoirs are from open source and public availability.

Acknowledgments

Thanks to the United States Geological Survey for supporting and facilitating the free satellite data acquisition.

Conflicts of Interest

The authors declare no conflict of interest.

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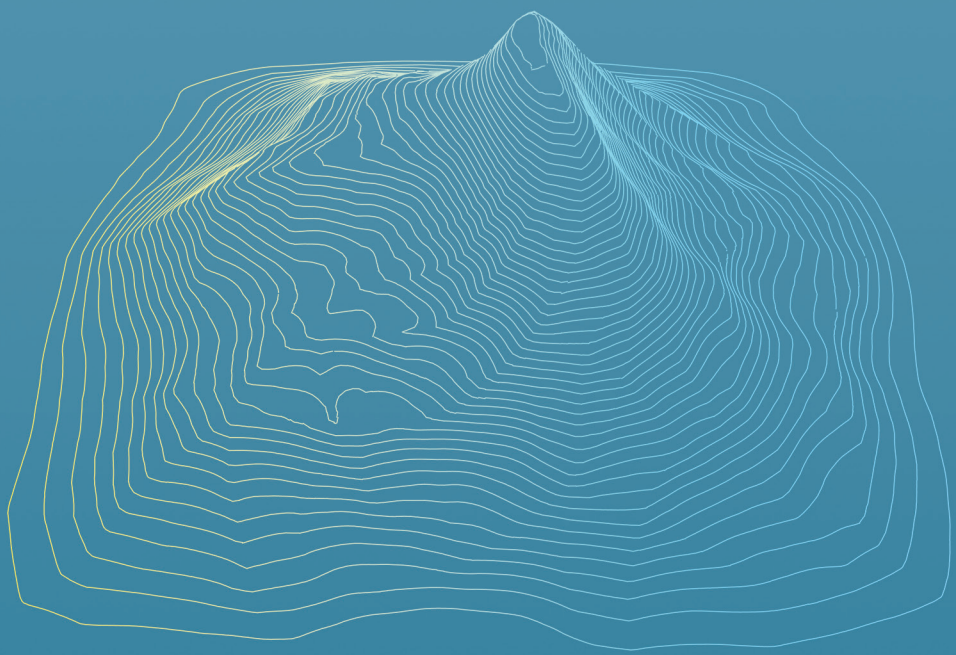

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ISSN 2630-5070