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DEVELOPING AN ENTERPRISE RISK'S EARLY WARNING SYSTEM FOR MANUFACTURING INDUSTRY IN LESOTHO USING RDI

BERNARD MOEKETSI HLALELE*[1] AND REITUMETSE PEARL MOTATI[2]

*[1]Department of Business Support Studies (BSS), Faculty of Management Sciences
Central University of Technology, Free State,
Private Bag X20539, Bloemfontein, 9300, South Africa
[2]The South African Police services, Pretoria, 0001, South Africa*

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ABSTRACT

Textile industry in Lesotho contributes approximately 40 to 45% of the Gross Domestic Product and employs over 40 000 Basotho. Although Lesotho is a water rich country, this industry uses large amounts of water and has put increased pressure on this major natural resource. In order to assist regulate and effectively manage water usage in the Lesotho textile industry, the current study develops an early warning system to keep this industry in business during the current rapidly changing climate regime. The study used both monthly average precipitation and temperature to compute a water balance standardised precipitation drought index (RDI) on 6,9 and 12-time scales obtained from Lesotho Meteorological Services. Expectation Maximum (EM) algorithm was used in replacing the missing values of both data sets. DrinC software was used in computing SPI values. Results revealed statistically decreasing Mann Kendall' trend on all RDI-6, 9 and 12-time scales. This implied a situation where the study area is moving into hydrological drought events. The spectral analysis revealed return periods of 3 to 7 years on all the three selected scales. This implied Lesotho drought is driven by El Nina events whose cyclicity is 3 to 7 years. With these results, the study area is expected to be in drought in 2019. The industry is therefore expected to use water sparingly during the expected drought events. The study warns all water users and the government to use water with caution as RDI is significantly getting negative. Measures such as water restrictions and rationing are therefore encouraged as the study area in its second year after the 2015/16 drought disaster.

KEY WORDS : Business risk, Drought, Manufacturing industry, Hazard, RDI

INTRODUCTION

The textile manufacturing industry was officially introduced to Lesotho initially during the year 1980, between the year 1980 and around 1990s the clothing industry gradually grew in Lesotho. During those years, simply because Lesotho based clothing companies had a good advantage in terms of trade contracts in the western world that was signed under the Lome Convention allowing non-taxable admittance of exporting clothes to the European Union Marketplace. During the year 2000 the African Growth Opportunity Act was then presented by the United States of America; which Lesotho became aware of the cumulative foreign investment from the Asian textile companies most factories in the industrial garment areas in Lesotho are categorised as Cut Make and Trim factories. This explain that the fabric is imported to be knitted into sartorial, which are then washed in the Country to be exported. (Bello *et al.*, 2007; Ministry of Industry, Trade and Marketing. n.d; Mallika, n.d). Agoa (2018) shows that the sector is a crucial source of employment and one of the few industries of scale the nation can boast. Both apparel, footwear and textile manufacturing industry are considered to be Lesotho's main recognised employer which approximately providing work for about 46 500 workers. Textiles and clothing contribute about 45 per cent of exports currently the employment rate is lower when compared to its peak in 2003 ranging between 54 000 workforces. When the Multi-Fibre Arrangement was phasing-out the industry grieved huge declines in hiring and, about 82% of all industry employments opportunities are given to women (Bennett, 2017). The Manufacturing industries are contributing largely to Lesotho's economy way far than any other sectors there are significant occupation and financial multipliers *(AGOA, 2013; Lesotho Embassy,* n.d). A range of formal/informal sector activities occur that feed into/off the industry. Starting in April 2016 skilled clothing employees are remunerated a minimum wage amounting to US$94 monthly, and unexperienced employees are getting roughly minimum wage of US$86 (Bennett, 2017). *According to* Mokhethi (2015); Bennett, (2017) major manufacturing industries in the Capital Maseru include textiles, clothing, footwear, food and beverages. See the Table 1.

The textile manufacturing industry plays an important role in the Lesotho's economic growth and employment opportunities. It contributes most approximately 40-45 % of the country's Gross Domestic Product and hires above 40 000 Basotho Nation, which ranks in the second main employer after the Lesotho government (Masupha, 2007). The Manufacturing industries contribution to GDP weakened from 20.1% during the year 2004 to 11.4% in 2010 because of international economic catastrophe and the quick growth of additional sectors in Lesotho. Before Lesotho Government fortified foreign direct investment in manufacturing of clothing, textiles and footwear to gain privileged trade provisions with the USA (Common wealth, 2018). The report that was produced by World Economic Forum Global Competitive in the 2012-2013 rated Lesotho 124th out of 144 countries in terms of manufacturing process which scored 2.8 out of 7, compared to the other bordering country such as South Africa which came 43rd and scored 4.2 out of 7 (Common wealth, 2018).

Manufacturing industries and use of water

The manufacturing industries are situated in the Ha-Nyenye and Thesane Community. Most jeans necessitate processing to happen in the laundry to result with the expected quality. There are numerous types of washes which include stone, bleach, enzyme, and soft washes. These washes need massive amounts of water and they make a wasteful water usage that need the attention of Lesotho to resolve and is considered to be a possible environmental hazard. Many of these plants have laundry facilities that are utilised to unstiffen garments or to get rid of pigment dyes (Salm *et al.*, 2002). Manufacturing industries in Lesotho has broaden exports in the country and has created substantial employment opportunities for Basotho nation even though the Government as well as the private sector have established numerous wet manufacturing industries that produce big amounts of wastewater discharges (Pullanikatil, 2007). Kiron (2004) Water usage mostly take place through textile processing operations. Practically every dye, specialty chemicals, and finishing chemicals are placed to textile substrates from water baths. In addition, the preparation steps for fabric include

Table 1. Sub sectoral value chain manufacturing industries, jobs and production volumes

Category	Firms	Jobs	Approximate Units of Basic Garments Produced Per Annum
Textile	1	1 220	Yarn - 18 000t Fabric – 15.6m linear meters
Denim (woven bottoms)	9	13 124	23 304 000
Non–denim Woven Fashion	4	1 580	6 360 000
Industrial Workwear	6	4 696	11 003 800
Knit Garments	33	24 513	115 143 600
Footwear	2	1 253	7 200 000 pairs
Supporting Industry	11	218	-
Total	66	46 604	155 811 400 (typical clothing units) 7 200 000 (pairs of typical shoes)

Source: (Bennett, 2017).

scouring, desizing, bleaching and mercerizing, Utilizing aqueous systems. The water usage differs from each industry that is depending on exact processes that is being operated at the grinder, equipment used and prevailing management practice regarding water usage. Textile processing differ in water consumption, but it was discovered that Wool and felted fabrics processes consume and demand more water than any other processing subgroups like carpet, woven, stock, and knits. The manufacturing industry consumes large amount of water in its varied processing operations. When processing mechanical the water consumption is low such as of spinning and weaving, where's with textile wet operations process, water required is more. Almost all chemicals are applied to textile substrates using water baths. The two reasons while processing wet textile are firstly, solvent for processing chemicals and secondly, a washing and rinsing medium. Separately from the mentioned, water is used up in ironing, steam drying boiler, cooling water and cleaning (Muhammad, 2009). The use of water at textile mills can make millions of litres dyes wastewater daily. The unwanted water usage adds significantly to the pricing of finished products through bigger charges for fresh water and for sewer discharge. The quantity of water required for textile processing is large and varies from mill to mill depending on fabric produce, process, equipment type and dyestuff (Gibbs, 2002). When the processing takes place much longer there will be higher quantity of water needed and also at the end of each processes the bulk of the water is used (Muhammad, 2009). As already indicated processing operation requires large volumes of water. The water usage of different purposes in a stonewashing/washing process operation depend on the style and weight of the load to be processed. The quantities of water and chemicals used during operation for the chemicals and water used see below the example of the factory that is using a particular style with a weight load of 70 kg.

Impacts of drought on manufacturing industries

Impacts are usually mentioned as well as direct and indirect. Direct impacts comprise of decrease in productivity, fire risk, and reduced water levels. The repercussions of these direct impacts create indirect impacts. For instance, a decrease in productivity may end in reduced income for manufacturing industries, increased costs for food and job losses, reduced tax incomes due to reduced expenditure. (Ojos, 2014). Drought affects mostly communities and environment. Drought impacts are often gathered as social, economic and environmental impacts. These drought impacts must be utilised during planning and responding to drought situations (NDMC, 2018). Drought persuaded economic losses including those from reduced agriculture production, lack of control by industrial use, decrease in agriculture dependent industries increased job loss and other drought stricken

Table 2. Quantities of chemicals and water used during the stone washing/washing process combination

Operation	Inputs	Quantities	Water temperature	Operation time (minutes)
Desizing	water Ractase Multiclean	500 L 500 mL 500 mL	50 °C	13
Rinsing	water	1 500 L	± 20 °C	5
Stone washing	water stones BT 620 Felosan soda ash	500 L 3 drums 1 000 g 500 mL 50 g	35 °C	72
Rinsing	water stones	1 000 L 3 drums	± 20° C	5
Washing	water Felosan	500 L 500 mL	± 20° C	5
Rinsing	water	1 500 L	± 20° C	5
Softening	water DMT 50	500 L	± 20 °C	5
Total for relevant process		6 000 L	1 000 mL	110

Source: (Masupha, 2007)

industries put pressure on financial institutions such as Funds shortfalls, loss of revenue and credit risks, to governments, such increased costs for transportation of water and improvement of new sources are responsibility of municipalities, private business, industries, agricultural enterprise, families, public and governments (NOAA, 2007). The other way to determine the impact of a drought disaster is to look at vicissitudes in Gross Domestic Product or Gross National Product in the past three decades, droughts may decrease GNP. Determining GDP in many cases show that economic recessions mostly appear after a drought has passed. Drought can cost public, industries and government's money. These may impact local, and only disturb persons in the drought affected region, it might be extensive and impact those living outer to drought area. Drought also has an impact on various sectors, like agriculture, recreation and tourism (NOAA, 2007).

Socio-economic impacts of drought

Drought impacts is very costly and comes in different forms. Examples of economic impacts will comprise of those who lose money only because drought destroyed their livelihood. Economic impacts can be both direct, such as reductions in production, and indirect, as increases in the prices will be experienced (NOAA, 2018). Economic impacts often involve losing money either by individuals or families businesses and governments. Government revenue too will remain indirectly affected by the decrease in profits of businesses associated to the agricultural sector. Not only the economy but drought affects the society and environment. Plants and animals' lives depend on water consumption same as General public do. The damage caused by drought can cause a huge disaster, shrinking of food supplies and damage in house hold consumption. On most cases the damage can be temporary, and on the other hand permanent (NOAA, 2018). Drought can touch negatively on people's health and safety. Drought impacts on people comprises of anxiety or depression in relation to economic losses, conflicts within the community with not enough water, reduced incomes, less entertainment activities, and even loss of people's life. Drought may create damage that are not totally tolerated by agriculturalists, but another percentage of the damages are distributed on to customers through higher prices. The higher the price, further losses will be passed on to customers. The circumstances of drought can also cause a considerable rise in wildfire risk. Like plants and trees weaken and die from a lack of rain, increased insect infestations, and diseases-all of which are related to drought add to wildfires. When drought takes long it equate to more wildfires, which affect the economy, the environment, and society (NOAA, 2018). Droughts can impact directly on water supply and on water dependant economic sectors, such as hydroelectricity and irrigation production, Agroindustry on water and precipitation dependant, as well as on other economic activities (Garrido, 2014). Drought water scarcity impact on production, sales, and business operations of different manufacturing industries. Direct costs of drought include not only limited to the physical harms but also business disruption and job loss. The indirect costs arise from connections and dealings between economic industries and sectors. Experiencing decrease in farming earnings and the related decline in the profits of the similar industries will impact negatively on personal income. The decrease in personal income will unavoidably lead to lower individual expenditure. During the time of drought business losses and investment costs for industrial/commercial firms; revenue weaken and emergency costs for water supply goes up (Ding, 2010).

The use of indices is an attempt to quantify and capture drought severity on the landscape through assimilation of data on rainfall, snowpack, streamflow and other water supply indicators into a comprehensible numerical value (Sivakumar *et al.*, 2011). Most decision makers usually use one or more indices prior to making decisions (Sivakumar *et al.*, 2011). Reconnaissance Drought Index (RDI) is a meteorological drought index that measures drought severity which is based on cumulative values of both precipitation and potential evapotranspiration. This condition of combining both precipitation and potential evapotranspiration serves as an advantage over other indices that rely on only precipitation such as the standardised precipitation index (SPI) (Tsakiris and Vangelis, 2005). RDI is calculated in three expressions, initial (a_0), normalised and standardised values (Tsakiris, Tigkas and Vangelis, 2015). Furthermore, the inclusion of the potential evapotranspiration PET in the calculation can be very sensitive to climate variability (Zehtabian, Karimi, Fard, Mirdashtvan and Khosravi, 2013). The Potential Evapotranspiration (ET_0/PET) is estimated from a number of equations such as Thornthwaite, Hargreaves and Blaney-Criddle methods. In this study the Thornthwaite equation was used since it only uses temperature as its input parameter. The Food and Agriculture Organisation (FAO) has adopted the globally accepted Penman-Monteith method as a global standard for estimating the Potential Evapotranspiration (ET_0/PET). However, this approached needs a number of parameters such as temperature, wind speed, radiation and relative humility which make computation quite complex and costly (Shahidian *et al.*, 2012). To help reduce the complexities of the method, one of the temperature-based methods for calculation potential evapotranspiration is depicted below. Similarly, Hargreaves and Samani developed a temperature-based method whose input parameter is only temperature (Shahidian *et al.* 2012). This is the equation that this researcher used in calculating the (ET_0/PET) in the (RDI). The following equations depict the commonly used temperature-based methods, namely Thornthwaite and Hargreaves, and Samani respectively. According to Zehtabian *et al*. (2013) both SPI and RDI indices are classified as shown in the Table 3 below. The current study therefore used RDI-6,9 12 to quantify and characterise hydrogeological drought events in the study area.

Table 3. Classes of SPI and RDI

SPI and RDI value class	
Special wet	>2
Extremely wet	1.6-2
Severely wet	1.3-1.6
Medium wet	0.8-1.3
Small wet	0.5-0.8
Normal	-0.5-0.5
Small drought	-0.8- -0.5
Medium drought	-1.3- -0.8
Severe drought	-1.6- -1.3
Extreme drought	-2.0 - -1.6
Special drought	< -2

Source: Zehtabian *et al.*, 2013

MATERIALS AND METHODS

This study followed a quantitative method research design where a researcher relies on numeric data in testing relationships between variables (Creswell *et al.*, 2007). The above authors assert that the researcher also relates the variables to determine the magnitude and frequency of relationships. Moreover, the ultimate goal for quantitative research is to describe the trends, if any exist, or explain relationships between or amongst variables. This study used the positivist research paradigm. Positivism is defined as quantitative research methods, such as surveys, structured questionnaires and official statistics due to their good reliability, validity and representativeness of the populations (Wilson, 2010).

Data collection and possessing

Trevor (1993) and Cheng and Phillips (2014) define desk research as the collection and extraction of secondary data from various source documents. According to these authors, some of the advantages of this type of research are as follows: data are already in existence, access time is relatively short and data are generally less expensive to acquire. Data for this study was collected Mejametalana station situated in Maseru, Lesotho. The data collection was mainly focused on monthly precipitation and temperature data from the past 41 years (1977-2017) over all the identified weather stations with complete available data in Lesotho. The Lesotho Meteorological Services and Water Affairs are the responsible government departments for the keeping of meteorological and stream flow data in Lesotho respectively. Therefore, the two sets of data (precipitation and temperature) were collected from the Lesotho Meteorological Services and Water Affairs.

All stations from which data was completely missing were exempted from participation in the study. However, the missing values were filled by the Expectation Maximum (EM). Expectation Maximum (EM) is defined as a statistical algorithm suitable when there are missing or hidden values in the data sets (Hauskrecht, 2017). Borman (2006) adds that EM is a popular tool used in statistical estimation problems that involve incomplete data. Similarly, Chuong and Serafim (2008) refer to EM as an algorithm that enables parameter estimation in probabilistic models with incomplete data. Prior to missing values estimation, data collected form LMS and Water Affairs were compared for quality, reliability and validity. The EM was therefore used in the study. Both monthly values of temperature and precipitation were entered into an IBM SPSS v. 24 where the EM algorithm was applied to estimate all missing values in the data sets. The three complete data sets were then subjected to outliers' detection aided by the IBM SPSS v24 program. Prior to any climatological data analysis, data sets must be tested for homogeneity.

RESULTS AND DISCUSSION

RDI-6, 9 and 12 are associated with hydrological drought events which results in lack of water from the reservoirs, dams, streams and underground. Figure 1 below shows a plot of RDI-6 of the study area where Mann-Kendall's p-value = 2.65×10^{-8} which less than the significance level of 0.05. This situation indicates a threatening condition for the textile and manufacturing industry and community members' livelihood means. On RDI-6, the most extreme drought happened in 1994.

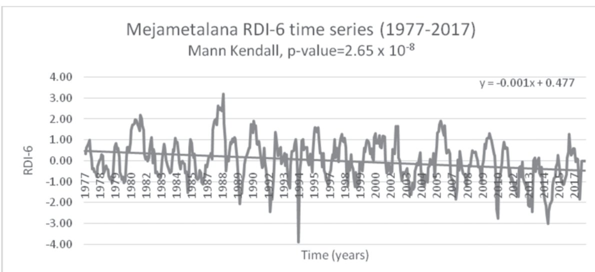

Fig. 1. Mejametalana RDI-6 time series (1977-2017)

Similarly, Figures 2 and 3 show statistically decreasing values of RDI that implies severe to extreme drought episodes to come in the near future. The M.K trend analysis shows both p-values less than 0.05 significance level. Decreasing values of RDI indicate intensifying conditions of drought events. According to the results shown in figures 2 and 3, 2014/15 had the most extreme drought events than all other years in the selected time steps. This concurs with what is documented in literature about drought disaster that occurred in both Lesotho and South Africa in 2014/15. These results show how accurate current study results are.

Figures 4, 5 and 6 show the graphs of RDI-6, 9 and 12's spectral analysis indicating peak frequencies generated by simple periodogram. Each peak frequency is reciprocated to determine the period in time domain then divided by 12 to get the number of months to elapse before the next circle. From the three figures, the time period in years was found to range between 3 and 7 years. These circles coincide with the periodicity of the El Niño-Southern Oscillation (ENSO).

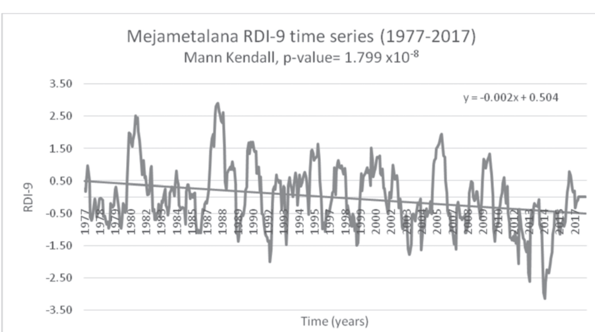

Fig. 2. Mejametalana RDI-9 time series (1977-2017)

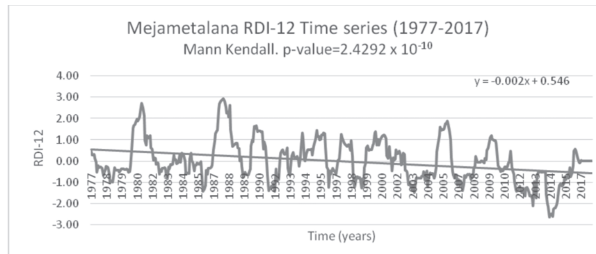

Fig. 3. Mejametalana RDI-12 time series (1977-2017)

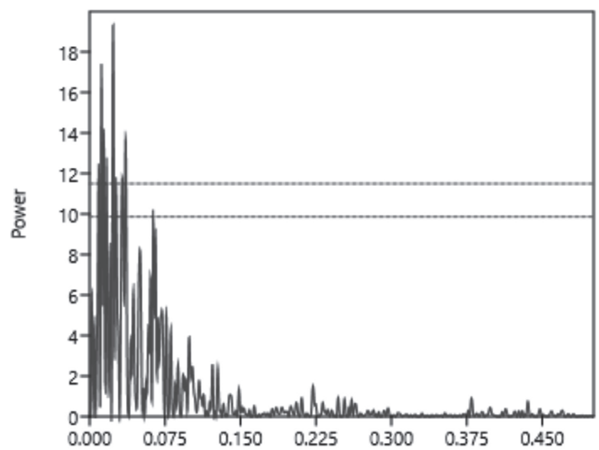

Fig. 4. Spectral analysis RDI-6 (peak frequency = 0.02342)

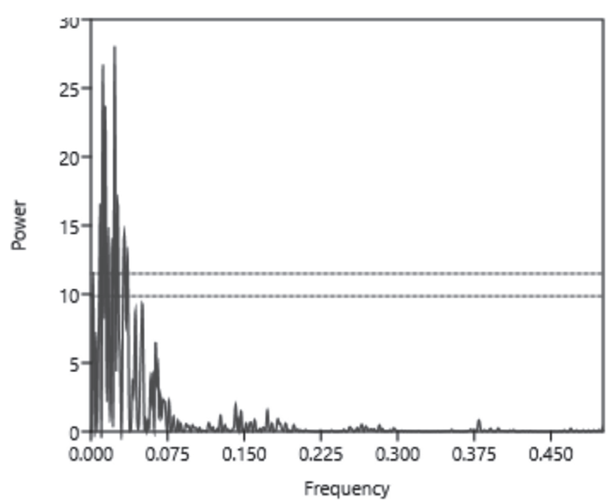

Fig. 5. Spectral analysis RDI-9 (peak frequency = 0.02317)

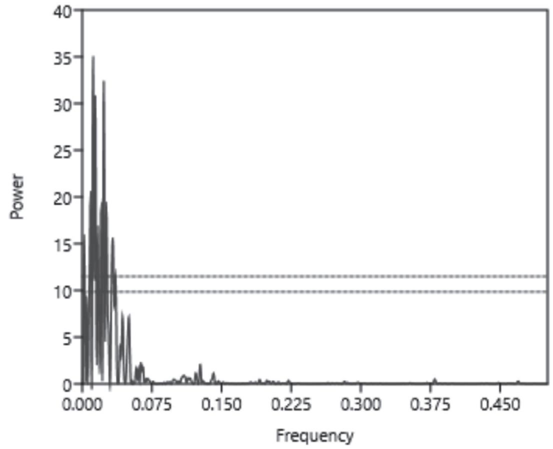

Fig. 6. Spectral analysis RDI-12 (peak frequency = 0.01171)

CONCLUSION

Although Lesotho is a water rich country, this industry uses large amounts of water and has put increased pressure on this major natural resource. In order to assist regulate and effectively manage water usage in the Lesotho textile industry, the current study develops an early warning system to keep this industry in business during the current rapidly changing climate regime. The study used both monthly average precipitation and temperature to compute a water balance standardised precipitation drought index (RDI) on 6,9 and 12-time scales obtained from Lesotho Meteorological Services. Expectation Maximum (EM) algorithm was used in replacing the missing values of both data sets. DrinC software was used in computing SPI values. Results revealed statistically decreasing Mann Kendall' trend on all RDI-6, 9 and 12-time scales. This implied a situation where the study area is moving into hydrological drought events. The spectral analysis revealed return periods of 3 to 7 years on all the three selected scales. This implied Lesotho drought is driven by El Nina events whose cyclicity is 3 to 7 years. With these results, the study area is expected to be in drought in 2019. The industry is therefore expected to use water sparingly during the expected drought events. The study warns all water users and the government to use water with caution as RDI is significantly getting negative. Measures such as water restrictions and rationing are therefore encouraged as the study area in its second year after the 2015/16 drought disaster.

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