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Forecasting as a Framework for Reducing Food Waste in Ethiopian University Canteens

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ABSTRACT

This paper uses forecasting model to prevent over production of uneaten food in student's cafeteria in Woldia University (Ethiopia). Students arrival in the university is highly variable. And it is difficult for the canteen management to estimate the number of students attend the meal during first two weeks of operation. The moving average and exponential smoothing forecasting methods were used to forecast the student's arrival for the year 2019. Mean Absolute Deviation (MAD) was used as a measure of forecasting accuracy. Finally, it is found that moving average were more accurate forecasting method than exponential smoothing for forecasting student's arrival in Woldia University.

1. Introduction

Ethiopia is one of the fastest growing economy in the world. Education is a powerful tool for social, political and economic development of a country. In 2004/2015, the number of public higher education institution in the country increased from 8 to 36, distributed across the region of the country. Overall students enrolled estimated to be more than 500,000 [1]. However, as university canteens are main sources of food wastes, the growing of higher education institution in Ethiopia results in higher food waste accumulation near the university. This contributes to greenhouse emission to the environment. Mostly, universities call the assigned students to be registered by present in the campus upon the university completed its preparation to accept students. However, it takes at least two weeks from the start of registration to the start of normal class. Although, some students can be registered by their friends. This makes the students to arrive in the campus at different point of time within the first two weeks. As a result, it is hard for the canteen management to estimate the number of students attend the meal within the first two weeks. The aim of this paper is to investigate the effect of the student's arrival on the operation of Ethiopian university canteens.

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2. Problem Statement

From observation, it is clear that higher amount of food waste is generated from Ethiopian university canteens. Mostly, the generated food wastes are going to landfill and this contributes to environmental pollution [2]. However, sometimes the food waste forms the university canteens could be used for generating electricity but very rare. Waste minimization or reduction at source is the most desirable activity, because it does not incur expenditure for waste handling, recycling, and disposal of waste that is never created and delivered to waste management system [3]. Producing food that is not consumed has environmental impacts and costs money. Hence, according to the European Waste Framework Directive food waste prevention and management options are priorities in the waste action hierarchy [4]. Therefore, it is essential to propose a working framework for university canteens in Ethiopia to avoid food waste. This paper uses forecasting models to reduce food waste in student's cafeteria.

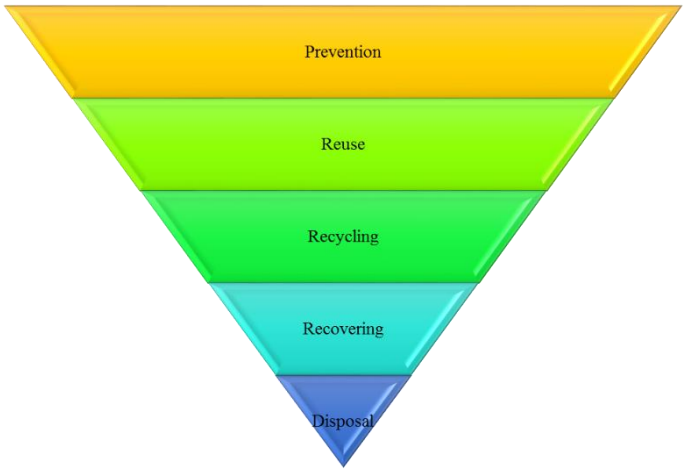

Fig. 1. *Pyramid of food waste hierarchy.*

3. Forecasting

Forecasting is the art and science of the prediction of future events [5]. Forecasting problems are classified as short, medium, and long-term forecast. Short-term forecast involves only a few time periods such as days, weeks, and months into the future. Medium forecasts extend to 1 or 2 years into the future and long-term forecasting extend beyond that by many years into the future. Generally, there are two types of forecasting techniques that are most often used in practice. Quantitative techniques which are solely based on expert's opinion, and qualitative techniques that includes causal method such as regression analysis and time series or trend analysis [6].

Song and Li [7], stated that causal and time series methods remain the most popular forecasting methods and a combination of these approaches is being used increasingly, but add that new quantitative approaches have surfaced over the past few years. These include artificial neural networks, the rough set approach, fuzzy time series methods and genetic algorithms that can all be classified under artificial intelligence methods.

4. Methodology

Fresh and senior students enter into the campus at different point of time. Mostly, senior students called for registration prior to fresh students. For that reason, student's arrival data for fresh and senior students will be presented separately.

4.1. Data Collection

Fresh and senior student's arrival for the past 8-year operation of the university is collected from Woldia university student's cafeteria. However, as the capacity of the university increases continuously with time, the primary data collected from the cafeteria changed into percentage as shown in appendix 1. And then the percentage of student's arrival data for the first week from the start of registration date is changed by multiplying the current capacity of the university as presented in Tables 1 and 2.

Table 1. *Annually senior student's arrival data from 2012 to 2018.*

Year Day	2012	2013	2014	2015	2016	2017	2018
1	*4000*	*3405*	*2085*	*1900*	*4500*	*3215*	*3100*
2	*200*	*900*	*355*	*1100*	*310*	*850*	*900*
3	*1200*	*820*	*2410*	*340*	*1200*	*700*	*1250*
4	*805*	*950*	*1830*	*1595*	*335*	*1100*	*1300*
5	*130*	*110*	*87*	*60*	*30*	*170*	*35*
6	*185*	*230*	*95*	*430*	*20*	*665*	*70*
7	*415*	*520*	*73*	*1510*	*540*	*235*	*280*

Table 2. *Annually fresh student's arrival data from 2012 to 2018.*

Year Day	2012	2013	2014	2015	2016	2017	2018
1	*355*	*718*	*285*	*548*	*495*	*396*	*565*
2	*1250*	*275*	*1099*	*1032*	*874*	*1450*	*890*
3	*855*	*670*	*1030*	*884*	*1340*	*1150*	*1235*
4	*670*	*460*	*806*	*455*	*1170*	*540*	*200*
5	*156*	*170*	*75*	*70*	*26*	*85*	*105*
6	*862*	*802*	*408*	*800*	*203*	*467*	*807*
7	*347*	*1400*	*792*	*703*	*387*	*407*	*693*

4.2. Moving Average

A simple and most popular forecasting method is moving average method. When using average method, equal weights are given to all past observations used in computing the average [8]. When monthly data is considered, the previous 12 observations are chosen and given equal weights in determining the average [8]. Mathematically, the moving average can be expressed as follow:

$$F_t = (1/N)\sum_{i=t-N}^{t-1} D_i = (1/N)(D_{t-1} + D_{t-2} + \cdots + D_{t-N}) \quad (1)$$

Where, F_t is the forecast value for period t, N is the number of observations, and D_t is the actual demand for period t.

In our case, the eighth moving average forecast for 2019 were calculated for student's arrival of the first week.

Senior students arrival Forecast 2019 for Day-1: $F_8 = \frac{4000+3405+2085+1900+4500+3215+3100}{7} = 3172.1$.
Fresh students arrival Forecast 2019 for Day-1: $F_8 = \frac{355+718+285+548+495+396+565}{7} = 480.3$.

4.3. Exponential Smoothing

Exponential smoothing is also using average of the data, it assigns different weights to past observations used in forecasting a time series, unlike moving average methods. As such, these methods adjust the smoothing coefficients and reduce the fluctuations caused by the irregular component in the time series under consideration [8]. In general, the weights show an exponential decay and observations closer to the forecasting period therefore carry a greater weight [9].

$$F_t = \alpha D_{t-1} + (1-\alpha)F_{t-1} \tag{2}$$

Where, F_t is the forecast value of the next period, $0 < \alpha \leq 1$ is smoothing constant, D_{t-1} is current observation of demand, and F_{t-1} is the last forecast. We have calculated the forecast for 2019 by using smoothing constant of 0.9.

3.4. Measuring Error

Forecast error is the difference between the forecast value and the actual value for the same period. Given forecasting error over n periods the two common forecasting methods are Mean Absolute Deviation (MAD) and Mean Square Error (MSE). The formulas are given below:

$$e_t = F_t - D_t \tag{3}$$

$$MAD = \left(1/n\right)\sum_{i=1}^{n}|e_i| \tag{4}$$

$$MSE = \left(1/n\right)\sum_{i=1}^{n} e_i^2 \tag{5}$$

Table 3. *Forecast of senior student's arrival for 2019.*

Day	Actual value (2019)	MA (8)	$\|Error\|$	ES (0.9)	|Error|
1	*2,900*	*3172*	*272*	*3122*	*222*
2	*530*	*659*	*129*	*890*	*360*
3	*1420*	*1131*	*289*	*1199*	*221*
4	*1150*	*1131*	*19*	*1274*	*124*
5	*0*	*89*	*89*	*47*	*47*
6	*130*	*242*	*112*	*123*	*7*
7	*805*	*510*	*295*	*279*	*526*

Table 4. *Forecast of fresh student's arrival for 2019.*

Day	Actual value (2019)	MA (8)	|Error|	ES (α=0.9)	|Error|
1	*505*	*480*	*25*	*549*	*44*
2	*1060*	*982*	*78*	*940*	*119*
3	*1350*	*1023*	*327*	*1228*	*122*
4	*550*	*614*	*64*	*240*	*310*
5	*15*	*98*	*83*	*102*	*87*
6	*585*	*621*	*36*	*771*	*186*
7	*430*	*676*	*276*	*665*	*235*

The MAD value of eighth period moving average is 172.1 and 127 for senior and fresh students forecast respectively. The respective MAD value for exponential smoothing are 215.3 and 157.6. from this, we can conclude that moving average forecasting is more accurate over exponential smoothing method to forecast student's arrival in the campus each year for smooth operation of Woldia University student's cafeteria during the first week of education start. The comparison of the results and the actual demand data for the year 2019 are shown in the graph below.

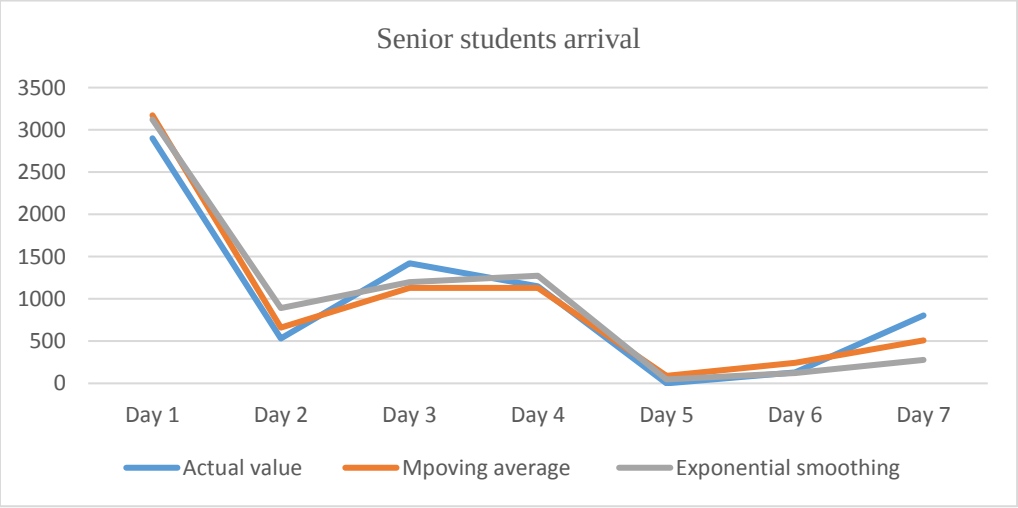

Fig. 2. *Comparison of senior student's arrival actual and forecasted value.*

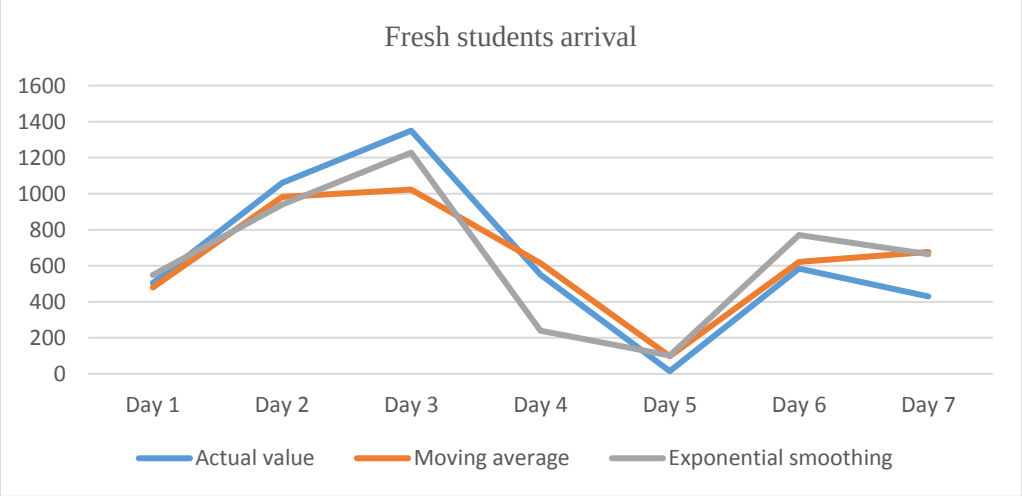

Fig. 3. *Comparison of fresh student's arrival actual and forecasted value.*

5. Conclusion

This study uses moving average and exponential smoothing forecasting with smoothing constant of 0.9 for forecasting senior and fresh student's arrival for the year 2019. Students arrival data from 2012 to 2019 were collected from Woldia University student's cafeteria. The average of absolute errors MAD for moving average is 172.1 and 127 for senior and fresh students respectively. And 215.3 and 157.6 for exponential smoothing. Therefore, it is concluded that eighth moving average is superior than exponential smoothing (α=0.9) for forecasting student's arrival in Woldia University to prevent over production of uneaten food which affect the environment.

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Appendix 1: Percentage of student's arrival data

Table I. *Annually senior student's arrival data from 2012 to 2018*.

No	2012 (%)	2013 (%)	2014 (%)	2015 (%)	2016 (%)	2017 (%)	2018 (%)
1	*57.6*	*49*	*30*	*27.4*	*64.9*	*46.4*	*44.7*
2	*2.9*	*13*	*5.1*	*15.9*	*4.5*	*12.3*	*13*
3	*17.3*	*12*	*35*	*4.9*	*17.3*	*10*	*18*
4	*11.6*	*13.7*	*26.3*	*23*	*4.8*	*15.9*	*18.7*
5	*1.9*	*1.6*	*1.3*	*0.9*	*0.4*	*2.4*	*0.5*
6	*2.7*	*3.3*	*1.4*	*6.2*	*0.3*	*9.6*	*1.0*
7	*6*	*7.5*	*1.0*	*21.8*	*7.8*	*3.4*	*4.0*

Table II. *Annually fresh student's arrival data from 2012 to 2018*.

No	2012 (%)	2013 (%)	2014 (%)	2015 (%)	2016 (%)	2017 (%)	2018 (%)
1	*7.9*	*16*	*6.3*	*12.2*	*11*	*8.8*	*12.6*
2	*27.8*	*6.1*	*24.4*	*23*	*19.4*	*32.2*	*19.8*
3	*19*	*14.9*	*22.9*	*19.7*	*29.8*	*25.6*	*27.5*
4	*14.9*	*10.2*	*17.9*	*10.1*	*26*	*12*	*4.4*
5	*3.4*	*3.8*	*1.7*	*1.5*	*0.6*	*1.9*	*2.3*
6	*19.1*	*17.8*	*9.0*	*17.8*	*4.5*	*10.4*	*0*
7	*7.7*	*31.1*	*17.6*	*15.6*	*8.6*	*9*	*0*