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Editorial

Remember: The Water

Dr. Morena Galesic, researcher in water resources management and water pollution risk assessment at the University of Split, Faculty of Civil Engineering, Architecture and Geodesy, Croatia.

As obvious as it would seem, water may be one of the essential ingredients in sustainable food systems, or in most living systems, for that matter. Innumerous books, papers, models, programs, and all the possible communication tools debate water, whether from the physical or managerial point of view, considering both technical and scientific literature (1,2,3). Yet, the water still gets taken for granted all too often. In the areas affected by water scarcity, people are dangerously aware (4), while in water-rich areas, scientists, engineers, and managers might be aware, thereby working on a lot of these issues. However, is it enough? This issue often gets dismissed in one's mind almost as the multiple charity advertisements pop up on the screens, so maybe it is time to look beyond technical, beyond managerial: what if humanity has to embrace back the personal connection with water? (5) What if all people have to go through this rebirth of an old but almost forgotten respect for water (6)?

What is the reason that water gets dismissed so easily? it the simplicity of it? Just a small chemical compound of two hydrogen atoms and one oxygen atom, i.e. H2O? Or its availability? Is it the tendency of human nature to act only when their comfort is endangered?

One inevitable fact is that the amount of clean water is seriously decreased as a by-product of the Anthropocene in which we live, as clearly shown by the world atlas of desertification (7). Basic human needs for clean water and nutritious food make the agricultural industry a priority in the water distribution scheme. On the other side, agrarian water usage creates significant pressure on water resources and asks for optimised strategies and careful monitoring of water usage (8, 9). Besides anthropological use of water, one needs to consider the interconnectivity between natural ecosystems and human existence,

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where vital ecosystem services (10) depend on quality water availability.

The "water usage pathology" gets even more pronounced in the case of different crises, whether generated by some local issues (pollution exposure, mismanagement, etc.) or global problems such as pandemics or climate change. When a crisis occurs, the most vulnerable systems (e.g., smallholder or family farms) get crashed, causing local economic imbalance, which then pours into the rest of the social structure, engaging a vicious cycle. Unfortunately, there are millions of people living in almost constant water crisis (4).

The importance of water has been recognised by the United Nations (UN) and covered directly by the sustainable development goal (SDG) number six (Clean water and sanitation) and indirectly through multiple other SDGs (11). Moreover, Agenda 2030's analysis disclosed that SDG 6 is where most technical issues are solved, but they lack the implementation on a larger scale (12).

The implementation of technical solutions needs a social and political structure to succeed, while such structures stem in turn from every person's willpower. The mere number of publications on all water-related issues highlights the fact that there is an obvious mismatch between attitude toward the water and a common sense for people's wellbeing.

Therefore, it is worthy of poking our detached minds, once again, and let us remember the water and practice more gratitude for that elemental force.

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Research Paper

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The impact of corruption on food security from a macro perspective

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Food Security; Corruption; Panel Data.

Despite the positive developments in recent years, food security is a common problem of all humanity. In order to eliminate this problem, different initiatives are conducted within the fields of political and international relations. Moreover, to be able to analyze the dynamics of this problem and determine the policies to be implemented, prospective research and academic studies are carried. This study aims to elucidate the corrupt policies negatively influencing food security in a macroeconomic framework by examining the variables including unemployment, dependent population, and per capita income. To be able to realize that, panel data of 75 countries obtained between the years 2012-2016 have been analysed using Driscoll and Kraay Method. According to the obtained results, corruption, although minor, has an impact on food security. Thus, in order to realize food security the following actions need to be taken: minimizing bureaucracy; increasing interaction with the public power for the sake of activities that would support good governance of the society and non-governmental organizations; minimizing the human factor by using technological innovations more effectively in public services and; putting the deterrent laws that would eliminate favouritism into effect.

1. Introduction

Despite the positive developments on the global decrease in famine, it is estimated that one in every nine person is impoverished (Helal, 2016). Thus, food security continues to be a global problem. In order to cope with this global problem, the UN takes important initiatives. Food and Agriculture Organization of the United Nations (FAO), has undertaken different tasks since its foundation in 1945. The Food Security Action Plan was implemented in 1979. In order to attract attention on the issue, the 16th of October is celebrated as World Food Day.

Globalization enhances mutual interaction in matters of food and agriculture as it does in many other fields. International trade might balance the inequalities of food supply and demand in different geographical regions. This might help achieve security in food supply to a certain extent. However, the pricing policies and incentives applied by developed countries may influence the markets of developing countries (Godfray *et al.,* 2010). Other than the mutual interaction that stemmed from globalisation, the inner dynamics of countries may also influence food security. Despite the overall increase of food production worldwide, food security is negatively influenced by natural disasters, economic crises, and conflicts. Moreover, rural poverty and corruption emerges as another important factor (Escobar *et al.,* 2009). The basic need of macro environments on food security, just like the needs in economic development, is righteousness in public government and avoidance of corruption (Tweeten, 1999).

The basic rule for achieving sustainable food security is keeping public needs aloof from changing interests of political power (Mwaniki, 2006). It is an unalienable fact that political stability and the law system are infected with widespread corruption in those countries with the lowest food security (FAO, 2005). When political power avoids transparency and accountability and corruption occurs, the food security of the country also suffers. Moving from this point, the present study aims at analysing the relationship between food security and corruption from a macro perspective. The analysis will include socio-economic factors for pioneering further studies in the field of food security.

2. The relationship between food security and corruption

In their 63rd meeting held in July 1974 after the food crisis in 1970s, FAO has ratified the "International Convention on World Food Security". This convention underlines that food security is a common problem of all nations and cooperation is necessary in this field. In this meeting food security was defined with particular attention paid to the food supply. Accordingly, food security is availability of sufficient, safe, and nutritious food at all times preventing fluctuation in production, consumption, and prices (Shaw, 2007). In the Rome summit in November 1996, FAO has defined food security as when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food which meets their dietary needs and food preferences for an active and healthy life (Lenné, 2011). Those definitions have been extensively used in the field(s) of food security. However, food security is a complex phenomenon influenced by many factors and occurs in different physical conditions (Stringer, 2016). This fact is elucidated in Figure 1, which shows the global, national, household, and individual dimensions of food security. Food production, trade, and household income, the main determinants of food security, have been extensively affected by macroeconomic conditions and policies. Here, the government policies in ensuring food security play crucial roles.

As an indicator of good governance corruption might influence food security from a macro perspective. Corruption highlights the gap between the rich and the poor. The efforts of national and international bodies that combat famine and hunger might be distracted by corruption. For instance, it is stated that a sum of 9 million British Pounds given to Kashipur region of India to International Agricultural Development Fund from 1977 to 1988 was exploited through systematic corruption (Uchendu & Abolarin, 2015). In the year 2001 Malawi government has sold an important amount of strategical grain reserved to cover an international balances deficit and the people who bought the said grains resold it in the domestic market with 500% profit. Due to this and similar examples, one of the important issues in Malawi about food security is corruption (Drimie & Mini, 2003). In addition to above quoted samples concerning the direct impact of corruption on food security, there are many other ways in which corruption may indirectly affect food security. This impact might be felt as a decrease in national and per capita income. Figure 1 shows household income affects food security. In many Asian countries, high economic growth reduces poverty and increases food security (Timmer, 2005).

There are studies that establish a relationship between economic growth and corruption. While corruption is accepted as a negative concept for economy in general others emphasize its positive impacts. Mauro (1995), Tanzi (1998), Mo (2001), Semenescu (2008), Dridi (2013), and similar studies assert that corruption decreases investments as it disturbs efficient deployment of resources and thus decreases GDP. However, Leff (1964) asserts that the negative results of rigid and inefficient implementations of public administration might be stretched by corruption and economic growth might be supported. This is called "speed money" or "greasing the wheel". Bayley (1966), Wedeman (1997), Acemoğlu and Verdier (1998), Wei (2000), and Swaleheen (2011) present empirical evidence on the positive relationship between corruption and economic growth.

While corruption might positively and indirectly influence food security as it produces "speed money" or "greasing the wheel" effects, it might also adversely influence food security if it has produced an effect that leads to decreasing economic growth. It might also be asserted that corruption directly reduces food security, as well.

3. Literature

The studies on corruption and food security are very

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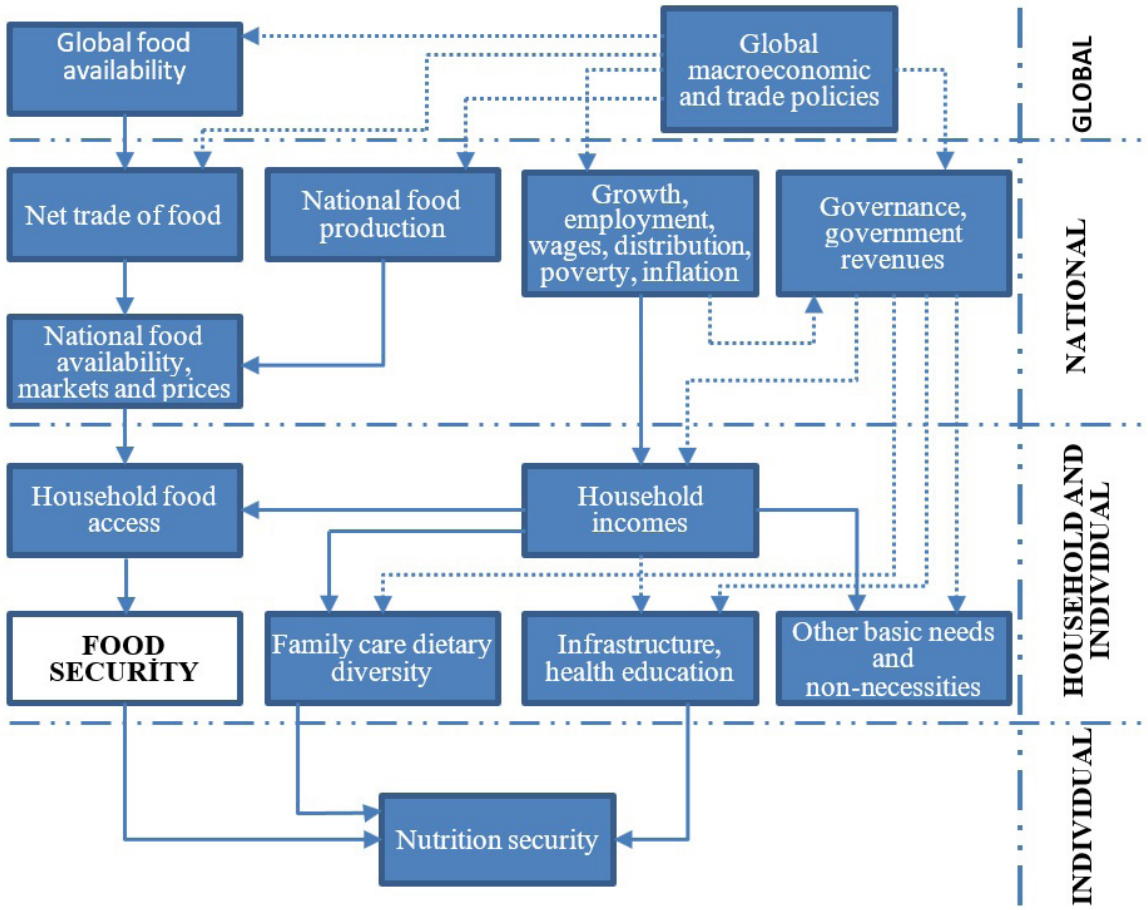

Figure 1. Food Security and Macroeconomic Policies (Eugenio, 2015)

limited. The main reason for this rests on the fact that the studies on food security are micro-level studies. In the studied literature a large number of survey studies focusing on a region, city, or group have been observed. Among the studies focusing on household food security, one might include Zezza and Tasciotti (2010), Sinyolo *et. al.* (2014), Brugh *et. al.* (2018), Dzanku (2019). Most of the mentioned studies were carried out on Africa and other underdeveloped countries. Similar studies on nations of different scales are very rare. For instance, Kirkpatrick and Tarasuk (2010) studied Canada, Coleman et. al (2014) studied the USA, Alexandri *et. al.* (2015) studied Romania, Zhou *et. al.* (2017) studied Pakistan in relation to food security.

Compared to household food security based studies the number of macro-level food security is very low. Those macro studies on African countries also cover a large portion of the work undertaken. Kirkpatrick and Dimitris (1985) studied food security and exchange restrictions in Sub-Saharan Africa. The authors assert that regulated income flow contributes to food security rather than policies based on foreign exchange restrictions. Arouna *et. al.* (2017) and Devereux (2016) have also studied the macro dimensions of food security on Africa. Etana and Tolossa (2017) have studied how a macro-scale problem like unemployment threatened food security in Ethiopia using a micro-based approach through surveys applied to household population. The researchers present evidence suggesting that households successfully partaking in labour market contribute to increasing food security.

These macro-scale studies investigate a rich variety of subjects alongside food security. Santangelo (2018) puts forth that using agricultural zones for direct foreign investments in developing countries endangers the food security of the country. Koizumi (2013) investigates the influence of biodiesel production on food security in China and Japan. The researchers have revealed that food security in China was under the threat of biodiesel production yet the impact was not high. Naylor et. al (2018), in support of Koizumi (2013), asserts that there is only a very minor relationship between biodiesel production and food se-

curity in literature. Liefert (2004) investigated Russia's economic growth and food security risks. The author states that economic growth in Russia decreases food security risk. Koç *et. al.* (2017), tried to determine the socio-economic determiners of food security in 18 MENA countries in their study and found out that price increases and inadequate water management led to a decrease of food security. Oke (2015), in their Nigerian sampling, assert that the decrease in food security related to price increases was influenced by high production costs, high exchange rates, and growing population size. Yu and You (2013) have grouped the production, consumption, distribution, import, and agricultural potential indicators of 175 countries according to food security criteria. The researchers, as a result of their study, assert that the concept of developing countries is not too inclusive in terms of food security.

Another problem analysed from the macro perspective is the relationship of corruption and food security. Helal *et. al.* (2016), who used Gallup 2014 world survey and Food Security Experience Scale of Food and Agriculture Organization in their study, assert that corruption and food security are inversely related. Anik *et. al.* (2013), in their micro-scale study using questionnaire method, conclude that corruption at the farm level decreases food security in Bangladesh. Moreover, they state that the impact is felt intensely by low-income groups. Uchendu and Abolarin (2015), tested the statistical significance between the two groups they have identified as least corrupt and most corrupt countries which they have selected using food security index values of 32 countries according to the values of The Global Food Security Index prepared by The Economist Intelligence Unit (The EIU) and Corruption Perceptions. As a result of their analysis, it has been asserted that food security and life expectancy increases in countries with low levels of corruption. They attribute this to the good governance practices of the public.

4. Research methodology and data

It is an undeniable fact that food security and corruption are the common problems of all humanity, and corruption, which is a socio-economic problem, adversely affects food security. The pioneering studies that have been carried out by Anik *et. al.* (2013), Uchendu and Abolarin (2015) shed light on this phenomenon. The model in Equation 1 has been formed in order to test the impact of corruption on food security. It differs from the model of Anik *et. al.* (2013), as it offers a macro perspective to the impact of corruption on food security. Moreover, the present model also includes the socio-economic control variables that have not been mentioned in the study of Uchendu and Abolarin (2015). The probable food security policies to be implemented by public authorities might be influenced by the socio-economic factors of the country. At the same time, they might help in choosing the policy to be implemented. Thus, the model in Equation 1 rests on the assumption that the socio-economic factors experienced by a country influences food security.

$$FoodSec_{it} = \beta_0 + \beta_1 Unemp_{it} + \beta_2 PopDep_{it} + \beta_3 Cor_{it} + \beta_4 GDP_{it} + u_{it} \quad (1)$$

In Equation 1, the variables Unemp, PopDep, Cor ve GDP are used to account for FoodSec variable which indicates food security. It is possible to explain these variables and the FoodSec variable which is the dependent variable of the model.

FoodSec: This variable is the dependent variable of the model and it stands for food security. This variable was constructed using the data obtained from The Global Food Security Index reports prepared by the EIU unlike the study of Helal *et. al.* (2016) (The Economist, 2018b). This index prepared by the EIU in order to define food security has been used by Uchendu and Abolarin (2015). Moreover, in the studies carried out by Scardigno *et. al.* (2017), Diaz-Bonilla *et. al.* (2014), and Chen *et. al.* (2019), the same Global Food Security Index figures defining food security have been used.. This index is accepted as the first one that evaluates affordability, availability, and quality across issues of 113 countries worldwide using 28 indicators (The Economist, 2018a). ıt is possible with this index to compare countries with reference to their food security values. The index values range between 0-100. The closer it gets to 100 the higher ranks the food security of the country in terms of the issues on debate.

Unemp: This variable shows the unemployment values of the related country during a given period of time. This variable was derived from The World Bank,

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World Development Indicators (WDI) Database. Although unemployment is generally associated with food security, few studies have been conducted on that issue. Among those are Etana and Tolossa, (2017), stating that unemployment has a negative impact on food security in African countries.
PopDep: This variable accounts for the ratio of dependent population. The mentioned variable was derived using the data from The World Bank, WDI Database and used in the model as the ratio of dependent population to total population. Pandey and Bardsley (2019) have stated that the increase in dependent population in rural areas of Nepal negatively affects food security. Adam *et. al.* (2019) emphasize a similar case in Ethiopia.

Cor: This variable stands for the perceived corruption levels of the country between given time periods. The variable was derived from The World Bank Worldwide Governance Indicators (WGI) database. The World Bank bases the data pertaining to this variable to Daniel Kaufmann and Aart Kraay methodology. This variable originally explains the power of public force in preventing corruption. The values of the variable range between 0-100. The values closer to 100 indicate the power of public force to prevent corruption. In this study, the data were reversed for ease of use. Thus, values closer to 100 would mean an increase in corruption.

GDP: This variable shows per capita income according to 2010 fixed prices. The mentioned variable was derived from The World Bank, WDI Database. Within this respect, the relationship between GDP and food security has been analyzed based on other variables. The study carried out by Manap and İsmail (2019) also states that food security has a great influence on economic growth. In a similar way, Applanaidu (2014) and Swietlik (2018) have indicated that economic growth affects food security. Thus, all these studies demonstrate that GDP and food security are interwoven and they have a positive relationship based on reciprocal basis.

The model in Equation 1 aims to test the impact of corruption on food security with the variables explained above. All data received from WDI has been used without any processing. To this end, data belonging to 75 countries for the years 2012-2016 were used. Food Security Index data prepared by the EIU has influenced our choice of the sampled period. The EIU has disclosed the Food Security Index statistics of 113 countries for the mentioned period. The other variables in the model and countries with missing values were removed from the sampling for achieving a dataset suitable for Balanced Panel Analysis.

The dataset prepared for determining the impact of corruption level on food security will be analysed using Balanced Panel Data Analysis. In order to carry out Balanced Panel Data Analysis the dataset needs to be free of heteroscedasticity, interdependence, and autocorrelation problems. Moreover, in Balanced Panel Data Analysis the pooled dataset would be analysed using suitable statistical analysis methods for determining whether Fixed Effect or Random Effect technique would be executed. These will be explained in the Results and Discussions part of the study

5. Result and discussions

Before continuing with the tests aimed at determining the stability provisions and analysis technique to be used with balanced panel data analysis, the descriptive statistics are given in Table 1.

The mean value for the FoodSec variable showing food security is 58. While this variable can reach the highest value of 89, the lowest possible is 22. Unemp variable, demonstrating the unemployment rate, points to a mean of 6%. While the value is about 5% for the lowest country, it rises to a significant value of 22% in the highest country. While the PopDep variable, indicating dependent population, has a mean of 36%, this variable varies in a margin between 26% and 52%. The fluctuation margin appears to be higher in the Cor variable, which shows corruption. This variable ranges from 0 to 98,57. The fixed per capita prices of the countries in the sampling and GDP revenue are on average 1575$.

In order to determine the suitability of panel data with the dataset, which was formed to determine the impact of corruption level on food security, heteroscedasticity, interdependence and autocorrelation problems have been tested, respectively, through Greene LR Panel Heteroscedasticity Test, Pesaran's test of Cross-Sectional Independence and Wooldridge Test

For Autocorrelation tests. The basic hypotheses related to these tests and the results of these hypotheses are presented in Table 2.

The results indicate that there are problems of heteroscedasticity, interdependence, and autocorrelation at the sampling at 5% statistical significance level. The existence of such problems at the dataset might result in inconsistencies at the coefficients of the analyses to be carried out. Thus, the Driscoll and Kraay estimator which produces estimates resistant to heteroscedasticity, interdependence, and autocorrelation problems will be used in the analysis of the model shown in Equation 1 (Han & Seneviratne, 2018). Panel data systems have complex standard errors. When these standard errors are not appropriately handled it is not possible to generate consistent and convenient estimators (Reed & Ye, 2011). Driscoll and Kraay Method, although its standard errors have an optimistic inclination, produces more consistent estima-

Table 1. Descriptive Statistics

	FoodSec	Unemp	PopDep	Cor	GDP
Mean	58.56187	6.780339	36.45107	47.64027	15875.71
Median	58.00000	5.250000	34.85300	52.40385	6562.767
Maksimum	89.50000	27.47000	52.78091	98.57820	90316.97
Minimum	22.70000	0.160000	26.44025	0.000000	218.2835
Std. Er.	17.56308	5.460087	5.747841	28.59006	20253.80

FoodSec: Food Security, Unemp: Unemployment, PopDep: Dependent Population, Cor: Corruption, GDP: Gross Domestic Product, Std. Er.: Standard Error.

Table 2. Stability Provisions and Determination of the Technique to be Used

Hypotheses	Tests	Test Statistic		Prob.*
$H_0: \beta_i = \beta$	F Test	24.2724		0,0001
$H_1: \beta_i \neq \beta$				
$H_0 : \sigma_u^2 = 0$	Breusch-Pagan Lagrange Multiplier Test	Cross-sec.	482,1	0,0001
$H_1 : \sigma_u^2 \neq 0$		Time	18,65	0,0001
		Both	500,8	0,0001
$H_0 : E(\varepsilon_{i,t}/x_{it}) = 0$	Hausman Test	27.8790		0,0001
$H_0 : E(\varepsilon_{i,t}/x_{it}) <> 0$				
$H_{0:}$ no autocorrelation	Wooldridge Test For Autocorrelation	83.717		0,0001
$H_{1:}$ autocorrelation				
$H_{0:}$ Homoscedasticity	Greene LR Panel Heteroscedasticity Test	9.49711		0,0498
$H_{1:}$ Heteroscedasticity				
$H_{0:}$ no Cross Sec*. Indep.	Pesaran's test of Cross Sectional Independence	34.145		0,0001
$H_{1:}$ Cross Sec. Indep.				

**Cross-sec.: Cross Section, Prob: Probability*

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tors compared to others especially on smaller samples with cross-sectional dependence (Hoechle, 2007).
Three different analysis models can be used in Panel Data Analysis. These are Pooled OLS, Random Effect, and Fixed Effect. The model to be used is determined after a series of analyses. While F test reveals whether Pooled OLS or Fixed Effect model would work, the Breusch-Pagan Lagrange Multiplier Test determines whether Pooled OLS or Random Effect model would produce an efficient estimator. The analysis results for both tests given on Table 2 are statistically significant at 1%. The results show that Pooled OLS model would remain ineffective against both Fixed Effect and Random Effect models. In order to make a choice between Fixed Effect and Random Effect models we need to use the Hausman Test. The results of the Hausman Test presented on Table 2 are significant at 1% thus Fixed Effect model would produce efficient and consistent estimators.

Under the light of the data obtained from Table 2, the Balanced Panel Data Model presented at Equation 1 will be analysed using both Fixed Effect model Driscoll and Kraay estimator. The analysis results obtained using Driscoll and Kraay estimator and Fixed Effect model are given on Table 3.

The analysis results presented at Table 3, the probability value of the F statistics that shows the general significance of the model indicate that the overall model is statistically significant at 1%. The Unemp variable is significant at 10% while other variables are statistically significant at 1%.

One of the independent variables, GDP has a positive relationship with FoodSec variable while other variables have an inverse relationship with FoodSec variable. While the PopDep represents the highest relationship with the independent FoodSec variable (-2,19) the variable with the lowest impact is GDP variable (0,0012).

A 1% change in PopDep variable would lead to a 2.19 unit decrease at FoodSec variable. Similarly, a 1% change in GDP variable would lead to a 0,0012 unit increase at FoodSec variable. A 1% change in Unemp and Cor variables would lead to a 0,4925 and 0,095 unit decrease at FoodSec variable, respectively.

6. Conclusions

Food security is a global problem. The food crisis that took place in 1970s as a result of the agricultural structure brought about by WW1 and WW2 in addition to the effects of the world oil crisis resulted in an increasing effort to raise global awareness concerning the issue. Although these efforts contributed to finding answers to the problem, especially through food aid to vulnerable African countries, could not provide a full resolution. The widespread poverty perception of the people living in these countries raises questions about whether the aid given was received or not. Moreover, the extensive amount of corruption might contribute to low investment and low-income levels which in return threaten food security.

Developed countries experience food security problems on a different level. Although the problem is not a general one yet, it can still be considered as a problem in rural or underdeveloped regions or in the low-income group to some extent. While food aids directed to those people in need are being distributed by

Table 3. Analysis Results

Variables	Coefficient	Std. Error	Prob.
C	127,023	2,8917	0,001*
Unemp	-0,4925	0,2111	0,080**
PopDep	-2,1915	0,0654	0,001*
Cor	-0,0959	0,0151	0,003*
GDP	0,0012	0,0002	0,012*
F-statistic= 1125,8	Prob. 0.0001		

C: Constant, Unemp: Unemployment, PopDep: Dependent Population, Cor: Corruption, GDP: Gross Domestic Product, Std. Er.: Standard Error, Prob: Probability.

public officers who might hinder just and coordinated distribution for their political or personal benefits and put the food security in the country at risk. The level of income is another threat to food security. However, developed countries make strategic plans about food just like they do in the energy sector. While these plans are prepared, international food corporations might exercise political pressure which might result in losses in public welfare especially when corporate interests and public benefits are at odds.

The above mentioned factors provided the motivation for this study. The findings suggest that corruption is a phenomenon that threatens food security. The results of the study are parallel to the findings of Uchendu and Abolarin (2015), Anik *et. al.* (2013), and Helal *et. al.* (2016). An increase in the level of corruption decreases food security. However, this effect is very low compared to those of income and unemployment. After the analyses, it was determined that the most important factor for achieving food security is making people successful participants in the labour market. This complies with the results of Etana and Tolossa (2017). The results which suggest the economic growth that stems from increasing per capita income would increase food security support the claims of Liefert (2004) and Timmer (2004) about Asian countries.

Consequently, good governance that would diminish corruption should be achieved and the public structure must be transformed to be transparent and accountable. Especially, when food aids are distributed the suspicions of the philanthropists and the public need to be erased. Thus, the criteria would be previously determined and publicized and only those who meet the criteria should receive aids. If possible the records of the aids should be kept electronically and opened to the public for increased transparency and accountability. Such regulations would help diminish the direct effect of corruption on food security. For indirect effects, de bureaucratization and increasing the interaction of public force and NGOs through actions in support of good governance might be beneficial. Moreover, widespread use of technological innovations in public services and minimizing human interference in addition to active control that prevents favouritism with disincentives as measures against corruption would also positively contribute to food security.

It must be emphasized that a learning-oriented understanding would have a large effect on food security regarding the outcomes of this study on the impact of corruption on food security. People's active participation in the labour market and their success would positively contribute to food security. Therefore, especially the integration of the disadvantaged workforce to the labour market through active employment policies would positively promote to food security on a different level. In this regard, special employment services might be founded or education of labour might be foregrounded. Participation of the unemployed workforce in production would contribute to economy in general and to food security through the increase in income.

A detailed study of the direct and indirect impacts of corruption on food security from a macroeconomic perspective might be fruitful. Structural equation modelling might be used in further studies on the issue. Thus, the impact and importance of corruption on per capita income and how it influences food security can be interrogated. Furthermore, the network of relations explored in this study might be studied for sampling from developed, underdeveloped, OECD, African, MENA, and EU countries and the dynamics of the models for subgroups might be laid bare.

Conflict of interest

The author declares that there is no conflict of interest.

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Determinants of organic food purchases intention: the application of an extended theory of planned behaviour

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Keywords

Organic products; students; theory of planned behaviour; structural equations model.

This study investigated the application of the extended theory of planned behaviour (TPB) to determine Iranian students intention to purchase organic food products. The statistical population comprised all students in the field of agriculture sciences at Mohaghegh Ardabili University, Ardabil, Iran. Data were collected from 340 participants. The research instrument was a questionnaire developed through a comprehensive literature study. Content validity of the instrument was ascertained by a panel of university professors and its reliability by Cronbach's alpha. Data were analysed using SPSS v22 and LISREL8.80 software packages. The results of structural equations model (SEM) showed that the variables of attitude, subjective norms, perceived behavioural control, moral norms, health consciousness, and environmental concern could account for 86 per cent of the variance of students intention to purchase organic products. In addition, results revealed that environmental concern and health consciousness highly influenced (41 per cent) attitude towards organic food products. Based on the results recommendations are made.

1. Introduction

The application of chemical pesticides and fertilisers to crop production systems enhances crop yields and quality. However, it has devastating impacts that cannot be ignored (Ghorbani *et al.,* 2014). The main impacts of these chemicals are, among others, the resistance of pests, diseases and weeds to chemical pesticides, poisoning, severe soil degradation and erosion, water pollution, human health hazards, the occurrence of skin diseases, cancer, neural disorders, diabetes, respiratory disorders, embryo disorders and diseases, birth disorders, fertility problems, genetic disorders, and severe poisoning and environmental degradation (Bondori *et al.,* 2018a, b; Bondori *et al.,* 2019). Consumer concerns on the use of chemicals, insecticides, and pesticides, among others, in food production systems will influence markets so that demand for certain foodstuffs will be influenced. Therefore, consumer preferences, their concerns for food quality, and the demand for chemical-free foods will affect the policy and production processes of producers, including wholesalers and retailers (Ghorbani *et al.,* 2014). In recent years, interest in organic agricul-

ture in most developed and developing countries has been provoked along with the increase in public concerns over food quality and population health, as well as the degradation of natural resources (Karimy *et al.,* 2012).

Organic agriculture is a production system that ensures the health of soils, ecotourism, and people and considers environmentally friendly processes and biodiversity. This system attempts to protect the environment and improve quality in contrast to the use of inputs that have side effects (Shams & Najafabadi, 2014). Presently, approximately 69.8 million ha of arable land in the world is managed organically (Willer & Lernoud, 2019; Yazdanpanah & Forouzani, 2015). Although the production and consumption of organic foods have been more prevalent in developed countries in the past, they are now promoted and accepted more in developing countries (Voon *et al.,* 2011). Presently, almost one-third of organic food-producing lands are located in developing countries (Willer & Lernoud, 2019).

In Iran, traditional agriculture has focused on food safety for thousands of years, but following population growth and the reduction of suitable lands, pesticides and chemical fertilisers are applied to a greater extent to increase returns per unit area (Sobhani *et al.,* 2018). As a result of inattention to the principles of optimal use of chemical fertilisers and pesticides, the application of chemical hormones, and their harmful residues in crops in Iran, the country has been ranked 123rd in this regard among 180 countries of the world by the World Health Organization (Mojaradi *et al.,* 2014).

People's growing awareness of chemical inputs used for increasing crop production, the increasing rate of diseases, and environmental problems have revealed the significance of organic food production and consumption more than ever (Sobhani *et al.,* 2018). Therefore, it is of crucial importance to explore consumer willingness to use organic products in an attempt to develop production and consumption plans (Yazdanpanah & Hasheminezhad, 2016).

The practise of organic agriculture in Iran dates back to 2000 on pistachio. It was aimed to enhance the knowledge of users and farmers in order to make them aware of the harmful effects of fertilisers and pesticides that were used for crop production (Mousavi *et al.,* 2015). Presently, some crops are produced organically, including fig, date, pistachio, peanut, medicinal plants, pomegranate, rose water, saffron, and animal products, as well as date palm gardens in the centre and south of Iran that are mostly managed in accordance with the principles of organic farming (Koocheki *et al.,* 2013).

It has been documented that Iran is the leading country in Asia in producing and exporting most organic agricultural products. While there is no precise statistic of per-capita organic food consumption of Iran, because most organic products are exported (Sobhani *et al.,* 2018), domestic consumers also display willingness towards the use of organic foodstuffs. Therefore, it appears logical to study the behaviour of the target population, i.e., consumers, as an important ring of an economic system (Yazdanpanah & Hasheminezhad, 2016). Social science researchers recommend the use of the theory of planned behaviour (TPB) (Yazdanpanah *et al.,* 2015; Sobhani *et al.,* 2018) as an approach to investigate the behaviour of consumers.

TPB is a major psychological model to explain people's behaviour (Ajzen, 1991). Overall, TPB focuses on studying three factors, namely, attitude towards behaviour, subjective norms, and perceived behavioural control. According to this theory, all these factors lead an individual towards shaping specific behavioural tendencies (Ajzen, 1985). As such, internal attitudes and tendencies towards purchasing a specific product that is the least harmful to the environment and society define the willingness to purchase organic products (Yadav & Pathak, 2016a, b; Sobhani *et al.,* 2018).

Although the model has proved to be valid in forecasting behaviours (Yazdanpanah & Hasheminezhad, 2016), some researchers of different disciplines have added extra constructs to the theory to increase its robustness in behaviour prediction (Burton, 2004; Yazdanpanah & Hasheminezhad, 2016). Moral norm is one of these variables that significantly contribute to accurately comprehending an individual's intention (Kaiser & Scheuthle, 2003). Moral norms are internal moral rules or values that are provoked by self-regulating rewards and/or punishments (Arvola *et al.,* 2008). It has been considered a perceived commitment that affects both intention and behaviour. Another component that has been included in this model is environ-

mental concern. Environmentally-friendly behaviour is an influential factor in environmental conservation, and it depends on environmental awareness to a great extent (Sobhani *et al.,* 2018).

After a review of the literature, the current study included two new components – health consciousness and environmental concerns – to TPB. Environmental concerns are regarded as a component that influences the behaviour of citizens. Environmentally friendly behaviour is a useful parameter underpinning environmental conservation and is mainly dependent on people's environmental awareness (Sobhani *et al.,* 2018). Previous research reported that environmental concern can promote people's attitude towards the purchase of organic products (Yadav & Pathak, 2016; Rahminia *et al.,* 2017; Sabzehei *et al.,* 2016; Haghjou *et al.,* 2013). Power et al. (2013) revealed that organic farmers had better environmental attitudes, were more aware of the relevant problems, and exhibited a more positive attitude towards the environment than conventional farmers did. Therefore, this may imply that environmental considerations have a direct impact on producers' willingness to purchase environmentally-friendly organic products (De Leeuw *et al.,* 2015). In addition, the environmental concern can increase the willingness to purchase organic products indirectly through other components like health consciousness and moral norms (Sabzehei *et al.,* 2016; Rahimnia *et al.,* 2017).

Health awareness and consciousness can be expressed as the degree of an individual's attention to health in everyday activities, especially the extent to which students and educated people consider the health and safety of foodstuffs when they are purchasing them (Sobhani *et al.,* 2018). Research has revealed that consumers who take more care of their health exhibit more optimal attitude towards organic purchases (Michaelidou & Hassan, 2008). Furthermore, it has been documented that such consumers show more willingness to purchase organic products (Yadav & Pathak, 2016; Yazdanpanah & Hasheminezhad, 2016; Haghjou *et al.,* 2013; Michaelidou & Hassan, 2008). Therefore, health consciousness is involved as a major factor in enhancing attitude and fostering a willingness to purchase organic foodstuffs (Sobhani *et al.,* 2018).

The preceding indicates that it is essential to address students' intention to purchase organic foodstuffs for two reasons: firstly, they are supposed to gain status in society in future (e.g., as a teacher, a lawyer, a policymaker, a researcher, etc.) who can directly or indirectly have implications for the purchase of organic products; secondly, they should take responsibility for promoting the advantages of organic food. According to the theoretical framework of the research, which is based on TPB, it was hypothesised that:

H1: Students' attitudes influence their intention to purchase organic products.
H2: Students' environmental concerns influence their intention to purchase organic products.
H3: Students' subjective norms influence their intention to purchase organic products.
H4: Students' perceived behavioural control influences their intention to purchase organic products.
H5: Students' moral norms influence their intention to purchase organic products.
H6: Students' health consciousness influences their intention to purchase organic products.
H7: Students' health consciousness influences their attitude towards purchasing organic products.
H8: Students' environmental concerns influence their attitude towards purchasing organic products.

The present study aims to develop a systematic model to assess the use of the extended theory of planned behaviour (ETPB) to examine Iranian students' intention to purchase organic foodstuffs.

2. Materials and methods

2.1. Sample selection

The research was a survey conducted in a correlational descriptive design. The statistical population comprised all 2018-2019 Bachelors, Masters, and PhD students from the Faculty of Agricultural Sciences registered at Mohaghegh-e Ardabili University because a similar study has not been conducted in this area yet. The university is located in Ardabil city in the northwest of Iran. The sample size was determined to be 315, according to Morghan's table (Cochran, 1977), but it was increased to 340 individuals to increase the reliability of the results. A random stratified sampling method was used to ensure a proportional allocation to the different educational levels.

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2.2. Data collection

The research instrument was a two-section questionnaire developed through a comprehensive literature review (Sobhani *et al.,* 2018; Yadav & Pathak, 2016; Yazdanpanah *et al.,* 2015). The first section requested demographic information such as age, marital status, educational level, and residential area. The second section included 26 closed-ended items to measure six components of the research model on the five-point Likert type scale ranging from 1 (completely disagree) to 5 (completely agree). A panel of academic teachers confirmed the content validity of the questionnaire, and its reliability was estimated and confirmed by Cronbach's alpha. Also, to determine the reliability of the model, combined reliability (CR) index above 0.6 was assumed, which indicates the intensity of measurement error control in SEM. Average variance extracted (AVE) indicator shows how much of the variance of the studied component was affected by the indicator variables. MacKenzie et al. (2005) considered the value of 0.4 to be sufficient for AVE, and it should be higher than 0.5 for each component. The components and their items are presented in Table 1.

2.3. Data Analysis

Data were captured from the completed questionnaires and coded. LISREL8.80 and SPSS v.22 software packages were then used for statistical analysis, which included descriptive and inferential statistics. Descriptive statistics included frequency distribution, mean, and standard deviation. The inferential statistics included the tests of means difference and correlation coefficients using the LISREL8.80 software package. The SPSS v.22 software package was used to conduct structural equations modelling (SEM) within two approaches of confirmatory factor analysis (CFA) and path analysis to find out the effect of independent variables on the dependent variable and to test the research hypotheses (Bondori *et al.,* 2018a). When using SEM, it is necessary to analyse the model fit with the observed data. Researchers usually use goodness-of-fit indices, among which the most famous and widely used is $\chi 2$ (Ping, 2004; Bondori *et al.,* 2018). The $\chi 2$ test is sensitive to sample size so that it increases with the sample size. Consequently, it is always significant for very large samples. To adjust this test for sample size error and to enhance its reliability, it is necessary to divide it by the degree of freedom (Jöreskog & Sörbom, 1996). According to the SEM results, the ratio of $\chi 2$ to the degree of freedom is 1.82, showing the acceptability of the model (Ping, 2004). Standardised root mean squared residual (SRMR) was estimated to be 0.052. Models show very high fit if this value is <0.05 and a good fit if it is in the range of 0.05 to 0.08 (Byrne, 2013; Giles, 2002). A major index evaluated here was the root-mean-square error of approximation (RMSEA), showing acceptable, relatively good, moderate, and weak fit if its value is <0.05, 0.05-0.08, 0.08-0.1, and >0.1, respectively. This index was estimated to be 0.048 for this model, implying its acceptable fit. Other indices are NNFI (0.97), NFI (0.96), CFI (0.98), IFI (0.98), GFI (0.87), and AGFI (0.84) that show the optimal fit of a model in SEM, including path analysis if their values are close to 1 (Bondori *et al.,* 2018; Ping, 2004).

3. Results and discussion

The average age of the students was 25 years, with a standard deviation (SD) of six years. The youngest was 18, and the oldest was 41 years old. Females accounted for 51.2 per cent and males for 48.8 per cent of the participants. Furthermore, students at Bachelors, Masters, and PhD levels accounted for 59.4, 27.1, and 13.5 per cent of the participants, respectively. The results in the table reveal that 67.1 per cent of the students were residents of urban areas, and 32.9 per cent were residing in rural areas (Table 2).

3.1. Descriptive statistics

According to Table 1, mean and standard deviation were found to be M = 3.45 and SD = 1.08, respectively, for environmental concern, M = 3.27 and SD = 1.01 for attitude, M = 3.48 and SD = 1.12 for subjective norms, M = 3.61 and SD = 1.00 for moral norms, M = 3.17 and SD = 1.06 for perceived behavioural control, M = 3.84 and SD = 0.946 for health consciousness, and M = 3.72 and SD = 0.908 for intention to purchase organic food. All these means are relatively optimal.

3.2. Inferential statistics

3.2.1. Correlation of students' intention to purchase organic food

Table 1. Indices and items measured by the questionnaire

Construct	Cronbach's alpha	Combined Reliability	AVE	Items	Mean	SD
Intention	0.87	0.91	0.73	I intend to consume organic products if they are available.	3.54	0.941
				If organic products are available when I am shopping, I will prefer to purchase them.	3.73	0.952
				I prefer eating organic products.	3.67	0.900
				If organic products are good for me, I will try to buy them	3.94	0.847
					3.72	0.91
Attitude	0.90	0.92	0.67	I think that purchasing organic food is interesting.	3.29	1.06
				I think that purchasing organic food is a good idea.	3.21	1.01
				I think that purchasing organic food is important.	3.30	0.946
				I think that purchasing organic food is beneficial	3.19	1.04
				I think that purchasing organic food is wise.	3.29	1.01
				I think that purchasing organic food is favourable.	3.39	1.01
					3.27	1.01
Subjective norms	0.74	0.84	0.56	My family thinks that I should buy organic food rather than inorganic food.	3.54	1.11
				Most people I value would buy organic food rather than inorganic food.	3.59	1.05
				People I value (e.g., my teacher) think that you should buy organic food.	3.72	1.14
				My close friends, whose opinions regarding diet are important to me, think that I should buy organic food.	3.07	1.20
					3.48	1.12
Perceived behavioural control	0.83	0.89	0.66	If I wanted to, I could buy organic food instead of inorganic food	3.11	0.978
				I think it is easy for me to buy organic food.	3.00	1.06
				Purchasing or not purchasing organic food is just related to me.	3.16	1.13
				I do have adequate (economic) resources and time to buy organic food.	3.43	1.10
					3.17	1.06

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Continue Table 1. Indices and items measured by the questionnaire

Construct	Cronbach's alpha	Combined Reliability	AVE	Items	Mean	SD
Moral norms	0.71	0.87	0.78	Consuming organic food rather than inorganic food makes me feel like a better person.	3.56	1.06
				If I consume organic food rather than inorganic food, I will feel as if I am making a personal contribution to something better.	3.67	0.945
					3.61	1.00
Environmental concern	0.80	0.85	0.65	The balance of nature cycle is critical and may be disrupted even with a small mistake.	3.51	1.08
				To survive, mankind should protect the balance and life of nature.	3.51	1.05
				Mankind misuses the environment severely.	3.34	1.11
					3.45	1.08
Health consciousness	0.75	0.86	0.67	I am careful in choosing food to ensure my health.	4.03	0.848
				I think that I am an informed consumer about health aspects.	3.80	1.01
				I usually think about health-related issues.	3.69	0.981
					3.84	0.946

Scale: 1=completely disagree to 5=completely agree, AVE: Average variance extracted; SD: Standard deviation
Source: (Yazdanpanah & Hasheminezhad, 2016; Yazdanpanah & Forouzani, 2015; Yazdanpanah, M., Forouzani, M., & Hojjati, M., 2015).

Table 2. Demographic characteristics of respondents

Variable	Frequency	Percentage
Age (years) M=25, SD=6		
<20	96	28.2
20-35	208	61.2
>35	36	10.6
Sex		
Male	166	48.8
Female	174	51.2
Residential place		
Rural area	112	37.9
Urban area	228	67.1
Education level		
Bachelors	202	59.4
Masters	92	27.1
PhD	46	13.5

The results of the correlation analysis (Table 3) reveal that students' intention to purchase organic food was significant ($p < 0.01$) and had a moderate to a substantial association (Daivis, 1971) with health consciousness, environmental concern, attitude, subjective norms, perceived behavioural control, and moral norms. In addition, the studied constructs were related to each other significantly ($p< 0.01$). These findings are consistent with those of Sobhani et al. (2018), Yazdanpanah and Hasheminezhad (2016) and Yazdanpanah et al. (2015).

3.2.2. Analysis of the relationships between the constructs of the students' intention to purchase organic food

SEM was used to identify the effects on the students' intention to purchase organic food. Based on the theoretical framework of the study, path analysis was applied by the LISREL8.80 software package to analyse the relationship between the variables.

All the variables were regarded as the observed variables of the model. The results indicated that the effect of attitude on the intention to purchase organic food was significant ($\beta = 0.17$; $p < 0.01$). Vermeir and Verbeke (2008) state that attitude is a strong predictor of people's intention to use organic food. It is, therefore, necessary to have a correct understanding of the youth's attitude towards organic food in order to increase their willingness to consume it (Yazdanpanah & Hasheminezhad, 2016). Intention to use organic products was also significantly influenced by perceived behaviour control ($\beta = 0.17$, $p < 0.01$). The effect of subjective norms was also found to be significant ($\beta = 0.23$, $p < 0.01$). Subjective values and beliefs of people are the factors that dictate the display of certain behaviour by them. Accordingly, by enhancing personal and social norms within an educational context, improvements can be made in developing optimal behaviours by students such as improving their nutrition. Therefore, hypotheses 1, 3 and 4 are accepted. These findings corroborate those of Tarkiainen and Sundqvist (2005), Chen, (2007), Vermeir and Verbeke

Table 3. Correlation of the constructs of factors influencing students' intention to purchase organic food

Variable	Intention	Attitude	Subjective norms	Moral norms	Perceived behavioural control	Environmental concern	Health consciousness
Intention	-	-					
Attitude	0.618**	-					
Subjective norms	0.663**	0.466**	-				
Moral norms	0.543**	0.378**	0.460**	-			
Perceived behavioural control	0.649**	0.483**	0.504**	0.523**	-		
Environmental concern	0.643**	0.483**	0.502**	0.429**	0.498**	-	
Health consciousness	0.619**	0.435**	0.461**	0.287**	0.451**	0.494**	-

** $p < 0.01$

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(2008), Yadav and Pathak (2016), Smith and Paladino (2010), Voon et al. (2011), Zagata (2012), Yazdanpanah and Forouzani (2015), and Paul et al. (2016).

The results for the extended TPB showed that moral norms had a significant effect on the intention to purchase organic products (β = 14). The purchase of organic foodstuffs by students provokes a better feeling about their personality and society (Sobhani *et al.,* 2018). Our finding of the effect of moral norms on motivating students to consume organic products confirms the findings of previous studies (Yazdanpanah *et al.,* 2015; Yazdanpanah & Hasheminezhad, 2016; Sandoghi & Raheli, 2017; Sobhani *et al.,* 2018; Yadav & Pathak, 2016 a, b; Arvola *et al.,* 2008; Michaelidou & Hassan, 2008). We found that environmental concerns influenced the students' intention to buy organic products significantly (β = 0.17). It has been reported that farmers who grow organic crops have a more positive attitude towards environmental conservation than those who grow conventional crops (Power *et al.,* 2013). This finding is consistent with that of De Leeuw et al. (2015) but contradicts that of Sobhani et al. (2018) and Shams and Najafabadi (2014). Given the significant role of environmental concern on the students' attitude (β = 0.40), the indirect impact of these considerations and concerns of students on their behaviour towards the purchase of organic food may be regarded to be important (Rahimnia *et al.,* 2017; Sabzehei *et al.,* 2016; Haghjou *et al.,* 2013; Sobhani *et al.,* 2018).

Among the variables included in the extended TPB, health consciousness was highly influential on the students' intention to purchase organic products (β = 0.26; $p < 0.01$). This finding implies that an individual's awareness of the benefits of organic products influences his or her intention to consume them. Previous research has also noted the specific role that this variable plays in behavioural models, such as the health beliefs model (Yazdanpanah & Hasheminezhad, 2016; Yazdanpanah *et al.,* 2015), and has asserted its role in the intention to purchase organic foodstuffs (Sobhani *et al.,* 2018). Students purchase organic food to enhance their own and their family's health; therefore, the higher their health consciousness is, the higher their intention to purchase organic products will be.

The effect of health consciousness was also significant (β = 0.31; $p < 0.01$) on the students' attitude towards organic products (Fig. 1).

According to the results of SEM, the variables of health consciousness, environmental concern, attitude, perceived behavioural control, moral norms, and subjective norms captured 86 per cent of the variance of the students' intention to purchase organic foodstuffs. Since the students' attitude towards organic products influenced their intention to consume them, it can be said that an individual's positive attitude towards organic products will enhance his/her intention to consume organic products. The results revealed that environmental concern and health consciousness were highly (41 per cent) influential on students' intention to consume organic foods (Table 4).

4. Conclusion and recommendations

The purpose of this study was to investigate Iranian students' desire to purchase organic food products. Overall, the results show that the theory of planned behaviour model was an appropriate model for investigating the factors influencing the willingness of students to use organic food products and had high potential predictive power. From the findings of the study, one could conclude that variables such as attitude, mental norms, perceived behaviour control, ethical norms, health motivation and environmental concern influence students' desire to purchase organic food products. Based on the results of the TPB, health motivation has the most significant impact on their willingness to consume these products. This variable also influenced the attitude of students towards purchasing organic food products.

Based on the findings of the study, a few recommendations are made. Health centres, health counselling and nutrition centres can be set up at the university to provide individual education for students to improve their knowledge and attitudes toward the benefits of organic food.

As moral norms influenced students' attitudes towards purchasing organic food products, it is recommended that organisations use this to market organic food products. As the effect of attitude on intention to purchase organic food was significant, more attempts should be made to improve attitude and institutional-

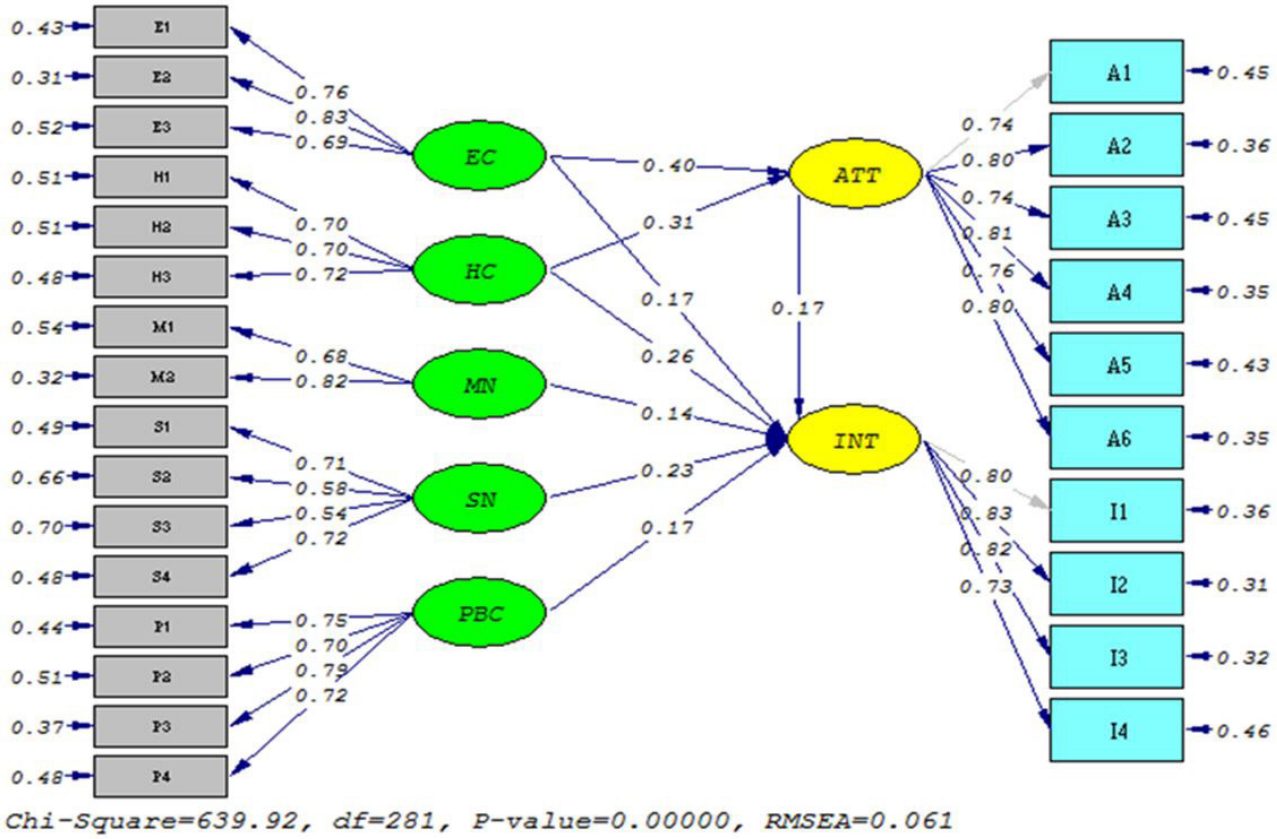

Figure 1. Path analysis model for students' intention to purchase organic food (HC = health consciousness; EC = environmental concern; SN = subjective norms; MN = moral norms; PBC = perceived behavioural control; ATT = attitude; INT = intention to purchase organic food)

Table 4. The direct effects on student's intention to purchase organic food: The application of the extended theory of planned behaviour

Dependent variable	Independent variable	Direct effect	Indirect effect	Total effect	t-value	R^2
Attitude	Environmental concern	0.40	-	0.40	4.73**	0.41
	Health consciousness	0.31	-	0.31	3.71**	
Intention	Attitude	0.17	-	0.17	3.59**	0.86
	Subjective norms	0.23	-	0.23	2.42**	
	Perceived behavioural control	0.16	-	0.16	2.77**	
	Moral norms	0.14	-	0.14	2.11**	
	Environmental concern	0.17	0.068	0.23	2.46**	
	Health consciousness	0.26	0.052	0.31	3.73**	

***p<0.01*

ise subjective concepts about the use of organic foodstuffs among students.

Since TPB showed that health consciousness was the most influential factor on students' intention and it also influenced their attitude towards the purchase of organic food, it is recommended that healthcare and nutrition consulting centres in universities provide

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general personal training to students to enhance their knowledge and attitude about the advantages of organic food.

As an individual's positive attitude towards organic product will enhance his/her intention to consume organic products, a culture of consumption of organic crops should be created among students, including the improvement of their awareness and attitudes. It is recommended to concentrate on informing and creating a positive attitude towards the consumption of organic products in training programmes through public media and universities. Furthermore, since moral norms are another component of TPB that affects students' intention to consume organic products, it is recommended that commercial organisations adopt strategies that rely on environmental friendliness in their marketing of products, thereby paving the way for increasing their consumption. Therefore, the more an individual perceives that the consumption of organic foods is a moral norm, the more he or she will show a willingness to consume them.

Since the variable of environmental concerns affects purchase behaviour indirectly, it is recommended to mention the practical benefits of organic agriculture on human life in curriculums and training courses. Furthermore, to facilitate the transit of the effect of this variable from attitude to behaviour, it is recommended to emphasise the challenges and crises of pesticide and chemical fertiliser application for the health of humans and the environment in the technical courses of universities and public media. In this way, greater awareness of environmental concerns may be developed in students.

Conflict of interest

The authors declare no conflict of interest. Furthermore, the funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; and in the decision to publish the results.

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Reaction to a low-carbon footprint food logo and other sustainable diet promotions in a UK University's Student Union 'Living Lab'

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Keywords

Choice experiment; sustainable food; consumer behaviour; food labelling; sustainable consumption; GHGE.

Public sector catering outlets have been proposed as ideal places to try new, sustainable food choice interventions. We report on promotions conducted during 2019 as part of a "living lab" at the University of Sheffield Students' Union. Living labs involve staging interventions or experiments in a real-world setting that are carefully monitored and evaluated systematically. Activities included (1) a survey of dietary habits, attitudes and knowledge of staff and students (n=643), (2) a low environmental impact indicator logo created and implemented in different ways across four food outlets in the Students' Union (some outlets also provided information in dining areas), (3) sales data (intervention period and the same period in the previous year) were analysed, and (4) on the day of the global Climate Strikes (20th September 2019), a food outlet introduced additional one-day-only promotions on low impact menu options; sales impact was assessed. An average of 39.4% of respondents recalled the low environmental impact indicator logo. There was a significant increase in oat milk use compared to 2018, but non-significant changes to other low and medium impact food sales. In one outlet, high impact items had the greatest total value of sales in 2018, whereas in 2019 medium impact foods had the greatest value of sales, suggesting a positive trend towards less impactful food choices. The Climate Strike intervention saw a decrease in beef burger sales and an increase in chicken and meat-free burger sales. This paper covers interventions to promote sustainable food choices and their efficacy across a university with ideas for future research avenues. This study applied novel concepts, including the use of a number of geographically close outlets each participating with different types of intervention, the inclusion of sales data for several outlets, and multiple scale temporal interventions (e.g., single-day global Climate Strike, and longer-term interventions).

1. Introduction

It is becoming increasingly apparent that current methods of food production and consumption are unsustainable. Food production systems produce 19-29% of global greenhouse gas emissions (GHGE)

(Camilleri et al., 2019) as a result of significant inputs of water, energy, chemicals and nutrients as well as being a driver of land-use change (Chen et al., 2016). Of GHGE, 18% are accounted for by livestock such as cows, pigs, sheep and chickens (van Hooijdonk & Hettinga, 2015). Ruminant animals, such as cows and sheep, are the main contributors to GHGE due to the methane (CH_4) produced during their digestion of feed, and the nitrogen oxides (NXO) released from their manure. The manufacture and application of fertilisers used on animal feed crops also release nitrogen oxides (Macdiarmid, 2012). Both methane and nitrogen oxides have greater global warming potential than carbon dioxide (CO2). A rapid dietary shift away from animal products, especially beef, lamb and dairy products is necessary to reduce diet-related GHGE and avoid further climate warming (Camilleri et al., 2019, Rust et al., 2020, Reynolds et al., 2014).

Given that only 3% of the UK population are vegetarian and even fewer are vegan (YouGov.co.uk, 2019), it is unrealistic to suggest a population shift to a meat-free diet at least in the short term, despite the significant reductions in GHGE that can be made (Camilleri et al., 2019). Eating meat is deeply ingrained in various cultures and is regarded as a symbol of affluence and success (Bacon & Krpan, 2018). Meat consumption has increased globally over the past 50 years (Bacon & Krpan, 2018), despite growing evidence of its negative impacts on health and the environment. However, not all meat is equal in terms of environmental impact and GHGE; hence, it may not be necessary to avoid meat altogether to reduce meals' environmental impact (Graham et al., 2019). Camilleri et al. (2019) found that replacing ruminant meat with non-ruminant meat and choosing a different species of fish resulted in a 30% reduction in food-related emissions of the weekly diet of an Australian family. Promoting sustainable food choices instead of a shift to vegetarian or veganism may be more effective in reducing GHGE from diets over a large scale and short period. Likewise, Grassian et al. (2020) found participants in UK-based meat reduction and vegan campaigns favour gradual dietary transitions. However, 'planned abstainers' (i.e. vegans and vegetarians) were more likely to report meeting their dietary goals than meat reducers (Grassian et al., 2020). Thus, abstaining from specific meat types (ruminant) in favour of non-ruminant meat may be an strong strategy for effective successful dietary transition.

It is difficult to break pre-established long-term habits (Chen et al., 2016), such as eating meat, especially when consumer awareness of meat production's environmental impacts is low (Camilleri et al., 2019).

However, promoting sustainable food choices can be achieved in various ways, including (but not limited to) changes to the choice architecture (Abrahamse, 2020). Attwood et al. (2020) recently produced 57 behaviour change strategies for the foodservice sector to encourage diners to choose more sustainable, plant-rich options. These strategies include changes to the product, placement, presentation, promotion, and people (staff). Colour-coding dishes listed on menus (e.g., red, yellow, green) to help diners recognise the "better" choice, and publicising the environmental benefits of plant-rich dishes using marketing materials like posters, leaflets, or TV screens, were identified as two possible strategies that could be engaged. Likewise, Bianchi et al. (2018), conducted a systematic review evaluating the effectiveness of interventions that restructured physical micro-environments to reduce the demand for meat. They found that (experimental) interventions offering the most favourable outcomes included reducing portion sizes of meat servings, providing meat alternatives, and changing the sensory properties of meat and meat alternatives at the point of purchase. However, Bianchi et al., (2018) highlights that there was consistently no evidence of purchased reduction effect for interventions that only manipulate the verbal description /label of meat or meat alternatives at point of purchase.

Labels (such as colour-coding or traffic lights) are one of the most straightforward ways to attempt to influence food choice (Camilleri et al., 2019, Brown, et al., 2020), and they have been shown to positively influence sustainable (see Camilleri et al., 2019; Vanclay et al., 2011; Pulkkinen et al., 2015; Bacon & Krpan, 2018), as well as healthy (Oliveria et al., 2018) food choices. Sustainability labelling (such as standards, origin and organic certification) has been shown to affect the sensory attributes of foods (de Andrade Silva et al., 2017), as well as perceptions of food safety/risk, animal welfare, deliciousness, purchase intention, energy density, and carbon footprint (Armstrong & Reynolds, 2020). A carbon label has previously been used at a university restaurant to increase sales of low emission dishes (11.5%) and decrease sales of high emission dishes (4.8%) (Brunner et al., 2018). A dual

traffic light labelling system (for carbon footprint and for healthiness) has been used in two sequential non-hypothetical discrete choice experiments focused on lasagne ready meals (Macdiarmid et al., 2020). It found that although consumers were willing to pay a higher premium for healthier and lower carbon footprint meals, this premium decreased when participants knew these meals contained less meat (Macdiarmid et al., 2020).

The literature suggests that consumers are rarely influenced by sustainability claims alone (Vanclay et al., 2011; Vlaeminck et al., 2014). To ensure price and label incentives of alternative products optimise impact, they must be close in flavour and convenience as the original counterparts (Hoek et al., 2016). Label and price interventions can also be used in tandem with interventions that make sustainable choices easier to see (Campbell-Arvai et al., 2014; Wansink & Love, 2014).

Other (public) catering interventions that can reduce purchases of animal-products include: (1) increasing vegetarian/plant-based meal availability (Garnett et al., 2019; Raghoebar et al., 2020), (2) changing the order of meals at the service counter and distance between vegetarian and meat options (Garnett et al., 2020), (3) providing climate change-health education to students (Jalil et al., 2020, Prusaczyk et al., 2021), (4) rearranging the menu in favour of vegetarian food (Gravert & Kurz, 2019, Sparkman et al., 2020, Wolstenholme et al., 2020), as well as enhancing the visibility of vegetarian dishes (Kurz, 2018), and (5) improving the name of the plant-based dish (Bacon et al., 2019; Gavrieli et al., 2020 Krpan, & Houtsma, 2020).

In the promotion of sustainable diets, public sector catering outlets (such as those in schools and universities) have been proposed as vanguards (Graham et al., 2019). Similarly, many customers expect restaurants to 'lead the way' and use more sustainable and ethically sourced ingredients than they might use at home (Curry et al., 2014). In universities, undergraduate students who have entered a new environment will be most susceptible to habit changes (Chen et al., 2016). Additionally, having a work or study space well suited to learning sustainable behaviours can then be transferred to private consumption (Schrader & Thøgersen, 2011). Still, there are contradictions to using out of home consumption to change at-home consumption as highlighted by Biermann and Rau (2020). Few people eat sustainably in both settings, as eating out and consuming meat is associated with the terms 'special' and 'treating oneself'. The normative and emotive expectations of eating out and eating at home diverge.

These tensions imply that in certain catering environments and with some clientele some types of intervention may not be as well placed [see Verfuerth et al., (2019); Verfuerth (2019) for an example of how customers of a workplace canteen responded to menu change/dietary choice intervention]. However, university catering outlets can be seen as an intermediary for students and staff between private food consumption (at home or halls of residence), and off-campus public food consumption. For this reason, they are particularly suited as a location to change immediate diets and longer-term dietary habits.

Due to being a prospective space to engage with sustainable behaviour change, universities have become popular candidates as spaces to deploy a 'Living Lab' method (Evans et al., 2015; Lipschutz et al., 2017; Dekker et al., 2019). A living lab method is a form of experimental governance, with co-development and testing of innovations and interventions to address sustainability challenges (Herrera, 2017). Living labs involve staging interventions or experiments in a real-world setting (i.e., a university campus) that are carefully and systematically monitored and evaluated. In some university living labs, students co-create, run and evaluate the experiments with university facility staff and academics as part of dissertations or summer projects. Examples of related previous living labs include Crosby et al. (2018) and Favaloro et al. (2018). They used a living lab to engage a university campus in managing food waste and achieving sustainability benchmarks, respectively. Staisey and Harris (2019) increased food sales at a farmer's market using a living lab approach, and Roggema and Yan (2019) used Urban Living Labs to co-design new food futures for local communities.

This paper seeks to broaden the understanding of diets and views towards sustainable diet interventions in an academic university setting by reporting on research activities conducted under the auspices of a sustainable food living lab at the University of Sheffield. Much of these activities were carried out within the Univer-

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sity's Student's Union building over 2019.

This paper provides a further practical example (with quantified sales impacts) of different labelling, information, and menu change interventions carried out within a living lab framework. In doing so, it complements and extends the current evidence base around carbon labels and catering interventions. The main novelty of our study is the use of a number of geographically close outlets each participating in different levels and types of intervention, the inclusion of sales data for a number of outlets, and the use of multiple scale temporal interventions (e.g., the global Climate Strike day, as well as longer-term interventions). Our research questions are 1) what are student and staff attitudes towards sustainable diets? 2) What are the effects of different types of interventions on promoting sustainable food choices across campus?
We are publishing the information in this paper to inform and inspire the wider sustainable food movement and living lab communities who are currently undertaking similar work, and can use these results as a comparison. Also, to impact businesses and sustainability teams that can use our results as a business case to promote change in their organisations.

2. Materials and methods

2.1. Context

The University of Sheffield employs 7,802 staff members and has 29,666 full-time students. It has 18 different university-owned food outlets covering a range of cuisines and dining styles (Graham et al., 2019). A focal point of The University of Sheffield campus is the University of Sheffield's Student's Union (SSU), which features multiple food and beverage outlets. Due to its central nature and multiple outlets, the SSU is a practical environment to explore student perceptions and responses to a living lab intervention to promote sustainable diets. Indeed, sustainability is heralded as one of the SSU's key values (see: https://yoursu.sheffield.ac.uk/get-involved/sustainability).

The SSU's Sustainable Diets Strategy Action Plan (Graham 2018) acted as a springboard for this investigation. The Action Plan outlined key actions SSU catering could take over the next 16 years to deliver their strategy of developing and promoting sustainable diets, including but not limited to veganism. The focus was on promoting sustainable diets from a greenhouse gas emissions (GHGE) perspective, i.e promoting foods with low associated GHGE and hence defined here as having a low environmental impact.

The mix of methodologies discussed below, and co-created interventions is central to the living lab approach. Dekker et al. (2019) outlined that these multiple methods and co-created approaches are needed for methodological robustness, practical implementation, and to mitigate ethical and legal issues and provide value for practitioners and participants.

2.2. Menu interventions

2.2.1. Creation of a low impact food logo

In order to indicate foods that had a low environmental impact, a low impact logo was created. Following the method outlined by Graham (2018), each menu item was categorised as "low impact", "medium impact", or "high impact" (see Table 1). The categorisation exercise used the value of median associated Greenhouse Gas Emissions (GHGE) KgCO2e per kg for each prominent ingredient (Clune et al., 2017). Graham classified the top two protein sources (both outliers of the main dataset) as "high impact", taking the third product as an upper threshold of "medium impact" (9.25 kgCO2e per kg). The lower threshold of the "medium impact" category was half the value of the upper bound (4.44 kgCO2e per kg). Items below this threshold were rated as "low impact". However, since the capture/farming method of fish in dishes in the SSU was unclear, they were included in the medium impact category. Menu items were assigned a low impact rating if they did not contain any medium or high impact ingredients.

The researchers designed the final logo using background research and feedback from restaurant managers and University of Sheffield academics. The logo was designed with the carbon footprint iconography in mind with additional text to signify the items' low GHGE impact. The logo's aim was for it to be easily recognisable, making it usable across different menus and promotional materials (see Figure 1, see Appendix for other prototype logos). Red (high impact) and orange (medium-low) logos were also created, but not

used in the intervention. The choice to not use the red and orange logos was arrived at through iterative discussion with restaurant managers. This choice was due to cost implications of full menu redesign, and some initial nervousness about not wanting to "disincentivise/demonise" medium and high impact foods on campus. The outlet managers instinctively wanted to start lower down the "Nuffield Ladder of Interventions" (Nuffield Council on Bioethics, 2007) by educating and incentivising desirable choices first, rather than negatively educating/disincentivising undesirable choices. The Nuffield Ladder tells us that moving upwards balances greater effectiveness with less acceptability. Like all other outlets, the Students' Union initially wanted to start with less effective but more acceptable interventions. Other versions of the traffic lights can be found in the Appendix 4.

2.2.2. Location and type of interventions

The menus were altered across four SSU food outlets: New Leaf (a build your own salad bar), Bar One (a bar which predominantly serves burgers), Interval (a sit-down restaurant) and Coffee Revolution (a café) (further details can be found at https://yoursu.sheffield.ac.uk/eat-drink-shop). Different methods of altering menus were used in each outlet, as discussed below. All menu alterations were in place in the outlets by 17th May 2019, with the interventions running until the 8th of June 2019. It was hypothesised that the more prominent and visible menu alterations would increase recognition and understanding of the low impact logo and thus be more effective in promoting sustainable food choices.

2.2.3. New Leaf – logo on menu

In the New Leaf salad bar, customers can build their salad choosing from a variety of ingredients grouped into different categories (Base, House Mix-ins, Deli Mix-ins, Dressings and Garnishes). Ingredients in these categories are shown on a magnetic board on the wall. A magnet stating 'low impact foods below' accompanied by the logo (Figure 1) was used in the 'Deli mix-ins' and 'House mix-ins' category. Options in these categories were split into two columns, one

Table 1. Impact categories of different foodstuffs based on their associated greenhouse gas emissions. Reproduced from Graham (2018).

Impact Category	Prominent ingredient
High	Beef, lamb
Medium	Cheese, pork, prawns, fish, butter*, cream*
Low	Poultry, Egg, Vegetables

* Applied to pastries and desserts only.

Figure 1. The low impact logo used throughout the study.

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containing low impact ingredients headed by the magnet and the other containing medium impact options with no distinction. 'House mix-ins' consisted of just one column as all options were low impact. Additionally, an A4 informational poster was displayed by the till to help customers recognise and understand the logo. This is provided in the Appendix.

2.2.4. Coffee Revolution – milk guide

Being a café style outlet, the highest selling items in Coffee Revolution are hot drinks. As such, the main focus here was to nudge patrons to try plant milk in their drink rather than cow's milk. An A4 'milk guide' was produced containing information on the environmental benefits of plant milk alongside the low impact logo (Figure 1), as well as information on SSU's local milk supplier 'Our Cow Molly', as outlet managers were keen to avoid a negative slant on cow's milk given the effort put into its local sourcing. This guide was displayed on the end of poles designating the queuing area. Milk guide is provided in Appendix.

2.2.5. Interval – milk guide and logo on menu

Similar to Coffee Revolution, hot drinks are a key seller at Interval, so the milk guide was also implemented and placed alongside coffee stirrers and sugar on a table by the till. Additionally, the low impact logo (Figure 1) was placed alongside low impact food items on the A4 main food menu; however, it was not included on their smaller lunchtime menu. Both milk guides are provided in the Appendix.

2.2.6. Bar One – separate low impact menu

Bar One has an extensive menu, comprised primarily of burgers. The menu is split into daytime, lunch, meat-free and sharer sections housed on a clipboard. Burger sales are roughly evenly split between beef (high impact), chicken (low impact) and vegan burgers (low impact). An additional menu section was produced called the 'Low carbon impact menu' which featured the low impact logo (Figure 1) alongside six existing low impact menu items as chosen by the outlet manager. This menu was of A6 size (notably smaller than the other menu sections) and was placed at the front of the clipboard menu.

2.3. University survey

Baseline data on the diets and other factors surrounding the food choice of patrons of SSU were collected via face-to-face interviews and an online survey. Interviews were conducted on 29th April and 2nd May 2019. Two researchers staffed a stall located outside SSU on 29th April and within SSU on 2nd May. A selection of homemade vegan cakes was used as an incentive to complete the survey. The researchers offered guidance to respondents when and if needed, when completing the survey, for example, if they needed clarification on answering any of the questions.

The same survey was sent out as a Google form via email to all staff and students at the University of Sheffield that had opted to receive 'staff announce' (7th May 2019) or 'student announce' (8th May 2019) emails. In the survey, diet type was split into nine categories using the same question as deployed at the Take a Bite Out of Climate Change events (Kluczkovski et al., 2020), based on questions asked in the ScenoProt sustainable proteins research survey (Makery, 2016). Further detailed information on the survey can be found in Appendix 1. Surveys were analysed in Excel and Google Sheets. In the results this survey data is compared to that collected by YouGov.co.uk (2019).

2.4. Interviews

The reaction to the above menu interventions across outlets was assessed through short, semi-structured face-to-face interviews. These took place on 23rd and 25th May, approximately one week after the menu interventions were in place. An adaptable interview script (Appendix 6) was produced and contained questions regarding whether the interviewee had seen the menu or logo, their thoughts regarding the logo and their thoughts on the SU promoting sustainable diets. Doing so allowed the interviewer to follow the conversation in a content-focused manner (Dunn, 2010).

Interviews lasted approximately five minutes. A researcher would approach outlet customers and ask if they wanted to complete a short interview. Like the survey, homemade vegan cakes were offered as an incentive, but participants could also choose a voucher for £1 off a low impact food or drink item (as adver-

tised by the various menu interventions). Participants were able to choose which incentive they wanted after completing the interview. Some interviews were completed in groups as often several people would be dining together, but responses were recorded separately. Two researchers were present throughout the interview, with one asking the questions and the other taking notes. Additionally, the interviews were recorded with consent and transcribed, with the transcript's content analysed using the software NVIVO.

2.5. Sales and purchasing data

Sales data and supplier-end purchasing data for the intervention period were collected for each outlet and the corresponding period for the year before. These data were used to assess current uptake of low, medium and high impact foods across outlets. Different types of data were collected for each outlet as a result of the data that was available. For Interval and Bar One, sales data were collected, showing the monetary sale values of low, medium and high impact items. At Coffee Revolution, data for the amount of dairy, soya and oat milk used was collected. At New Leaf the amount (kg) of each 'Deli Mix-in' ingredient used was collected, as all the 'House Mix-in' ingredients were low impact. Sales data were grouped and analysed in Excel and Google Sheets.

2.6. Additional intervention- Climate Strike

On the day of the global Climate Strikes (20th September 2019), SSU outlets introduced one-day-only promotions on low impact menu options. Here we assessed the impact of Bar One's additional promotion. Bar One typically provides a 2 -for-1 offer on all burgers at the beginning of each semester, but for the Climate Strike, Bar One excluded all beef burgers from the offer. A total of 31 customers were verbally surveyed and asked nine questions to test whether the promotion impacted beef burgers' sale (please see Appendix 2 for question list; with more detailed analysis in Appendix 7). Their responses were coded using content analysis to allow for categorisation and calculate percentages. The sales data for the Climate Strike day and the day before were also collected, although vegetarian and vegan burgers were categorised into one category (meat-free burgers). Sales data was analysed in Excel and Google Sheets.

3. Results

3.1. Diet survey results

3.1.1. Survey population demographics

A total of 643 people completed the survey. Overall, 57.9% (n = 372) of respondents were classified as staff of either the University of Sheffield or SSU. University of Sheffield students comprised 41.2% (n = 265) of the sample, while the remaining participants classed as 'other' as they did not fall under either category (n = 6). Researchers completed 139 (21.6%) surveys 'face to face' along with the food incentive with the remaining 504 people (78.4%) survey completed the survey online. Study participants were 69.4% female (446) and 25.5% male (164).

3.1.2. Survey age demographics

In the face-to-face surveys, a much greater percentage of participants fell into the 18-25 age-group compared to the online surveys (see Figure 2). There was a broader age range for the online surveys, with approximately 20% of participants falling into each age category apart from 55+ (lower at 9.1%). A significant association was found between the survey method and participant age ($\chi 2 = 215.4$, $df = 4$, $p < 0.001$). Those in the 18-24 age category were more likely to have completed the survey face to face, whereas those aged 35 and above were more likely to have completed the survey online.

3.1.3. Dietary identification

The majority of respondents (29.2%) identified their diet as 'I often eat both meat and vegetarian food', followed by 'I frequently eat vegetarian food and occasionally eat meat (flexitarian)' at 22.2% of the whole survey population (see Figure 3a). For ease of analysis, 'I frequently eat meat and I am not interested in trying vegetarian food', 'I often eat meat and I occasionally eat vegetarian food' and 'I often eat both meat and vegetarian food' were grouped under the term 'meat-eater'. Similarly, 'I eat dairy and eggs in addition to products derived from plants (ovo-lacto-vegetarian)' and 'I eat dairy in addition to products derived from plants (lacto-vegetarian)' were grouped under the term 'vegetarian'. Using these groupings,

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the majority of respondents were labelled meat-eaters (44.9%) followed by flexitarians (22.3%) (see Figure 3b). Detail of all original diet classification categories can be found in Appendix 8. For some analyses 'I frequently eat meat and I am not interested in trying vegetarian food' was left separate and shortened to 'Meat only' to assess the amount of push back that may exist towards more sustainable diets.

Students were more likely to be flexitarians, vegetarians and vegans than staff, with the majority of staff being meat-eaters (see Figure 4). However, more students had no interest in trying vegetarian food (5.28%). The diet types of those who conducted the survey online and face-to-face were similar (see Figure 5). However, those who completed the survey online were more likely to eat meat, whereas those who completed it face to face were more likely to be flexitarian, which may be attributed to the different age demographics of the study populations.

There was a significant association between age and diet type ($\chi 2 = 71.96$, df = 44, p = 0.005) (see Figure 6). Meat-eaters predominated in all age groups; however, this was more prominent in those aged 35 and over. The proportion of flexitarians was similar across all age groups but dropped in the 45 – 54 age category. There was a significant difference between the diet proportions found in our study sample and those found by YouGov.co.uk 2019 ($\chi 2 = 913.63$, df = 6, p < 0.001). Our study found greater percentages of flexitarians, pescatarians, vegetarians, and vegans than the YouGov study (2019) (see Figure 7).

3.1.4. Reasons for reducing meat intake and likelihood of changing diet

Both staff and students had similar reasons for reducing their meat intake, with environmental concerns, health concerns, and animal welfare concerns being those most frequently cited (see Figure 8). The cost was a greater issue for students than for staff.

This data was assessed in a similar way to the YouGov.co.uk (2019) report 'Is the future of food flexitarian?', focusing on meat-eaters and flexitarians' behaviour. There was a stark difference in the response to the question 'To what extent do you agree with the statement 'I

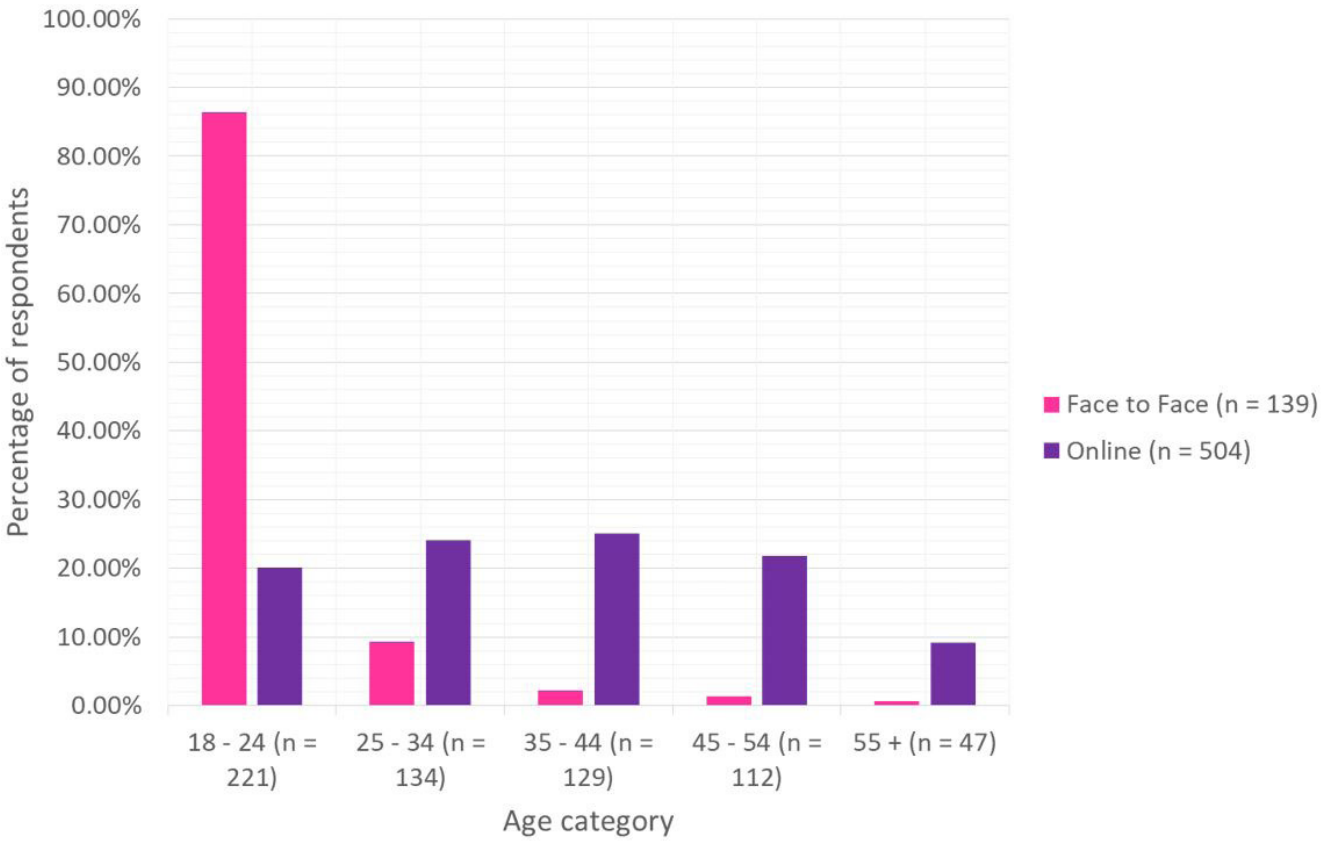

Figure 2. The spread of ages across of survey respondents online and face to face

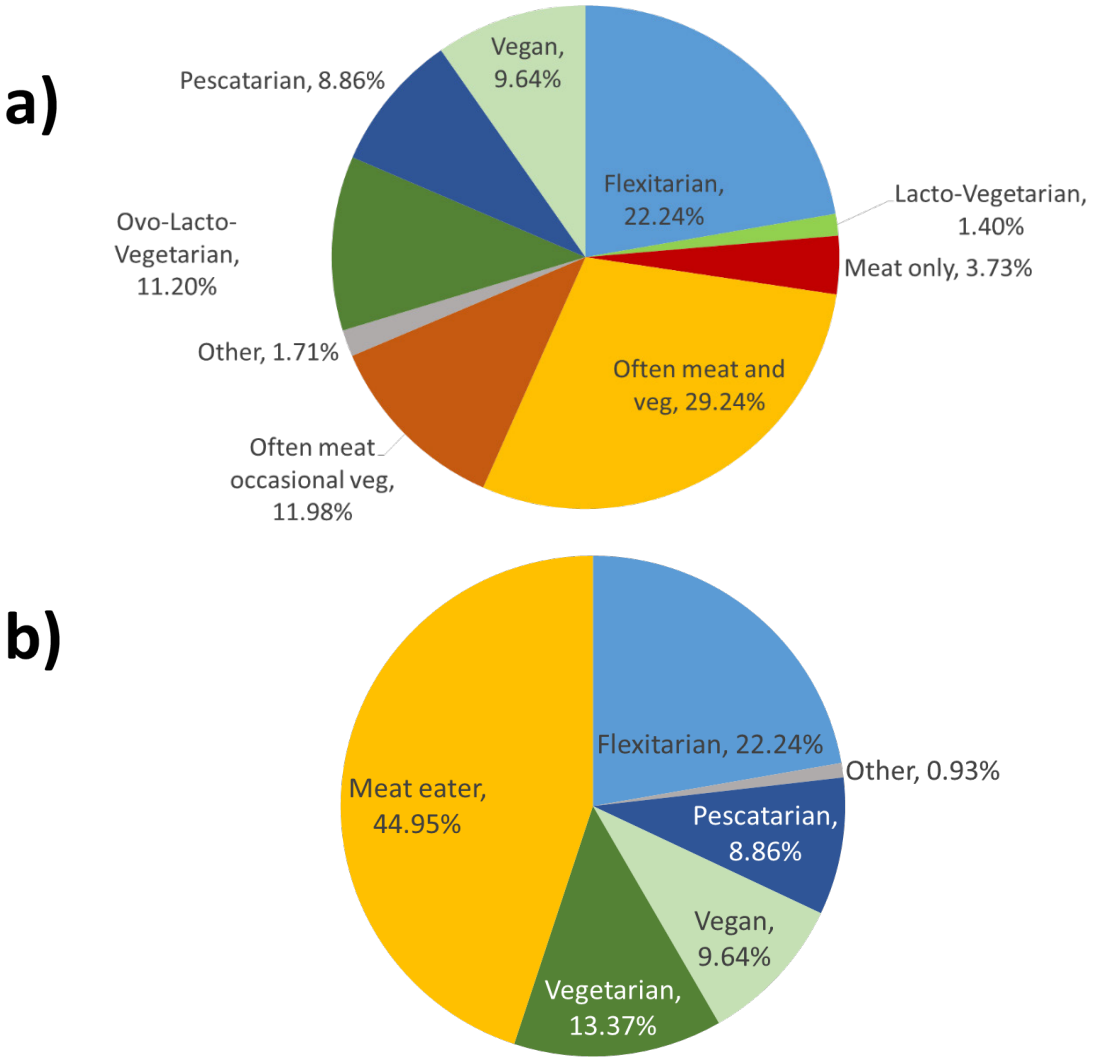

Figure 3. Diet types across all survey respondents using a) separate and b) grouped categories

am actively trying to reduce my meat consumption'?' between meat-eaters and flexitarians. The majority of flexitarians either tended to agree or definitely agree with the statement (84.6%). In contrast, the majority of those who had no interest in trying vegetarian food ('Meat only') tended to disagree or definitely disagree with the statement (79.2%). Despite this, the majority of those who often ate both meat and vegetarian food and those who ate vegetarian food occasionally ('Meat-eaters') tended to agree with the statement or neither agree nor disagree (63.0%) (see Figure 9).

When asked the likelihood of becoming a vegetarian in the next 12 months, the majority of both meat-eaters and flexitarians answered 'not very likely' (46.0% and 40.6%, respectively). The majority of those not interested in trying vegetarian food at all unsurprisingly answered 'not likely at all' (83.3%). Nevertheless, Figure 10 shows the answers of flexitarians were slightly more positively skewed. These findings mirror those of the YouGov.co.uk (2019) report, with 79% of meat eaters 'not likely at all' to become vegetarian in the next 12 months. Similarly, the majority of flexitarians (40%) were 'not very likely' to change their diet either.

The majority of both flexitarians and meat-eaters were 'not likely at all' to become vegan in the next 12 months (42.0% and 81.5%, respectively; see Figure 11). This majority was greater for meat-eaters and 'meat only' than for flexitarians. Approximately 5% of flexitarians were 'likely' or 'very likely' to become vegan in the next 12 months. This is slightly higher than that found

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by YouGov.co.uk 2019, with only 2% of flexitarians 'likely' or 'very likely' to become vegan. The majority of flexitarians and meat-eaters questioned by YouGov. co.uk (2019) were 'not likely at all' to become vegan in the next 12 months (68% and 93%, respectively).

3.2. Menu interventions interview findings

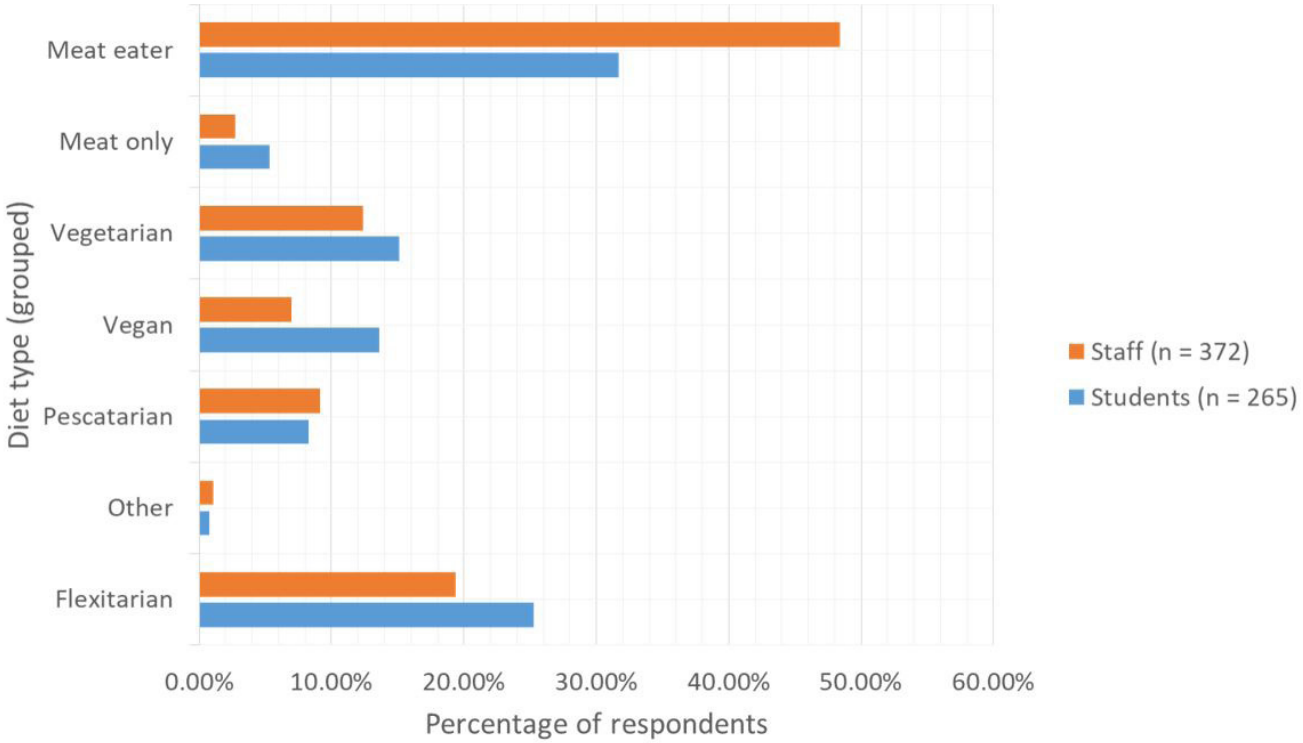

Figure 4. Comparison on the diet types of staff and students using grouped diet definitions

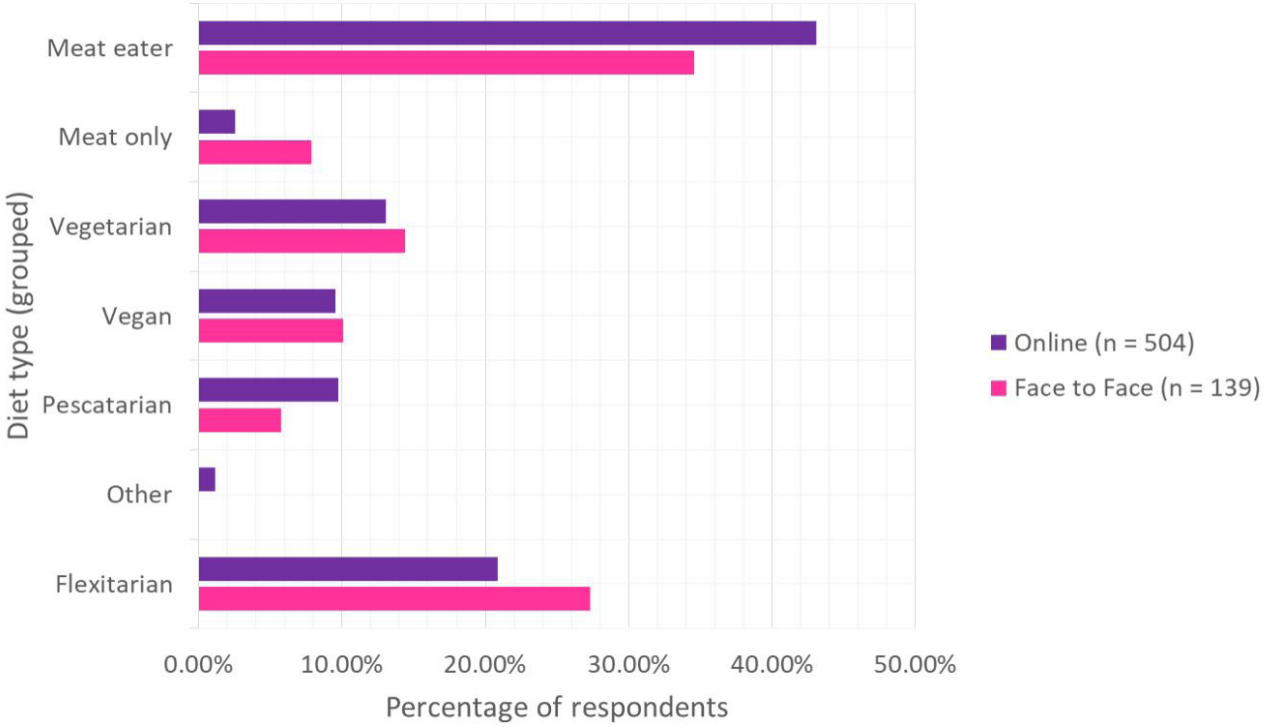

Figure 5. Comparison of diet type between those who completed the survey online and those who completed it face to face

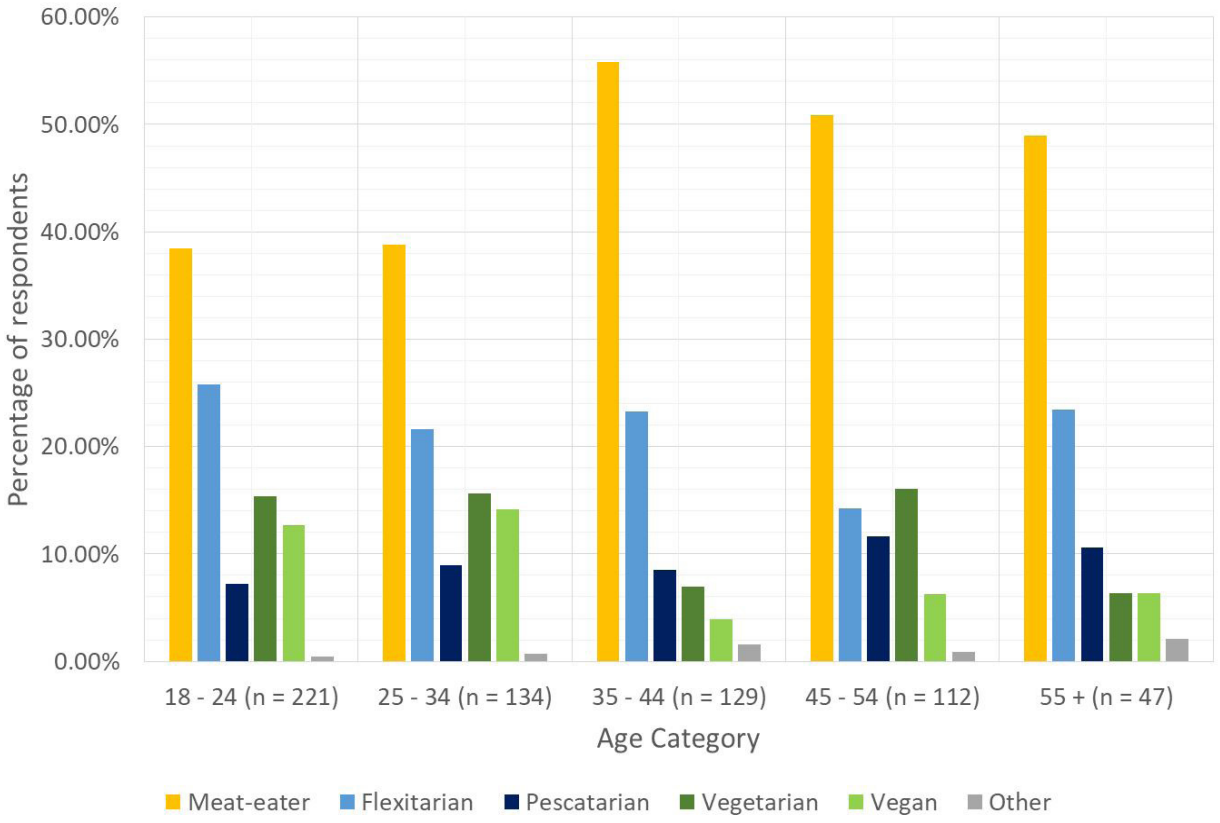

Figure 6. The grouped diet types of each age category

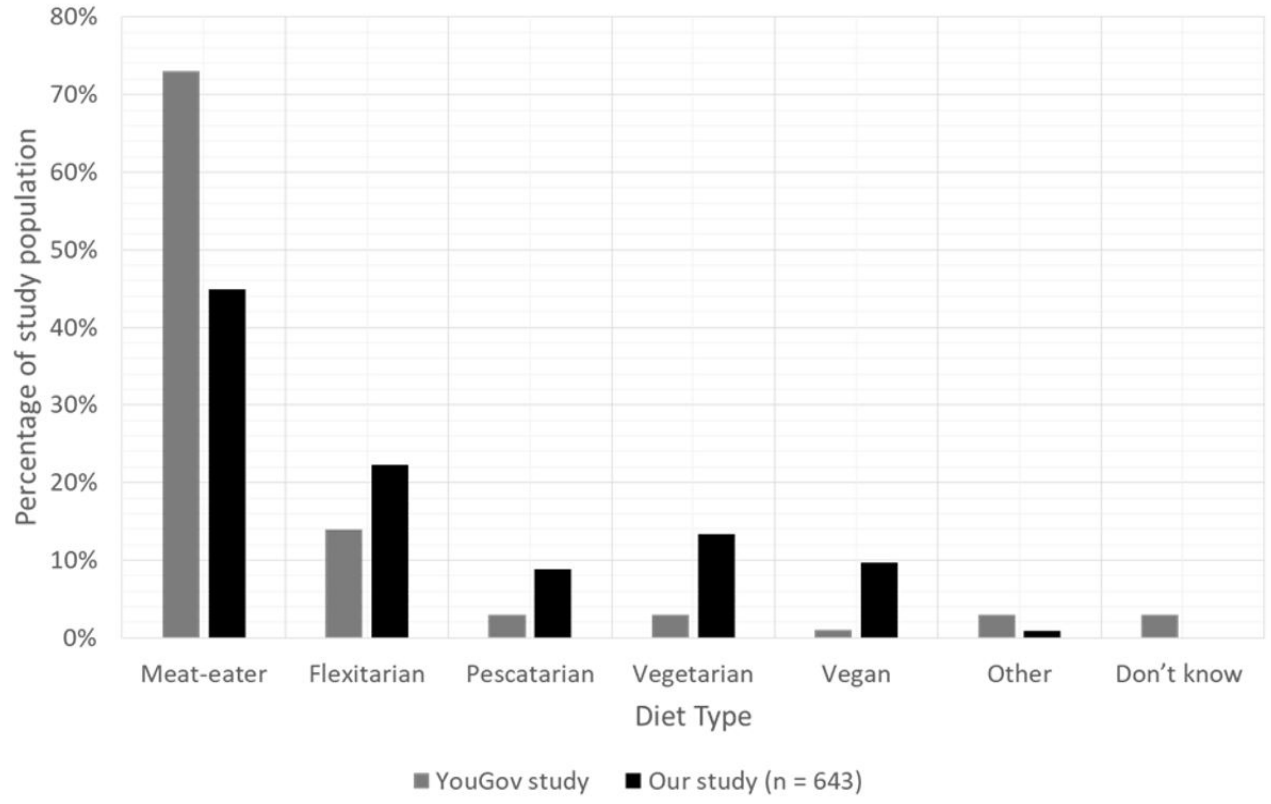

Figure 7. A comparison of the percentage of each diet types found across our study population and that found by YouGov.co.uk 2019

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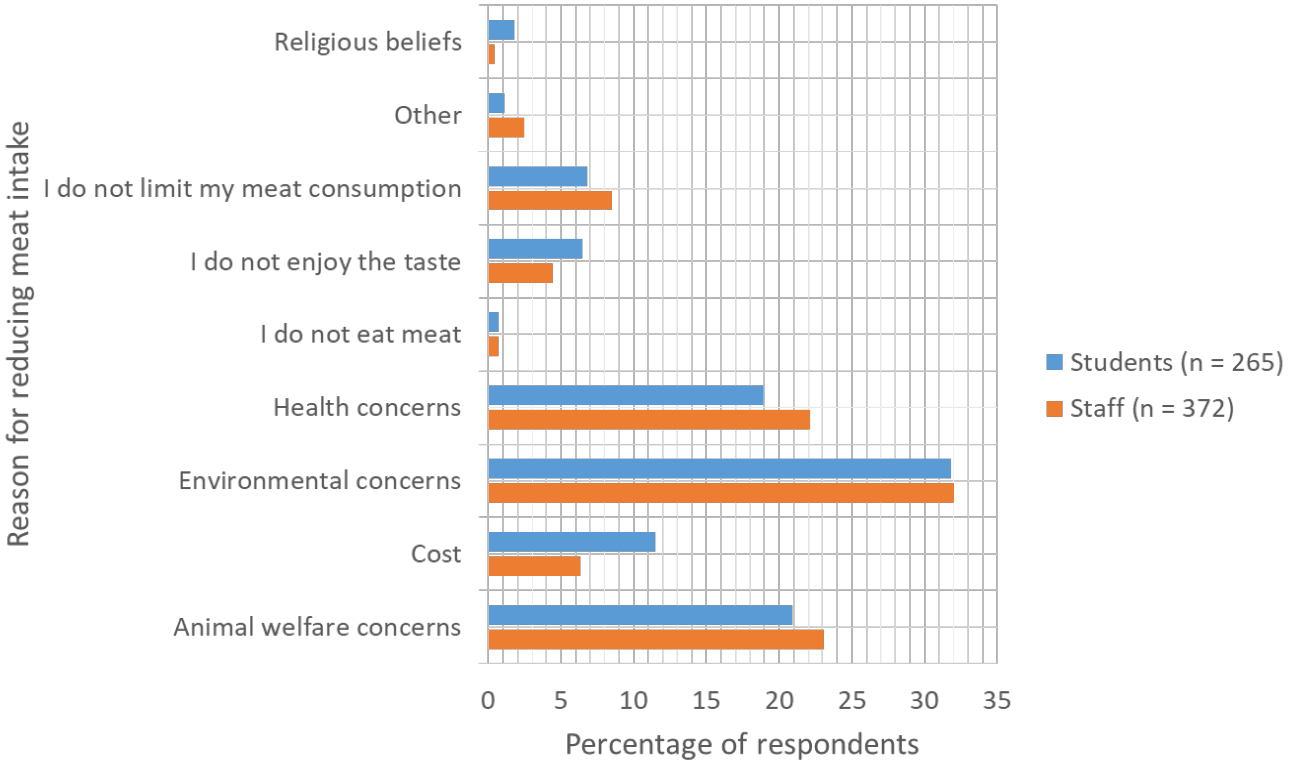

Figure 8. The reasons staff and students cited for reducing their meat intake

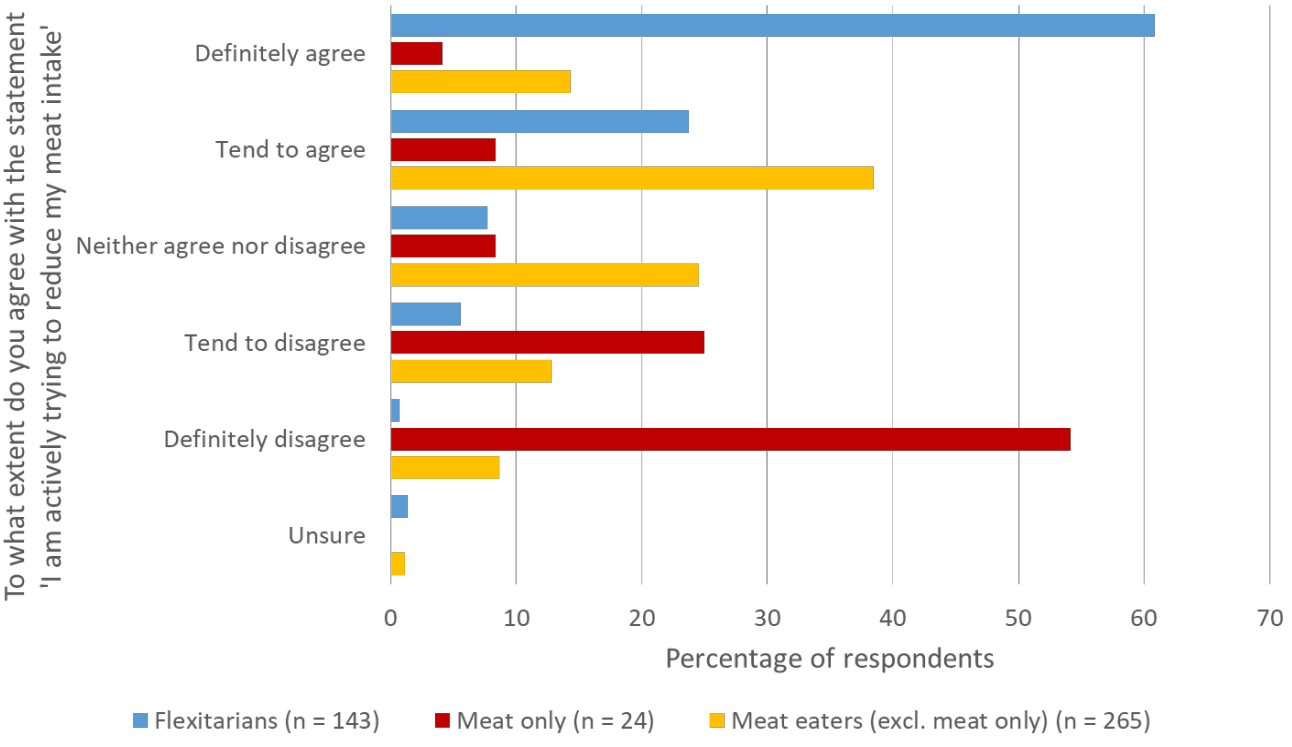

Figure 9. The extent to which flexitarians, those with no interest in trying vegetarian food (meat only) and meat eaters agree with the statement 'I am actively trying to reduce my meat consumption'.

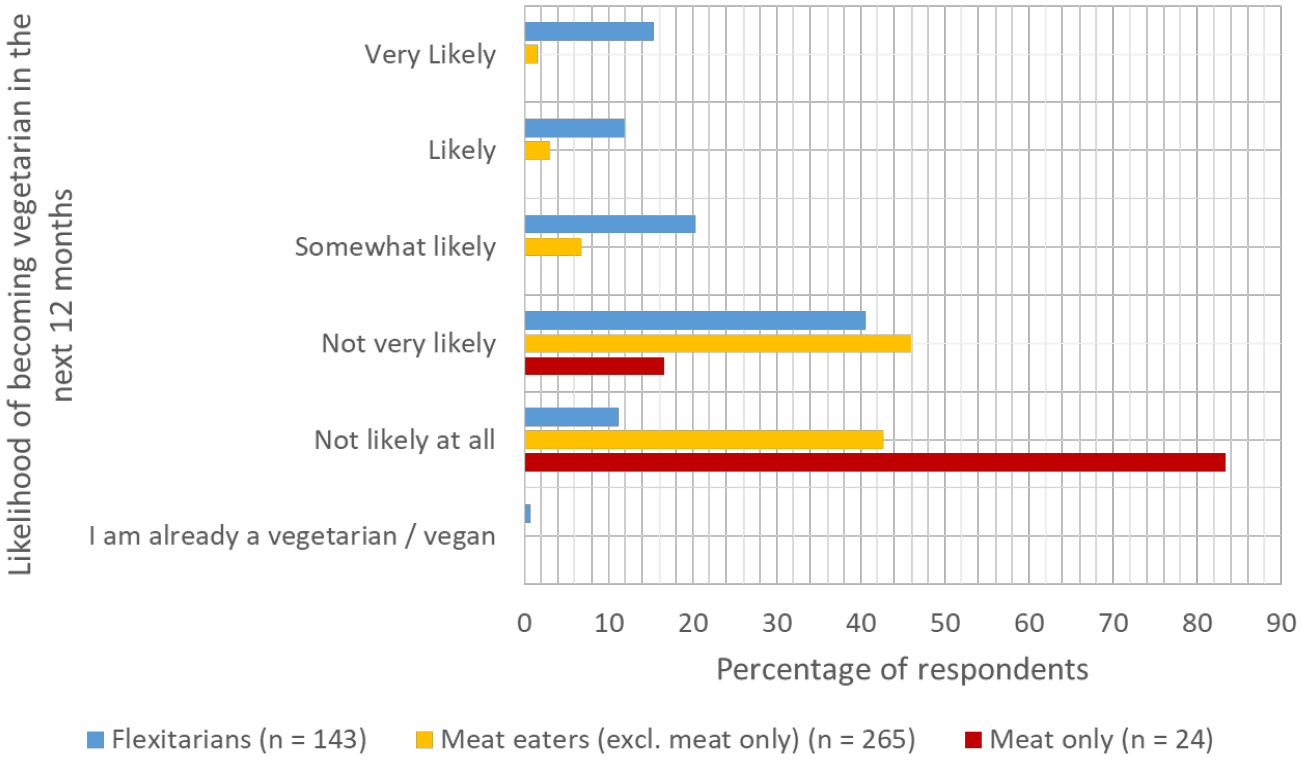

Figure 10. The likelihood of flexitarians, meat eaters and those with no interest in trying vegetarian food ('meat only') in becoming vegetarian in the next 12 months

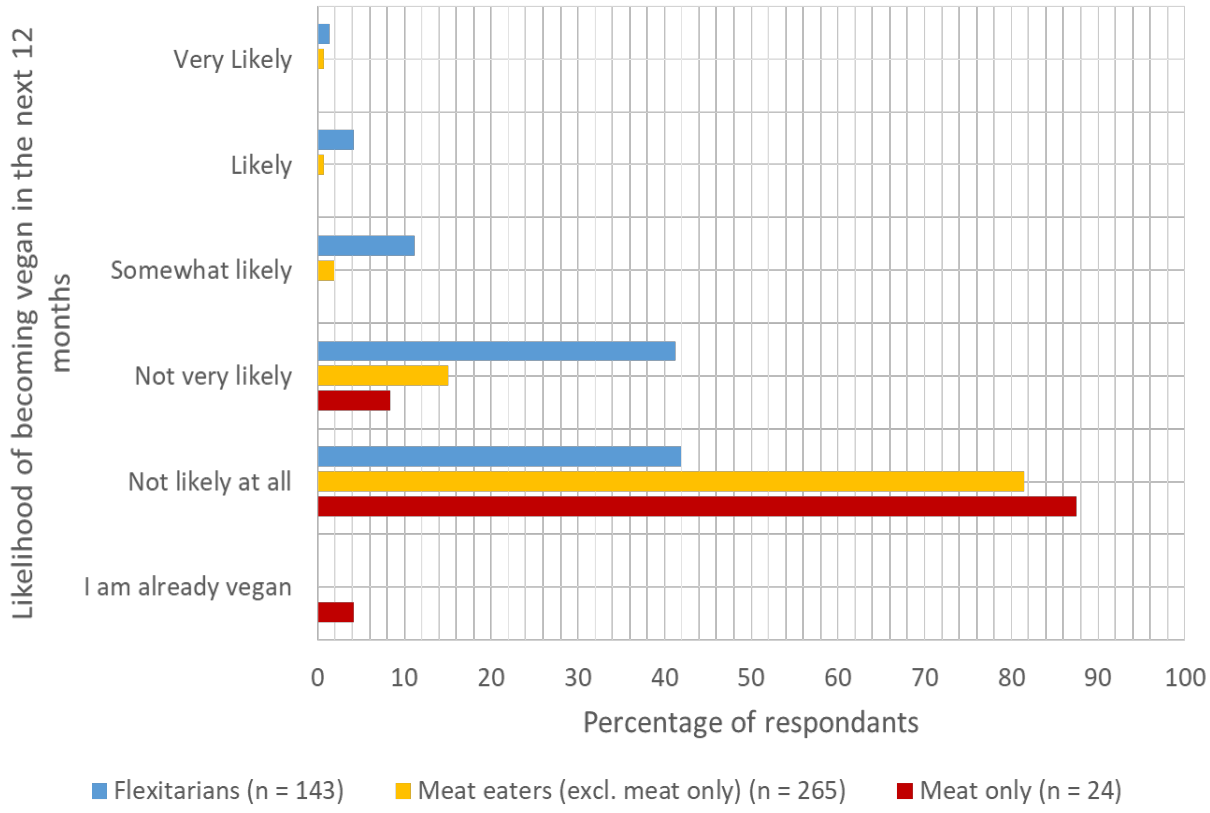

Figure 11. The likelihood of flexitarians, meat eaters and those with no interest in eating vegetarian food ('Meat only') of becoming vegan in the next 12 months

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Table 2 details when interviews took place in each outlet and the number of participants and the gender ratios.

Table 3 summarises the main results from the interviews and the interventions used in each outlet. More people had not seen the logo (59.1%) across all restaurants than had seen it (39.4%). The low impact logo's most significant recognition rate was at Interval (47.1%), whereas the lowest recognition rate was at Coffee Revolution (23.5%). In none of the outlets had more people seen the logo than not seen it.

Nevertheless, the majority of respondents (86.4%) said that further rollout of the low impact logo would positively affect their meal choice. Frequently mentioned was the fact that if the person may be choosing between more than one food options and one was low impact, they would be more likely to choose the low impact one as the logo has "[done] the research for you". Many of those who said the logo would not influence their choice were already looking to make more sustainable food choices or already ate a diet that included low impact foods such as vegetarian or vegan.

Reaction to the logo design was similarly positive and it "encompasse[d] a lot of what [we're] trying to say". However, there was some confusion regarding what 'low impact' was referring to, with some thinking it was linked to packaging and recycling rather than the emissions from food production. Also, a few participants thought the logo might be related to health.

3.3. Sales and purchasing data

Table 2. Dates and times of interviews for each outlet as well as number of participants and gender ratios

Outlet	Day interviews conducted	Time interviews conducted	Total number of participants	Gender ratio m:f
New Leaf	23/05/19	12:30 - 14:00	14	3:4
Coffee Revolution	23/05/19	10:30 - 12:30	17	4:13
Interval	25/05/19	14:45 - 16:45	17	5:12
Bar One	25/05/19	12:45 - 14:00	18	2:5

Table 3. Respondents (%) who had seen the low impact logo and reported it would positively affect their food choice

Restaurant	**Intervention Type**	**Total number interviewed (%)**	**Percentage** (%) **who had seen the logo**	**Percentage** (%) **who had not seen logo**	**Percentage (%) who self logo reported would positively affect their food choice**
Coffee Revolution	Milk Guide	17	23.5	70.6	82.4
New Leaf	Logo above low impact choices	14	42.9	57.1	85.7
Bar One	Stand alone low impact menu	18	44.4	55.6	88.9
Interval	Logo on main menu and milk guide	17	47.1	52.9	88.2
Overall		66	39.4	59.1	86.4

Table 4. Usage of 'Deli mix in' ingredients across 2018 and 2019

Ingredient	Impact category	Usage in 2018 (kg)	Usage in 2019 (kg)	Increase in usage?
Falafel	**Low**	105.7	91.8	No
Basil Tofu	**Low**	28.5	18.7	No
Hummus	**Low**	73.7	65.1	No
Tuna chunks	**Medium**	33.3	23.0	No
Roasted Mediterranean Vegetables	**Low**	27.9	32.4	Yes
Vegan Sausages	**Low**	374 sausages	723 sausages	Yes
Back Bacon	**Medium**	6.6	-1.5	No
Piri Piri Chicken	**Low**	125	86.6	No
Chicken Breast Slices	**Low**	76.2	58.4	No
Greek Feta	**Medium**	61.6	55.7	No
Mature Cheddar	**Medium**	31.3	53.1	Yes
Stilton	**Medium**	0.07	19.6	Yes
Bacon	**Medium**	891 portions	492.8 portions	No

3.3.1. New Leaf

As New Leaf sales data does not record the specific ingredients used in each salad, the quantity of 'Deli mix-in' ingredients used in 2018 and 2019 was compared. The 'Deli mix-in' category was selected as it contained low and medium impact food items. The rest of the categories such as 'House mix-ins' where the logo was also used contained predominantly low impact items. In 2018, ten medium impact items were available across all categories, whereas in 2019 this had fallen to 8. Of the 'Deli mix-in' ingredients that remained across both years, the usage of the majority of medium impact ingredients decreased (4/6). However, the use of the majority of low impact ingredients (5/7) also decreased between 2018 and 2019. Table 4 illustrates this data.

3.3.2. Coffee Revolution

Data on milk usage in 2018 and 2019 were collected and compared. In 2019 there was a significant increase in use of oat milk compared to 2018 ($\chi 2 = 307.07$, df = 2, $p < 0.001$). The use of soya milk stayed relatively the same across years, and there was a slight decrease in dairy milk usage in 2019 (see Table 5).

3.3.3. Interval

Sales data were collected from the period 29/04/2019 – 08/06/2019 and for the same period in 2018. Given that Interval serves a range of food across the day, the data was split into three categories: 'Afternoon' which includes all hot food served during the lunchtime period such as small pizzas, 'Sandwiches' which includes all hot and cold sandwiches served during the lunchtime period and 'Evening' which includes all hot food served in the evening such as larger pizzas, pasta, salads and nachos. Dessert foods and hot drinks were not included in this data set.

Across all categories, Interval sold more types of medium impact foods than low impact foods. Medium impact foods had a greater value of sales in relation

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to the number of options available across all categories. On average, each medium impact item generated more money than low or high impact items. Despite this, for the 'Sandwiches' category in 2018, the value of sales in relation to the number of items available was similar for both low and medium impact options. In other words, sales of both low and medium impact sandwich items generated a similar amount of money on average. In 2019 however, medium and high impact items had a greater value of sales than low impact items suggesting they were more profitable as they generated more money. Table 6 illustrates this.

3.3.4. Bar One

Sales data was collected from the period 29/04/2019 – 08/06/2019 and for the same period in 2018. For the purpose of this analysis, the sales of burgers were the main focus. In 2019 the number of low impact options available had increased; however, they had the lowest total value of sales. In 2018, high impact items had the greatest total value of sales. In contrast, in 2019, medium impact foods had the greatest sales value, suggesting a positive trend towards slightly less impactful food choices. This data is illustrated in table 7.

3.3.5. Subsequent action research results – Bar One

Following the feedback of intervention results and co-design of ideas for future interventions to the restaurant outlet managers, Bar One redesigned its menus to promote lower-impact foods. These changes targeted subconscious as well as conscious processes. The date of redesign was September 2019, in use from the first day of trading in 2019 (16/9/2019). Prices of beef and chicken burgers were made more comparable (with beef previously being priced cheaper than chicken). Chicken burgers were placed at the top of the menu above beef burgers along with a textbox explaining the environmental impact of beef burgers. The low impact logo was not used.

Initial results suggest these interventions have been successful in promoting low impact items. Data collected over the first two weeks of the adjusted menu's circulation show an increase in the proportion of chicken burgers consumed and decreased beef burgers (see Table 8). The proportion of vegetarian and vegan burger sales remained the same.

3.4. Climate Strike intervention

3.4.1. Sales

Table 9 illustrates the changes in sales of beef, chicken and meat-free (vegetarian and vegan) burgers on Climate Strike day from the previous day. There was a considerable reduction in the percentage of beef burgers sold and a subsequent increase in chicken and meat-free burgers sold.

The Climate Strike intervention saw the following changes in sales compared to the previous day: a 35.5% decrease in beef burger sales, a reduction of 6.6% of total burger sales (to 18 burgers), a 20.3% increase in chicken burger sales (161 burgers), and a 15.1% increase in meat-free burger sales (92 burgers). In total, 36 more burgers were sold than on the previous day. (Sales 99 beef, 92 chicken, and 44 meat-free)

3.4.2. Interviews

A total of 31 customers were interviewed. The majority identified as either a 'meat-eater' or a 'flexitarian'. Approximately a quarter was either a 'vegetarian' or a 'pescatarian' and 10% were 'vegan'. When asked why they chose what they had ordered, only five of the respondents mentioned 'environmental reasons', with 'favourite order' and 'it sounded nice' being the most frequently cited reasons. Most respondents were aware of the 2-for-1 promotion, but not all were aware that beef burgers were not included in the deal. Two

Table 5. Milk usage and its impact category in Coffee Revolution in 2018 compared to 2019

Milk Type	Impact Category	2018 Usage (Litres)	2019 Usage (Litres)	Increase in Usage?
Dairy	Medium	2460	2206	No
Soya	Low	252	240	No
Oat	Low	282	564	Yes

Table 6. The number of options available in Interval, 29/04/2019 – 08/06/2019 and the same period in 2018. Value (£) of their sales in total, in relation to options available.

Sub-Category	Year	Number of items in each impact category		Value of Sales (£)	Value of sales in relation to number of other options available (£)
Afternoon	2018	Low	4	215.64	53.91
		Medium	13	1283.15	98.80
		High	0		
	2019	Low	7	1088.76	155.54
		Medium	20	10250.97	512.55
		High	0		
Evening	2018	Low	13	4984.85	383.45
		Medium	29	16803.60	597.41
		High	0		
	2019	Low	5	1860.77	372.15
		Medium	10	6615.88	667.59
		High	1	894.20	894.20
Sandwiches	2018	Low	1	430.70	430.70
		Medium	8	3933.85	3933.85
		High	0		
	2019	Low	2	358.55	179.28
		Medium	6	4048.92	674.82
		High	1	596.37	596.37

Table 7. The number of burger options available in Bar One, 29/04/2019 – 08/06/2019 and the same period in 2018. Value (£) of their sales in total, in relation to options available

Year	Number of items in each impact category		Value of Sales (£)	Value of sales in relation to number of other options available (£)
2018	Low	16	14673.49	917.09
	Medium	10	13088.28	1208.83
	High	12	15091.62	1257.64
	Other	9	3843.10	
2019	Low	19	10964.60	577.08
	Medium	13	21848.83	1680.80
	High	13	16795.51	1291.96
	Other	8	2695.41	

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Table 8. Comparison of percentage sales of different burger types during the first two weeks of term in 2017-18 and 2019-20. A new menu promoting low impact burgers was introduced in 2019-20.

Year	Burger Type	Percentage of Sales (%)
2017-2018	Beef	39
	Chicken	35
	Vegetarian/Vegan	26
2019-2020	Beef	30
	Chicken	44
	Vegetarian/Vegan	26

Table 9. % Burgers sold on Climate Strike Day, previous day, over the 2019-20 new menu first two weeks (September 2019).

Burger Type	Impact Category Climate	Strike Day (20-9-2019)	Previous Day (19-9-2019)	2019-20 new menu first two weeks (September)
Beef	High	6.6%	42.1%	30%
Chicken	Low	59.4%	39.1%	44%
Meat-free	Low	33.9%	18.8%	26%

respondents chose chicken burgers as they thought beef was off the menu; a misunderstanding possibly based on another SSU outlet (Our Shop) not to sell beef burgers from their express counter on Climate Strike day. Most said that not including beef burgers in the 2-for-1 promotion did not influence their choice, mainly because they had pre chosen what they would have had. Four respondents said the promotion did influence their choice, with one flexitarian saying it led them to choose chicken instead of beef. Most respondents were aware of the climate strike. However, most said that it did not influence their meal choice. Of the seven respondents who said it did influence their choice, four chose vegan burgers (2 meat-eaters, 1 pescatarian, 1 vegetarian) and 3 chose chicken burgers (all flexitarians).

The response for the suggestion of removing beef from the Bar One menu was very positive from all respondents, regardless of their meal choice or diet. Some said that it would be a "bold move" but would remain supportive of it and recognise its environmental rationale. The two respondents who said that they would have ordered beef had they known it was on the menu were also supportive. They said that they would recognise the rationale behind it despite being 'slightly disappointed' that they would not be able to have it. They also said that as long as chicken remained on the menu, they would not miss beef too much, suggesting a positive response to the promotion of low GHGE foods without a complete shift to a plant-based diet in the short term. No customers who had ordered a beef burger on this day were surveyed. Still, those surveyed' responses indicate they would give positive affirmation to Bar One for supporting the climate crisis in this way. Flexitarians who chose meat options opted for chicken over beef, as many said they do not eat red meat.

4. Discussion

A major dietary shift is needed to reduce the GHGE from food production as altering agricultural practices alone will not be sufficient (Hoek et al., 2016). Despite most staff and students at the University of Sheffield and Sheffield Student's Union being 'meat-eaters', interview findings suggest that reaction to the introduction of a low impact logo to distinguish foods with low associated GHGE would be overwhelmingly positive in this setting. This finding mirrors a 2008 focus

group by the supermarket Tesco, which found that consumers were concerned about climate change and interested in the carbon labelling of products (Vanclay et al., 2011).

This study found that 'clearer signposting of environmental impacts on menus and packaging in SSU outlets' was one of the main things people wanted to see from SSU regarding sustainable diets. Despite this, more research is needed to establish whether such interventions would impact consumption patterns of low impact foods both within SSU and at home. Initial reactions from a menu redesign in Bar One emphasising lower impact chicken items, converging prices of high and low impact items and providing information on environmental impacts has been positive. Over the first two weeks of its introduction, percentage sales of chicken burgers increased, while beef burgers decreased (see Table 8). This effect was replicated in the climate strike intervention (see table 9). One logical next step would be integrating the existing red and orange labels into the new menus - something that was discussed but not actioned in this living lab intervention. This integration of additional colours might have an off-putting effect on consumers to high/medium impact choices, rather than just making low impact choices more appealing (Shewmake et al., 2015; Sonneberg et al., 2013).

Chen et al. (2016) suggest that low impact items may have higher profit margins, given their more efficient means of production. Nevertheless, this may not be the case in this scenario as the value and percentage of sales as investigated by this paper may not represent profit margins of each type of food. Bar One beef burgers are cheaper to buy and thus more profitable than vegan burgers. However, chicken burgers have a high-profit margin and low impact. They would be a good initial point of promotion until vegan burgers become more readily available and cheaper to produce.

This study found that staff and students' diets at the University of Sheffield and patrons of SSU were significantly different from those found by YouGov.co.uk (2019). This contrast is somewhat unsurprising given that the study population can be considered skewed towards those in the 18-24 age bracket. Additionally, during face-to-face surveys, vegan cakes were offered as an incentive. In the online surveys, 'sustainable diets' were mentioned, which may have skewed the population towards those already following or interested in sustainable diets (See Appendix). Given that the proportion of those with 'lower impact' diets (flexitarians, pescatarians, vegetarians and vegans) was greater in this population than the population examined by YouGov.co.uk (2019), interventions to promote sustainable diets may better serve communities and workplaces with a lower awareness of the climate impact of diets.

It should also be noted that people may follow these diets for reasons other than their low climate impacts, such as for health or cultural reasons. Further study into other factors, such as the social connotations of diet, would therefore be relevant.

This study shows which interventions involving a low impact logo had the most significant impact on conscious food choice. Interval had the greatest logo recognition rate of all outlets suggesting that having a low impact logo, directly beside low impact food items on the main menu, is the best-studied method to engage with more environmentally-conscious food choices. Despite this, further study is needed to see whether this impacts food choice long term both within the outlet and if it has a knock-on effect on food choice in the home. Higher rates of logo recognition and understanding may be achieved by using a similar strategy to Interval across all outlets. We are aware that similar interventions using logos and traffic lights are now being trailed in other universities such as London School of Hygiene & Tropical Medicine and Oxford (White, 2019, Brown, et al., 2020, Harris, 2020 and Potter, 2020)

Combining menu interventions with a price incentive would also motivate behaviour change, as shown by Vanclay et al. (2011) and the Bar One menu redesign which included price convergence between beef and chicken burgers. Indeed, this would be beneficial in settings with large student populations given cost is a prominent issue for them than for staff (according to this study). During the interviews, many respondents noted that the 'cup levy' already being applied to all hot drinks bought in take away cups across the SSU, was successful in reducing take-away cup use: "I always bring my own coffee cup just because it saves

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money".

The additional global climate strike day intervention highlights that students are receptive to monetary incentives, with the added benefit of raised awareness of the climate impacts of beef products. However, there were multiple limitations to this additional intervention: 1) Many customers on this day had attended the climate strike themselves and were therefore already environmentally conscious - this may have skewed results. 2) Customers who ordered beef burgers were not surveyed, and their responses may have changed the overall responses. 3) There was confusion amongst customers about whether beef was served on this day or not. 4) Most people seemed to think that beef was not being served which may have been why beef sales were low. 5) Customers may have worked out the purpose of the study and subsequently altered the truth with their responses to give a more desirable or socially acceptable answer. For these reasons further research is needed to understand if menu interventions with a price incentive may be viable as a long-term solution.

When initially devising this living lab project, the intention was to investigate both conscious (such as the low impact logos) and subconscious methods of nudging food choice towards more sustainable options. However, it was decided to focus on conscious interventions following feedback from restaurant outlet managers. Since the majority of both meat-eaters and flexitarians were unlikely to change their diet to vegetarian or vegan in the next 12 months, as well as the difficulty in breaking long-term habits (Chen et al., 2016), nudging more sustainable food choices via subconscious methods such as salience building and menu rearrangement (Wansink & Love, 2014) may have a substantial impact across all diet types. Indeed, initial findings from Bar One's menu redesign following this study have proved effective in reducing beef burger consumption.

Results from interviews suggest that social norms may be a useful avenue to assess food choice, especially in students. Many mentioned that their friends and housemate's diet impacted on their own diet, i.e., if their friends were vegan, they would be more likely to choose vegan food themselves. Some studies have found social norms to facilitate behaviour change (Camilleri et al., 2019).

Our findings also lead to specific theoretical and practical implications regarding living labs. This paper shows that the living lab methodology helps co-create and deploy successful sustainable food interventions on a university campus. Our study could be used as a model for further interventions. However, there are many aspects to successfully deploying a living lab methodology (Dekker et al., 2020); care must be taken to carefully co-design the lab/interventions with the location, outlets and community. For this reason, living lab co-creation theory and methods need to be further explored for a broader range of living lab settings (i.e. beyond the campus). Practically, this means that discussions with possible locations, outlets and communities need to occur to understand what is right for each. In this context, we suggest using the interventions suggested by Bianchi et al. (2018), Abrahamse (2020) and Attwood et al. (2020) as starting points for this discussion.

Our study has shown that living labs can assist a university in moving towards its sustainability strategy targets. From a practical policy perspective, we suggest that governments and organisations (such as universities) could use, deploy, (and fund) living labs as part of their toolbox to change diets, improve health, and decrease carbon emissions.

5. Conclusions

This paper suggests that introducing a low GHGE impact logo on main food menus within the university and Student's Union food outlets would be received positively and are something students want to see from their Student's Union. However, it is uncertain if this would be reflected in purchasing and consumption behaviour both within the Student's Union and in people's homes. Information campaigns and cost incentives supporting such interventions may be needed to improve awareness and engagement. Initial findings from a menu redesign where low impact items are given prominence, their cost reduced, and information about environmental impacts provided, has yielded promising positive results. Student diets are atypical to those across the UK, with flexitarian, vegetarian and vegan diets being more popular among students. This would, therefore be an interesting and

receptive study system to encourage widespread sustainable food choice.

Conflict of interest

The authors declare no conflict of interest, though they do highlight that many of the authors do work for the venues used as study locations.

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Please note that due to this project being initiated and carried out by staff and students from within the Students' Union (with advisory from academics at the University of Sheffield) no internal University of Sheffield ethics application and review process was carried out for the above interventions. (However, future living lab interventions will now undergo ethical application).

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Appendix 1 – Additional online survey information

The online survey was sent to staff on 7th May 2019 and to students on 8th May 2019.

It was sent with the subject line 'Sustainable diets at Sheffield: Survey participants needed' and was accompanied by an email that follows:

'The Students' Union is looking into ways that we can help promote sustainable diets.

We know the world of sustainability can be confusing at times. This is why we're aiming to make changes to menus to help environmentally conscious students choose low-impact choices. But we need your help!

Please fill in the survey at this address: https://docs.google.com/forms/d/e/1FAIpQLSc-ZwH1C0zF7tQq6C33Vb8EQ_9kMMtn36jIF-wEa-65qwSlYJOw/viewform?usp=sf_link

Filling in this survey will only take 2-3 minutes and provide us the information on how to best help you make sustainable choices.

Together let's make the Students' Union more sustainable!'

The survey comprised of 19 questions including questions regarding the respondent's diet, the importance of different factors on food choice, whether they were trying to reduce their meat intake, the likelihood they would change their diet, how they thought the student's union promoted issues surrounding diet and what other sustainable activities they were involved with. Additionally, demographic questions on age, gender and occupation were asked.
In the survey, diet type was split into 9 categories following the questionnaires designed for the Take a bite out of climate change (Kluczkovski et al., 2020) and ScenoProt projects (Makery 2016).

I frequently eat meat and I am not interested in trying vegetarian food
I often eat meat and I occasionally eat vegetarian food
I often eat both meat and vegetarian food
I frequently eat vegetarian food and occasionally eat meat (flexitarian)
I eat fish, dairy and eggs in addition to products derived from plants (pescatarian)
I eat dairy and eggs in addition to products derived from plants (ovo-lacto-vegetarian)
I eat dairy in addition to products derived from plants (lacto-vegetarian)
I only eat products derived from plants (vegan)
Other

Appendix 2 – Climate Strike Questionnaire.

What have you ordered?
How would you describe your diet?
Why did you choose you chose today?
Are you aware of the promotion today?
Did it influence your choice?
Are you aware of the climate strikes today?
Did the climate strike influence your choice?
What do you think of Bar One supporting sustainable diets with promotions?
What would you think if Bar One took beef off the menu?

Appendix 3 Information flyers
Appendix 4 - Other designs of the traffic light logos

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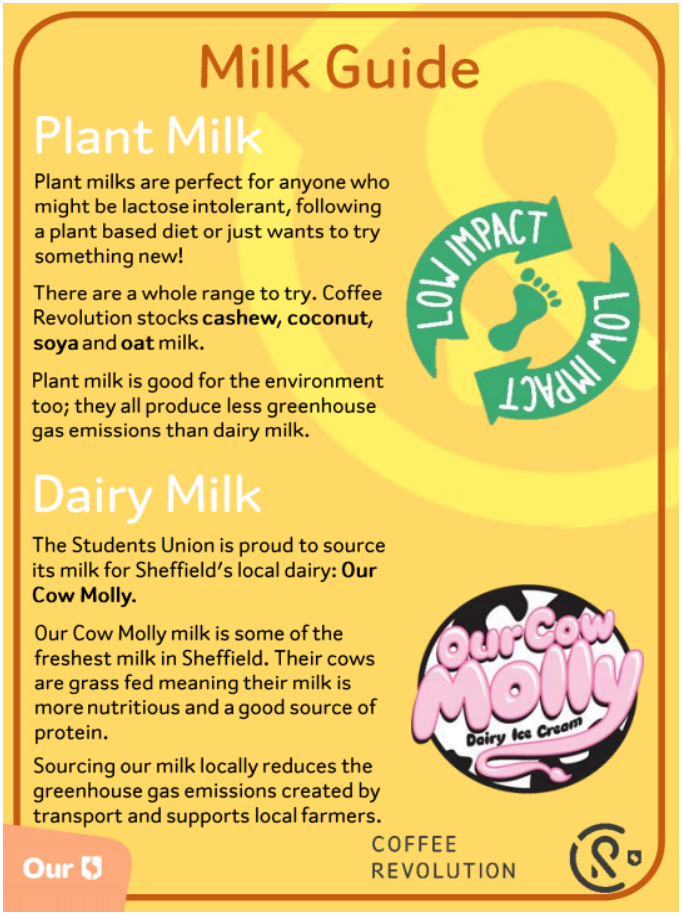
Appendix 5 - Menu information milk guides

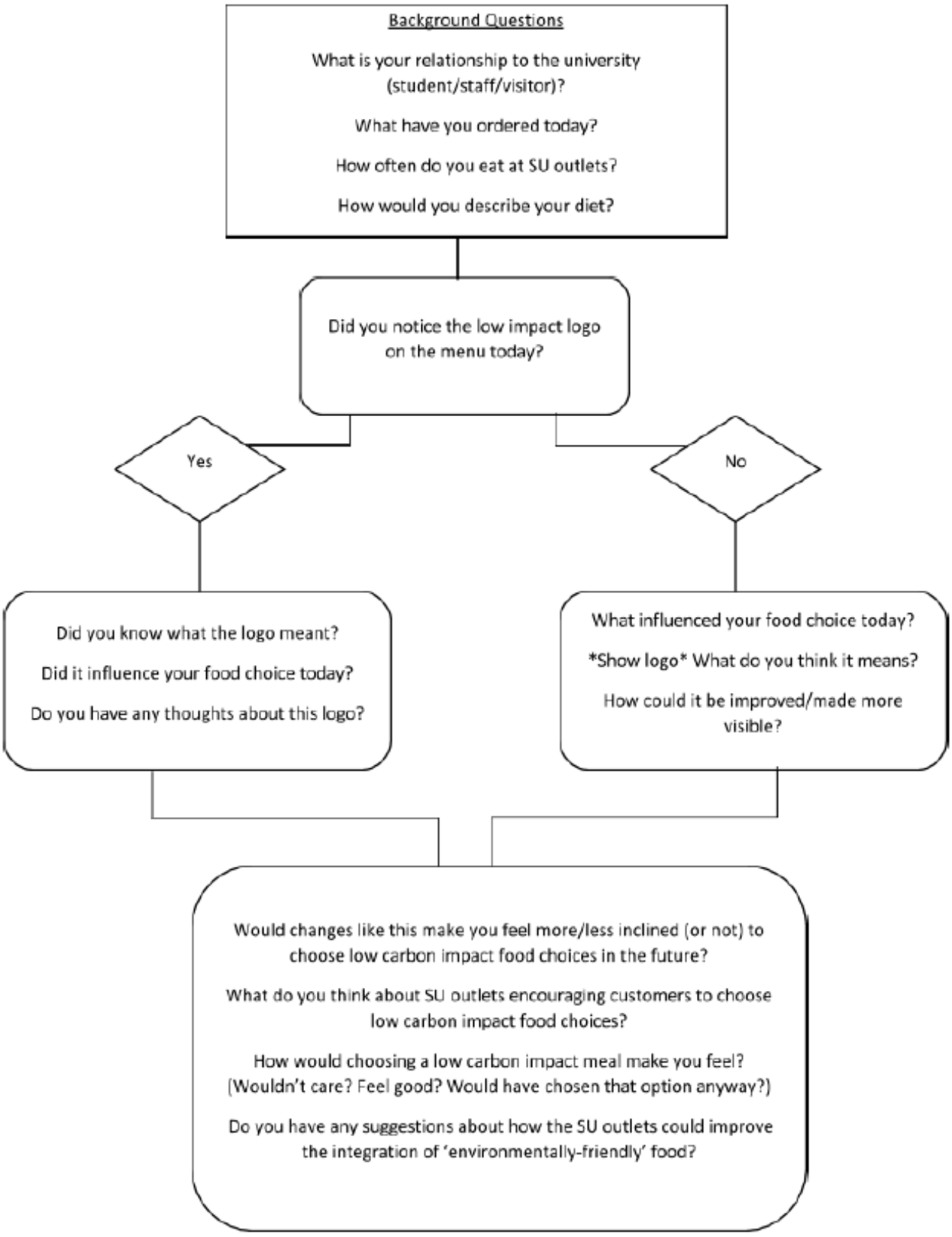
Draft logos

Final traffic light logos



Appendix 6 - Question script

Appendix 7 - Bar One Climate Strike Menu Choice Survey



Change 'logo' to 'Low Impact Menu' for Bar One interviews, or 'Milk Menu' in Coffee Revs/Interval

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Key Points

Bar One customers were surveyed to find out what they ordered on the day of the climate strike, and whether the exclusion of beef burgers from the 2 for 1 promotion influenced their choice.
There was a significant decrease in the sale of beef burgers, compared to the previous day's sales, and an increase in chicken and meat-free burgers
Customers supported the idea of Bar One removing beef from the menu completely, including those who eat beef

Introduction

On the day of the global Climate Strikes, Student Union outlets introduced one-day-only promotions on low impact menu options. Bar One hold a 2 for 1 offer on all burgers at the beginning of each semester. For the Climate Strike, Bar One excluded all beef burgers from the offer as the highest impact dishes on the menu. To test whether or not the promotion had an impact on the sale of beef burgers, 31 customers were surveyed.

Methods

Customers who had ordered food were approached and asked 9 questions:

What have you ordered?
How would you describe your diet?
Why did you choose what you chose today?
Are you aware of the promotion today?
Did it influence your choice?
Are you aware of the climate strikes today?
Did the climate strike influence your choice?
What do you think of Bar One supporting sustainable diets with promotions?
What would you think if Bar One took beef off the menu?

Their responses were simplified to allow for categorisation and calculate percentages. The sales data for the Climate Strike day and the day before were also collected, although vegetarian and vegan burgers were categorised into one category (meat-free burgers).

Sales Results

The promotion saw the following changes in sales compared to the previous day:
35.5% decrease in beef burger sales
20.3% increase in chicken burgers
15.1% increase in meat-free burgers
36 more burgers sold

Key Findings

Diets. Two-thirds of customers described themselves as either a meat-eater or flexitarian. Around 25% were either vegetarian or pescatarian, and the remaining 10% were vegan.

Reasons for ordering.

When asked why they chose what the ordered, 5 out of 31 people said 'environmental reasons' after 'favourite order' and 'it sounded nice'. 2 people said they made their choice because they thought that beef was not on the menu and had to make an alternative choice

Table 9. % Burgers sold on Climate Strike Day, previous day, over the 2019-20 new menu first two weeks (September 2019).

Burger Type	Impact Category Climate	Strike Day (20-9-2019)	Previous Day (19-9-2019)	2019-20 new menu first two weeks (September)
Beef	High	6.6%	42.1%	30%
Chicken	Low	59.4%	39.1%	44%
Meat-free	Low	33.9%	18.8%	26%

(both respondents chose chicken burgers)- a misunderstanding possibly based on the Our Shop decision not to sell beef burgers from the express counter on Climate Strike day.

Influence of the promotion.

Most people were aware of the 2 for 1 promotion, but not everyone was aware that beef burgers were not included in the deal. Most people said that this part of the promotion did not influence their choice, often because they chose what they would have had anyway.

4 people said the promotion did influence their choice. 2 meat-eaters said it was because they thought there was no beef on the menu today. 1 vegetarian chose a vegan option because 'not many places sell seitan chicken so it was a treat'. 1 flexitarian said it led them to choose chicken instead of beef.

Influence of the climate strike.

Most people were aware of the climate strike, however most said that it did not influence their meal choice. Of the 7 people who said it did influence their choice, 4 chose vegan burgers (2 meat-eaters, 1 pescatarian, 1 vegetarian) and 3 chose chicken burgers (all flexitarians).

Thoughts on the removal of beef in Bar One.

The response for the suggestion of removing beef off the Bar One menu was very positive from all customers, regardless of their meal choice or diet. Some said that it would be a 'bold move' but would be fully supportive of it and would recognise it as support for the environment and climate change.

The two customers who said that they would have ordered beef had they known it was on the menu were also supportive. They said that they would recognise it as support for the climate despite being 'slightly disappointed' that they would not be able to have it. They also said that as long as chicken remained on the menu, they would not miss beef too much. Unfortunately, no customer who had ordered a beef burger on this day were surveyed, but these responses indicate that praise would be given from customers to Bar One for supporting the climate crisis in this way.

Flexitarians who chose meat options opted for chicken over beef, as many said they do not eat red meat

Limitations and Considerations

Many customers on this day had attended the climate strike themselves and were therefore already environmentally conscious. This may have skewed results. Customers who did order beef burgers were not surveyed and their responses may have changed the overall responses.

There was confusion amongst customers about whether beef was being served on this day or not. Most people seemed to think that beef was not being served which may have meant that beef sales were low for this reason.

Customers may have worked out the purpose of the study (especially likely due to many respondents being students) and subsequently slightly altered the truth with their responses in order to give a more desirable or socially acceptable answer.

Recommendations

Reduce the choice of beef burger options on the bar one menu to limit choice and encourage meat-eaters to choose chicken over meat.

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Appendix 8 - Detail of diet categories in Online Survey

Original Diet Category	Grouped Diet Category
I frequently eat meat and I am not interested in trying vegetarian food	Meat eater / Meat Only
I often eat meat and I occasionally eat vegetarian food	Meat eater
I often eat both meat and vegetarian food	Meat eater
I frequently eat vegetarian food and occasionally eat meat (flexitarian)	Flexitarian
I eat fish, dairy and eggs in addition to products derived from plants (pescatarian)	Pescatarian
I eat dairy and eggs in addition to products derived from plants (ovo-lacto-vegetarian)	Vegetarian
I eat dairy in addition to products derived from plants (lacto-vegetarian)	Vegetarian
I only eat products derived from plants (vegan)	Vegan
Other	Other

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Research Paper

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Diversification of maize-based intercropping systems in tropical rainforest agroecosystem of Nigeria: productivity, profitability and soil fertility

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Keywords

crop diversification; cowpea; groundnut; sweet potato; sustainable intensification.

Smallholder farmers in Africa are in dire need of resilient maize-based cropping systems that can guarantee food, nutrition, and income security in the face of increasing armyworm infestations, erratic rainfall and drought occurrences. Thus, this study aims to identify adaptive maize-based systems with high productivity, increased profitability, and enhanced soil fertility for the tropical rainforest of Nigeria. We evaluated four maize-based systems, comprising of sole maize; maize/cowpea intercrop; maize/groundnut intercrop; and maize/sweet potato intercrop for higher productivity, profitability, and soil fertility. Results showed that the system productivity of maize/sweet potato intercrop (4.2 t ha^{-1}) was significantly higher ($P = 0.05$) than those of maize sole (2.6 t ha^{-1}); maize/cowpea (3.5 t ha^{-1}); and maize/groundnut (3.0 t ha^{-1}). Also, maize/sweet potato ($ 1081 ha^{-1}) significantly increased the net income in terms of monetary profits compared to those of maize sole ($ 557 ha^{-1}); maize/cowpea ($ 882 ha^{-1}); and maize/groundnut ($ 699 ha^{-1}). However, the net benefit-cost ratio of maize/sweet potato (2.47) and maize/cowpea (2.35) was similar. The effect of cowpea, when intercropped with maize, significantly increased the total nitrogen (N) content and available phosphorus (P) in soil by about 22% and 6-12%, respectively, compared to those of maize sole, and maize/sweet potato and maize/groundnut. Here, we conclude that the intercropping of maize with sweet potato and/or cowpea in this agroecosystem is an adaptive and resilient system, which is capable of meeting the food, nutrition, and income stability of farmers while maintaining the soil health. Crop diversification through intercropping can contribute to agroecological balance and maintenance of the soil ecosystem services.

1. Introduction

Maize (Zea mays L.) is an important staple crop that is grown under rainfed and irrigated systems in southern and northern Nigeria (Olaniyan & Lucas, 2004). About 80 % of the total maize production is consumed by humans and livestock, while 20 % is utilised for industrial processes such as ethanol and starch production (Onuk *et al.,* 2010). Many farmers in Africa grow maize as a sole crop during the cropping seasons; however, this mono-cropping practice is unsustainable as weather variability such as drought, flood, and pests and disease outbreaks can lead to crop failure and loss of income (FAO, 2014). In recent years, armyworm infestation is devastating millions of hectares of maize farms across Nigeria, Africa, and globally with a significant yield loss of up to 50-60 %. Furthermore, this is threatening the food security of more than 300

million people in Africa, coupled with a significant economic loss of up to $ 4.8 billion from maize production alone (FAO, 2017).

Increase in maize production in Nigeria is due to the expansion in area cultivation rather than an increase in yield (Ogundari *et al.,* 2006). However, crop diversification with the maize-based intercropping system can contribute to increased yield per unit area without increasing the land area while creating a more resilient production system. Also, diversification within cropping systems maximises the use of soil, water, and biological resources, and the benefits of on-farm nutrient cycling and pest and disease control (Kremen & Miles, 2012; Lin, 2011). The diversification of maize-based systems is crucial to improving food, nutrition, and livelihood security while providing insurance against climate uncertainties (Senger *et al.,* 2017). Research has shown that intercropping enhances productivity, profitability, resource use efficiency, and soil fertility by increasing land-use efficiency, improving soil fertility, ensuring economic stability and utilising on-farm available resources (Li *et al.,* 2020; Gong *et al.,* 2020; Altieri *et al.,* 2012).

Maize is suitable and adaptable for the intercropping system due to its wide inter-row spacing and erect growth habit, which allows for complementary benefits for the intercrops. Intercrops with different light distribution intensity and root systems can utilise resources more efficiently (Gong *et al.,* 2020; Prasad & Brook, 2005). The combined yields and profits from intercropping systems often exceed those of monocultures; thus, it is popular among farmers (Javanmard *et al.,* 2009). For example, maize intercropped with cowpea, soybean, potato, and groundnut showed a significant yield advantage compared to sole cropping in tropical agroecosystems (Begum *et al.,* 2016; Mucheru-Muna *et al.,* 2010; Chinaka & Obiefuna, 2000). Maize, when intercropped, is less susceptible to pests, diseases and weed infestations (Bilalis *et al.,* 2010). More importantly, the inclusion of legumes in intercropping systems plays an essential role in soil fertility restoration through biological nitrogen fixation (Sanginga, 2003; van Kessel *et al.,* 2000).

However, research on adaptive maize-based intercropping systems that are resilient to the changing climate is lacking. Thus, there is an urgent need for the identification of diversified cropping systems due to the devastating effects of army-worm invasion on maize yields. This study focuses on the productivity, profitability and soil fertility of maize-based intercropping systems in the rainforest of Nigeria. We hypothesis that intercropping of maize with either of cowpea, groundnut, and sweet potato would increase productivity, profitability, and soil fertility compared to maize sole cropping.

2. Materials and Methods

2.1. Site description and experimental design

The field experiment was conducted during the 2017-2018 rainy season in tropical rainforest in Nigeria. The soil is slightly acidic pH (4.4) and is classified as ultisol according to USDA soil taxonomy. Within 0-15 cm soil depth, the total nitrogen, available phosphorus and potassium, and organic carbon were 0.07 g kg^{-1}, 6.8 mg kg^{-1}, 0.2 mg kg^{-1}, 1.1%, respectively. The rainfall amount, average temperature and relative humidity recorded during the growing season were 1764 mm, 28 °C and 68 %, respectively. The field experiment layout was randomised design replicated four times with four treatments, namely: maize sole cropping, maize/cowpea, maize/groundnut, and maize/sweet potato intercropping. The experimental field was ploughed, and seeds of maize were sown manually at a spacing of 0.75 m × 0.25 m, while the intercrops of cowpea and groundnut were adjusted at 0.75 m × 0.15 m, and sweet potato at 0.75 m × 0.4 m.

2.2. Crop management practices

The seed rates for maize, groundnut (Arachis hypogea), and cowpea (Vigna unguiculata) were 20, 60, and 25 kg ha^{-1}, respectively, and sweet potato vine cuttings with 4-5 nodes of 30 cm long. Seeds of maize and groundnut and vines of sweet potato (Ipomea batata) were sown on the same day (May 20, 2018), while cowpea was sown 40 days after (June 30, 2018). Compound fertiliser of NPK (15:15:15) at the rate of 40:20:20 kg NPK ha^{-1} was applied, with half dose at sowing and the remaining half as top dressing 30 days after sowing. A pre-emergent herbicide (atrazine; 2 kg a.i ha^{-1}) was applied a day after maize sowing to reduce weed growth, and this was followed by manual weeding with a hand-hoe on day 30, 60, and 90. Economic yields of respective crops were harvested manually at the physiological maturity stage (i.e. cowpea pods: 70

days, maize cobs: 98 days, groundnut pods: 101 days, and sweet potato tubers: 126 days).

2.3. Assessment of crop growth and yields

Plant height (cm) of maize in the different cropping systems were measured at harvest, including the yields components such as the number of maize cobs per grain and 1000 seeds weight. The system productivity in terms of the equivalent yield of maize was derived by converting the yields of the individual intercrop(s) based on the grain yield of maize and the market price using the formula (Begum *et al.,* 2016; Bandyopadhyay, 1984).

$$\text{System productivity (t ha}^{-1}\text{)} = \text{Maize grain yield} + \frac{\text{intercrop(s) yield} \times \text{price of intercrop(s)}}{\text{price of maize grain}}$$

2.4. Economic analysis of the cropping systems

The cost of cultivation in Naira (₦)/US dollar ($) per hectare for the cropping systems was computed from the fixed and variable costs incurred during the growing season(s). Gross return was derived from the economic yields of the respective cropping systems based on the local market price, while the net return was derived by deducting the cost of cultivation from the gross return. The net benefit-cost is the ratio of gross returns to the cost of cultivation, which describes the profit advantage of the individual cropping systems for the farmer.

2.5. Evaluation of soil nutrients/fertility

Soils from the different cropping systems were analysed for total N, available N, P, and organic carbon (OC). The soil samples collected from 0-15 cm depth were air-dried, crushed, and sieved through a 2 mm mesh for total N, available N and P, and 0.5 mm for OC. Total N (g kg^{-1}) in soil was analysed using the Kjeldahl digestion method, while soil available P and K (mg kg^{-1}) were estimated by Bray P and flame photometer methods, respectively. The soil organic carbon (%) was estimated using the wet oxidation method.

2.6. Statistical analysis

Collected data were subjected to analysis of variance (ANOVA) for the randomised complete block design using the SAS package 9.1. Only the datasets with complete treatments were analysed. Where treatment effects were significant at $P \leq 0.05$, least significant difference (LSD) tests were used to compare the means of each treatment combination.

3. Results

3.1. Growth, yields and system productivity

The growth (heights) of maize remained the same for the different cropping systems (Table 1), whereas the number of maize cobs and grain weights was significantly different ($P \leq 0.05$). Maize yields from the diversified systems were significantly different (Table 2). The grain yield of maize sole cropping system (2.60 t ha^{-1}) was significantly higher than those of maize/cowpea (2.26 t ha^{-1}), maize/groundnut (2.22 t ha^{-1}), and maize/sweet potato (2.39 t ha^{-1}). The yields of the intercrops are as follows: sweet potato tuber yield (2.34 t ha^{-1}); cowpea pod (1.01 t ha^{-1}); and groundnut pod (0.85 t ha^{-1}). The system productivity in terms of maize equivalent yield was significantly higher in the maize/sweet potato (4.19 t ha^{-1}) compared to those of cowpea (3.50 t ha^{-1}), groundnut (3.00 t ha^{-1}), and the sole cropping (2.60) (Fig. 1).

3.2. Economics and profitability

Economics of the diversified cropping systems were significantly different ($P \leq 0.05$). The cost of cultivation decreased significantly in the maize sole cropping than those of the intercrops, whereas the gross revenue and net profits under the intercropping systems increased significantly compared to that of sole cropping (Table 3). Within the intercropping systems, the income generated from maize/sweet potato was significantly higher than those of maize/cowpea and maize/groundnut. However, the benefit-cost ratio was comparable between the intercropping systems but significantly higher than that of maize sole cropping.

3.3. Soil nutrients/fertility

Soil nutrients availability was significantly different ($P \leq 0.05$) among the diversified cropping systems (Table 4). The total N and available P in soil were slightly higher under maize/cowpea compared to those of maize sole, maize/sweet potato, maize/groundnut. In

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contrast, the available K and organic carbon remained the same.

Table 1. Yield components of the different cropping systems

Cropping systems	Plant height at harvest (cm)	Number of grains cob^{-1}	1000-grain weight (g)
Maize sole	194.00a	321.10a	179.52a
Maize/cowpea	191.30a	298.25bc	164.70b
Maize/groundnut	189.70a	288.58c	163.55b
Maize/sweet potato	191.00a	304.99b	173.12ab
LSD (0.05)	ns	13.25	10.19

Means with a different letter in the same column under respective cropping systems are significantly different based on LSD ($P \leq 0.05$).

Table 2. Economic and biological yields of the cropping systems

Cropping systems	Maize yields		Intercrop yields	
	Grain	Straw	Pod/tuber	Straw
	(t ha^{-1})			
Maize sole	2.60a	2.19a	-	-
Maize/cowpea	2.26c	1.81b	1.01b	1.09a
Maize/groundnut	2.22c	1.80b	0.85b	1.05a
Maize/sweet potato	2.39b	2.05ab	2.34a	0.98a
LSD (0.05)	0.32	0.39	1.51	ns

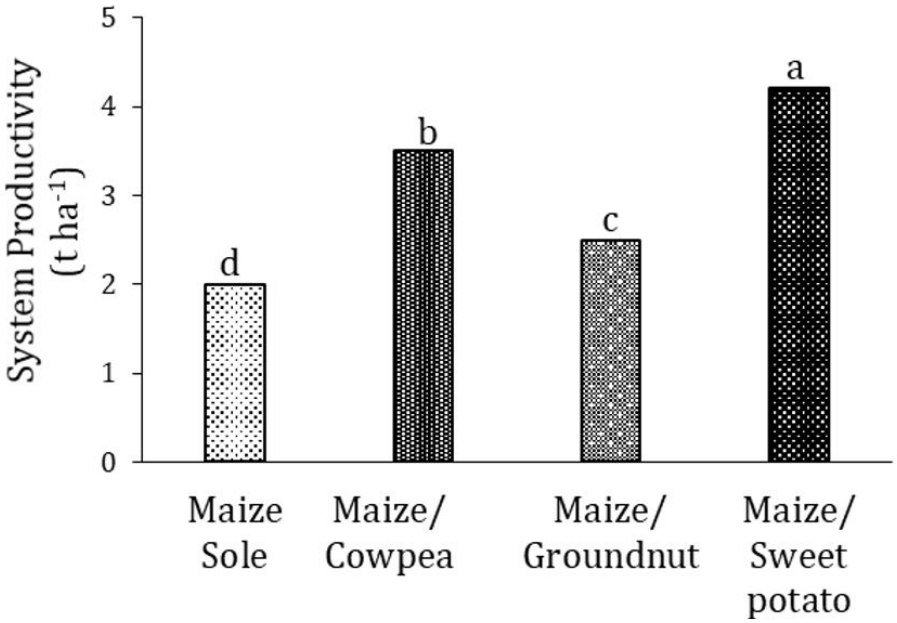

Figure 1. System productivity of the diversified cropping systems. Bars with a different letter under respective cropping system is significantly different based on LSD ($P \leq 0.05$).

Table 3. Economics of the cropping systems

Cropping systems	Cost of cultivation	Gross returns	Net returns	Benefit:cost
	₦ ha^{-1} ($*)			
Maize sole	170940 (570)	338000 (1127)	167060 (557)	1.98
Maize/cowpea	190940 (636)	455400 (1518)	264460 (882)	2.39
Maize/groundnut	180940 (603)	390600 (1302)	209600 (699)	2.16
Maize/sweet potato	220400 (735)	544700 (1816)	324300 (1081)	2.47

Market price (₦ kg^{-1}): cowpea (₦160 kg^{-1}); groundnut (₦ 120 kg^{-1}); sweet potato (₦ 150 kg^{-1}). *(1 USD = ₦ 300).

Table 4. Soil nutrients availability in the diversified cropping systems

Cropping systems	N (g kg^{-1})	P (mg kg^{-1})	K (mg kg^{-1})	OC (%)
Maize sole	0.07b	7.01b	0.15a	1.06a
Maize/cowpea	0.09a	7.46a	0.15a	1.09a
Maize/groundnut	0.07b	6.92b	0.15a	1.05a
Maize/sweet potato	0.07b	6.60c	0.14a	1.02a
LSD (0.05)	0.002	0.003	ns	ns

Means with a different letter in the same column under respective cropping system is significantly different based on LSD ($P \leq 0.05$).

4. Discussion

Higher grain yields achieved in the maize sole cropping than those of the intercrops is a function of the growth resources (e.g. space, light, nutrients, moisture) available to maize sowed as sole cropping than when intercropped with cowpea, groundnut, and sweet potato. Moreover, the increase in maize yields when intercropped with sweet potato could be attributed to complementary effect in terms of compatibility with light, space, nutrients and water use efficiencies than those of cowpea and groundnut. Competition for growth resources is a major tradeoff in intercropping systems, and hence, selecting crops that differ in photosynthetic activity, growth habit, duration, and nutrients demand are a prerequisite for higher productivity (Gong *et al.,* 2020). Similar to our study, Begum et al. (2016) and Chinaka and Obiefuna, (2000) reported that the system productivity of maize/sweet potato intercrops often exceeds that of sole crops due to synergism that favours the growth and yields of both crops. In a maize/sweet potato intercropping system, Begum et al. (2016) and Ifenkwe and Odurukwe (1990) showed that potato yield is always higher when maize sowing is delayed (30-45 days) than when both crops are sowed simultaneously. This observation is a result of maize canopy shading, which can intercept the availability of light, and consequently negatively affect the productivity of the intercrops. Thus, fine-tuning the planting dates of the intercrops can reduce the competition for growth resources, and hence increase productivity.

Increase in the cost of cultivation of the maize/sweet potato than those of maize/cowpea and maize/groundnut is due to the expenses incurred from additional agronomic management practices for the sweet potato. The yields of sweet potato positively

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affected the income generated than those of cowpea and groundnut. A good indicator of a cropping system is the actual profit obtained, which represents the suitability of a cropping system. Mucheru-Muna et al. (2010) showed that the gross returns from maize/potato, maize/cowpea and maize/groundnut increased significantly than that of maize sole cropping. Thus, the higher net returns from the maize/sweet potato are reflective of the increased productivity of both crops under intercropping systems compared to those of cowpea and groundnut. Interestingly, the benefit-cost ratio of the diversified cropping systems was greater than one, which shows that they were profitable.

Increased availability of N and P under the maize/cowpea system is a function of biological N fixation by cowpea. Legumes supply N, which can contribute to soil fertility improvement in diversified cropping systems (Sanginga, 2003; van Kessel *et al.,* 2000). For instance, cowpea and groundnut can supply about 80 to 350 kg N ha^{-1} through biological N fixation process (Mobasser *et al.,* 2014). Moreover, P availability increased when cowpea was intercropped with maize compared to maize without cowpea (Pypers *et al.,* 2007). Thus, the inclusion of legumes in cropping systems diversification offers a safety net for yield stability through enhanced soil fertility, particularly in the sub-optimal condition of poor-resource smallholder farms across Africa (Sanginga, 2003). Therefore, the choice of cropping systems that can withstand climatic uncertainties and contribute to soil health should become a prerequisite for sustainable diversification of cropping systems (Wang *et al.,* 2010).

5. Conclusion

Crop diversification through intercropping can contribute to yield stability, food security, and income security under the changing climatic conditions. Maize/sweet potato intercrop resulted in higher productivity and profitability, which is reflective of the synergism of both crops in utilising resources (space, light, water and nutrients) more efficiently than those of cowpea and groundnut intercrops. Moreover, increased soil availability of N and P under maize/cowpea and the comparable net benefit-cost with maize/sweet potato to demonstrate the positive effects of legumes in the cropping system diversification. The inclusion of a nutrient-enriching crop such as cowpea can contribute to soil fertility improvement while ensuring ecological balance. More importantly, diversification of maize-based systems through intercropping is a sustainable and adaptive approach for food, nutrition, and income security. Therefore, the development of adaptive intercropping systems tailored to farm typologies could contribute to sustainable intensification of crop production from resource-poor smallholder farmers across Africa.

Conflict of interest

The authors declare no conflict of interest. Besides, the funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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Research Paper

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Awareness creation of smallholder farmers and adoption of push-pull technology reduce the infestation of fall armyworm (Spodoptera frugiperda) on maize in Hawzien Woreda, Northern Ethiopia

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Fall armyworm (Spodoptera frugiperda), maize, silver-leaf desmodium, Sudan grass, push-pull technology, smallholder farmers

Recently, maize (Zea mays L.) production by smallholder farmers in Ethiopia has been threatened by an exotic pest called fall armyworm (FAW) (Spodoptera frugiperda J.E. Smith; Lepidoptera, Noctuidae). Devising or adopting sustainable, effective, affordable and smallholder farmer-friendly management strategies for the control of this pest are, therefore, vital. Push-Pull Technology (PPT) is considered one of the management methods for the control of FAW in East Africa. Therefore, this study aims to determine pre- and post-training perceptions of smallholder farmers on FAW and PPT, and evaluate the status of the pest and plant damage on PPT adopted maize fields through rain-fed and irrigated farming. The results revealed that smallholder farmers had little or no knowledge of biology, identification, and management methods of FAW and about PPT before training. However, the farmers responded to the acquisition of adequate knowledge and skills on these topics after training. FAW eggs and larvae and the proportion of damaged plants were significantly lower in PPT maize plots relative to maize monocrop plots. This study depicts the adoption of PPT by smallholder farmers, that along with training resulted in the reduction of FAW. Thus, adoption and extension of PPT are expected to play a vital role in the management of FAW, mainly in the smallholder farming system.

1. Introduction

In Ethiopia, maize (Zea mays L.) is one of the major cereal crops grown for its food and feed values, that serves as a stable food and feed source for millions in Ethiopia (Abate et al., 2016; CSA, 2016; Tefera et al., 2016). Maize plays an important role in Ethiopia's food security (CSA, 2016). Insect pest problems have been reported as one of the major challenges of maize production in the country (Waktole & Amsalu, 2012; Shiberu, 2013; Tefera et al., 2016). Moreover, recently, the maize productions in different states of the country have been threatened by an exotic pest called fall armyworm (FAW) (Spodoptera frugiperda Smith; Lepidoptera, Noctuidae) (FAO, 2017; Midega et al., 2018; Harrison et al., 2019; Gebreziher, 2020a). FAW, believed to be originated in the tropics and subtropics of America, causes damage to almost 100 plant species

including maize, rice, sorghum, wheat, and sugarcane but also vegetable crops and cotton (Andrage et al., 2000; Abrahams et al., 2017; Midega et al., 2018).

FAW is one of the most devastating pests in terms of loss of livelihoods and economic impact in high-income countries, let alone developing countries, where it causes substantial loss to maize and other crops (Hailu et al., 2018). Kenya has lost approximately 15,000 ha of maize to FAW, valued at Shilling 1.3 billion (Oketch, 2018). Similarly, this pest caused considerable damages to maize production in other Eastern countries (Kassie et al., 2018; Gebreziher, 2020a, 2020b).

FAW was first detected on the African continent in 2016 (Goergen et al., 2016; FAO, 2017; Day et al., 2017; Harrison et al., 2019), and outbreaks of the pest have been reported in West and Central Africa including Botswana, Democratic Republic of Congo, and Ghana. It spread quickly from West and Central Africa across the continent, causing extensive damage to maize crops (Goergen et al., 2016; Abrahams et al., 2017) such as Kenya, Malawi, Namibia, South Africa, Swaziland, and Zambia in the same year FAW was detected in the continent (Abrahams et al., 2017; Midega et al., 2017). Further spread of Fall Armyworm was observed in Ethiopia, Tanzania, and Zimbabwe in February 2017 (Midega et al., 2018). As of December 2017, 54 African countries were surveyed, and FAW was found to be spreading very fast, having covered about 38 countries in Africa (Westbrook et al., 2016; FAO, 2017; Harrison et al., 2019). The finding shows that the spread of FAW in the continent has been dramatically fast. The spread has not been confined to Africa; it has subsequently spread across Asia. In 2018 countries such as India and Yemen (by July 2018), Bangladesh, Sri Lanka and Thailand (by December 2018), Myanmar, China, Indonesia, Laos, Malaysia and Vietnam, and the Republic of Korea (by June 2019) and to Japan (by July 2019) all reported incidences (Harrison et al., 2019). The rapid spread of FAW might be because of its sporadic and long-distance migratory behaviour, with the adult moths capable of flying over 100 km in a single night (Andrade et al., 2000; Guerrero et al., 2014; Westbrook et al., 2016; FAO, 2020). In Ethiopia, the FAW infestation was reported in the Southern Nations, Nationalities and Peoples' State in March 2017 and spread fast to other states becoming an epidemic pest in June 2017 (Gebreziher, 2020a).

Therefore, devising sustainable, effective, affordable, and smallholder farmers-friendly management strategies for the control of these pests is vital. In many countries, management of FAW is mainly monitor-based Integrated Pest Management. Monitoring methods for FAW in various countries such as the USA, mainly involve use of specific pheromone traps (involving [(Z)-7- dodecenyl acetate), (Z)-9-dodecenyl acetate), (Z)-9-tetradecenyl acetate, and (Z)-11-hexadecenyl acetate] (Andrade et al., 2000; Guerrero et al., 2014). Pheromone-based monitoring has been proven effective in controlling the adult stage of many lepidopteran species (Guerrero et al., 2014) including FAW (Malo et al., 2002; Malo et al., 2004). Based on monitoring results, different management approaches are applied depending on the status of the pest. For instance, in America and Brazil, different strategies have been used to manage FAW including cultural practices, biological control using [parasitoids Cotesia marginiventris (Cresson), Chelonus texanus (Cresson) and Archytas marmoratus (Townsend)], predators (birds, rodents, beetles, earwigs) and pathogens [nuclear polyhedrosis virus (NPV), Baciluss thuringiensis (BT), Entomophaga aulicae, Nomuraea rileyi, and Erynia radicans] and botanicals (Assefa & Ayalew, 2019; FAO, 2020). Besides, Gebreziher (2020a) has reviewed the various FAW control methods such as monitoring (scouting, light traps, and pheromone traps), cultural methods (use clean seeds, avoiding late planting, increasing crop diversity or intercropping, optimizing planting depth, proper irrigation, destroying egg masses and handpicking and killing of larvae, push-pull technology, biological control, and chemical pesticides.

Push-Pull based integrated pest management, a multi-purpose use, climate-smart method, is considered one of the management methods recommended for control of FAW in East Africa (Kassie et al., 2018; Midega et al., 2018). The push-pull strategy is a novel tool for integrated pest management (IPM) programs which use a combination of behaviour-modifying stimuli to manipulate the distribution and abundance of insect pests and/or natural enemies (Holdrege, 2012; Khan et al., 2015; Midega et al., 2015b; Bhattacharyya, 2017; Midega et al., 2017; Gebreziher, 2020a, 2020b; Gebreziher & Gebreziher, 2020). In this strategy, the pests are repelled or deterred away from the main crop

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(push) by using stimuli that mask host apparency that releases repellent or deterrent semiochemicals. For example, the silver-leaf desmodium plant (Desmodium uncinatum Jacq.; Fabales: Fabaceae) is used as a repellent plant to various lepidopteran pests (Khan & Pickett, 2015; Midega et al., 2015a, 2015b). The pests are simultaneously attracted (pulled), using highly apparent and attractive stimuli to other areas such as trap crops like Napier grass (Pennisetum purpureum S.; Poaceae) or Sudan grass (Sorghum sudanense Piper; Cyperales: Poaceae), where the insect pests can be concentrated, facilitating their control (Khan & Pickett, 2015; Midega et al., 2015a, 2015b; Bhattacharyya, 2017; Midega et al., 2017; Gebreziher, 2020).

In the principle of push-pull systems the repellent plant, for instance, the silver leaf desmodium, produces volatile chemicals such as (E)-ß-ocimene and (E)-4,8-dimethyl-1,3,7-nonatriene (Midega et al., 2018), which repel the stemborer, FAW and other lepidopteran moths from the maize. The trap crops such as Napier- or Sudan grasses release volatile chemicals like octanal, nonanal, naphthalene, 4-allylanisole, eugenol and linalool, which attract female moths (pull-plant) to lay eggs on it (Midega et al., 2017). The volatiles released from the system also have an inhibiting effect on one devastating weed, the Striga (Midega et al., 2015a). Silver leaf desmodium roots produce chemicals that stimulate Striga seed germination, such as 4,5-dihydro-5,2,4-trihydroxy-5-isopropenylfurano-(2,3,7,6)-isoflavanone, and others which inhibit their attachment to maize roots, such as 4,5-dihydro-2-methoxy-5,4-dihydroxy-5-isopropenylfurano-(2,3,7,6)-isoflavanone (suicidal germination), thereby reducing Striga seed bank. The legume also improves soil fertility through nitrogen fixation (Midega et al., 2015a). In addition to its use in the system, the Napier- or Sudan grasses are good forage sources for livestock. Through the pushing and pulling effects of the companion plants, push-pull technology (PPT) has been reported to greatly reduce pest status in maize crops (Midega et al., 2017; Kassie et al., 2018; Midega et al., 2018; Gebreziher & Gebreziher, 2020).

PPT was first put into practice for the control of stem borer species and Striga in Eastern Africa such as Tanzania, Uganda, and Kenya (Midega et al., 2015a, 2015b; Midega et al., 2017). Recently, reports show that PPT has become a successful management tool for FAW in different East African countries such as Kenya, Uganda and Tanzania (Midega et al., 2017; Midega et al., 2018). Thus, adopting this technology to affected areas of Ethiopia is vital for the control of FAW in smallholder farmers involved in mixed farming.

FAW which has become a severe insect pest in all states of Ethiopia (Gebreziher, 2020), is also a serious maize pest in Eastern Tigray Regional State, Ethiopia; especially around Hawzien and nearby Woredas (administration level below zone). This insect pest has already become a significant challenge for smallholder farmers in the regional state. Thus, making the adoption trial of PPT (which has been proven effective in controlling FAW in other East African countries) in the smallholder farming system of the regional state is vital. Push-pull is one of the climate-resilience strategies in managing many lepidopteran species. The plant species used for push-pull, involve silver-leaf desmodium (repellent), Napier grass and Sudan grass (trap crops) which are widely available in Ethiopia including in different parts of Eastern Tigray Regional State. Considering the success of PPT in controlling FAW in our region (East Africa), adopting the technology in the already affected parts of Eastern Tigray is expected to reduce these pests to below economic threshold. Therefore, the objective of this study is to determine pre- and post-training perceptions of smallholder farmers on FAW and PPT and evaluate the status of the pest and proportion of plant damage by FAW on PPT adopted maize fields relative to maize monocrop plots.

2. Methodology

2.1. Project Area

The project was carried out twice through rain-fed (from June to October 2018) and by irrigation (from February to May 2019) in Hawzien Woreda, Hatset Kebelle. The district is located at 1850 - 2200 meter above sea level and receives an annual rainfall of 350-500 mm per annum, and temperatures range between 16-29oC. The Kebelle (administration area below Woreda level) fully involves smallholder farmers who are known for their production of maize, wheat, barley, and sorghum. Besides, vegetables such as tomato, onion, pepper, and leafy vegetables, and fruits, though not widely distributed, are also produced in the districts mainly by irrigation. The smallholder farmers

in the Kebelle produce maize twice a year through rain-fed (June to October) and irrigation (February to June). Similar to other Kebelles of the Woreda, the study area has been affected by the devastating FAW since 2017 and is predicted to be a problem in the irrigated and rain-fed crop production.

2.2. Materials and Methods

In the push-pull system, silver-leaf desmodium (Desmodium uncinatum Jacq.; Fabales: Fabaceae) as a repellent plant (push-plant) and Sudan grass (Sorghum sudanense Piper; Cyperales: Poaceae) as trap plant (or pull-plant) were used. The seeds of silver-leaf desmodium were obtained from Aksum Agriculture Research Center and Sudan grasses were obtained from Wukro Agriculture College. Maize (Zea mays L.; Variety: Melkassa-1Q) seeds were obtained from Hawzien Woreda Seed Distribution Office.

2.3. Description of the training and push-pull adoption

The study involved evaluating the perception of smallholder farmers on FAW and PPT before and after training, determining the status of FAW larvae and eggs on PPT adopted and monocrop maize plots and perception of farmers after the adoption of PPT. The smallholder farmers were asked about their awareness of FAW and PPT using a semi-structured interview. Interviews aimed to determine the awareness of farmers on the pest and the PPT technology. Then, training was given to nine smallholder farmers and two data collectors who were interested in adopting the technology (based on volunteerism) in June 2018 and covered topics on biology, identification and management of FAW, principles and practices of PPT, and application for FAW management. (Training topics are found in Tables 1 and 2).

After evaluating the response of farmers on the training (results show that farmers developed awareness about FAW and PPT; Table 4 and 6), a 10m by 5m maize plot was prepared with PPT on each farmer's field (description of PPT is found in 2.4 of this paper). Additionally, each farmer also had a 10m by 5 m plot of sole maize crops (monocrops), for a total of nine PPT maize plots and nine monocrop plots. The status of FAW at two stages (egg and larvae) and proportion of plant damage were compared between PPT maize plots and maize monocrop plots. The experiment regarding the infestation and damage of maize by FAW were carried out twice, that is, through rain-fed during 2018 (July to October) and by irrigation during 2019 (February to June).

2.4. Description of treatments

On each of the nine smallholder farmer's fields, a 10m x 5m field plot for PPT was prepared in addition to a 10m x 5m field plot for maize monocrops, both during the 2018 and 2019 experiment seasons. Thus, a total of nine plots for PPT adoption and nine plots for maize monocrop (as a control) were prepared. Each plot was considered as a replication. All farmers planted the maize simultaneously, mid-June for the 2018 experiment and at the beginning of February for the 2019 experiment. Maize crops were planted at 0.5m and 0.5m inter- and intra-row spacing, respectively. For the PPT plots, silver-leaf desmodium (push-plant) were intercropped at equidistance between maize plants in all rows. The maize field plots were surrounded by two rows of Sudan grass (pull-plant) at 0.5 m away from edges of the maize field plot with inter- and intra-row spacing of Sudan grass batch at 0.5m and 0.3m, respectively.

2.5. Evaluation of the PPT Adoption

Proper agronomic practices (weeding, cultivation, fertilization, and irrigation) were applied for both PPT adopted and monocrop maize plots. Daily inspections were carried out by farmers and supported with data collectors as well as weekly inspections by researchers for FAW eggs and larvae and the proportion of plant damages. The impact of the adoption of PPT during the rain-fed (2018) and irrigated (2019) experiments were evaluated by comparing PPT adopted maize plots with maize monocrop plots using FAW infestation (numbers of eggs and larvae), and proportion of plant damaged by the pest (if any) as parameters. Numbers of FAW eggs and larvae, as well as the proportion of plant damage, were collected from 10 randomly selected plants from a 3m-wide transect line which was demarcated diagonally across the PPT maize plots and monocrop maize plots.

Depending on the growth stage of maize, fall army-

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Table 1. Training topics and time allocation on biology of FAW and field practices

S.No	Topics	Description	Type of supporting materials used	Time allocated	Number of trainees involved
1	Biology of FAW*	Life cycle of FAW; - adult stage and identification (male and female) - eggs and identification - larval stages (1st to 5th instars) and identification	Photos of different stages of FAW	One day	9 farmers and 2 data collectors
2	Field practice on identification of eggs and larvae of FAW*	Based on the graphical presentation on biology of FAW from the previous training, each trainee collected eggs and larvae (different stages) of FAW	Field practice for identification	Two days	9 farmers and 2 data collectors
3	Insect collection methods, labeling, and reporting	Different jars (eggs and larvae, sweeping nets (adult), traps were demonstrated. Each trainee practiced the methods of specimen collection	Materials prepared at Adigrat university	One day	9 farmers and 2 data collectors

*Fall armyworm

Table 2. Awareness creation topics on PPT and application for management of FAW and soil fertility

S.No	Topics	Description	Type of supporting materials used	Time allocated	Number of trainees involved
1	Awareness on PPT*	- what is PPT - compositions of PPT - Economic functions of PPT	Photos and figures from internet sources	1 day	9 farmers and 2 data collectors
2	Companion plants for PPT*	Types of plants to be used and their function	Photos and figures from internet sources	1 day	9 farmers and 2 data collectors
3	Agronomic practices	Planting time, spacing, fertilization, irrigation	On field training	1 day	9 farmers and 2 data collectors

*Push-Pull Technology

worm larvae are found on young leaves, leaf whorls, tassel or cobs (Goergen et al., 2016). Therefore, infestation levels and damage of the pest on young leaves and leaf whorls during vegetative growth were assessed non-destructively. Each plant was then visually examined, and FAW eggs and larvae on the plant were counted, summed and then divided by the total number of plants and expressed as the number of eggs or larvae per plant. During the vegetative phase of the plants, feeding by the FAW larvae results in skeletonized leaves and heavily windowed whorls loaded with larval frass (Goergen et al., 2016). Therefore, damage caused by larvae was assessed by examining the vegetative parts of each of the 10 plants for visible larval damage and data were expressed as the percentage of plants damaged per plot.

2.6. Data analysis

Data on farmers' perceptions before and after training were summarized using cross-tabulations and processed descriptively using percentages. Data on fall armyworm infestation levels (eggs and larvae), and proportion of plant damage were averaged for each plot and farmer (each farmer being a replicate both for PPT maize plots and maize monocrops) and analysed using unpaired two-sample t-test to derive comparisons between the PPT adopted maize plots and maize monocrop plots. The analysis was made using MINITAP 17.

3. Results

3.1. Awareness of farmers on FAW management before and after training

As depicted in Table 4, the farmers had no or little knowledge of FAW before training. All of the farmers involved in the adoption of PPT to manage FAW had no knowledge (Table 4: 100%) on the basic biology of FAW such as the life cycle, feeding behaviour, spreading nature and other lifestyles of the pest. Before the training, 77.8% of the farmers had no knowledge and/or skills on how to identify the different stages (egg, larvae, pupae, and adult) of the pest and how to differentiate from other lepidopteran species. Only 22.2% responded that they have little knowledge and/or skills on the identification of the pest. 66.7% of the farmers had little knowledge and/or skills on management methods, of which most of them responded to cultural and chemical methods as control mechanisms. However, 33.3% of the farmers had no knowledge and/or skills on how to manage FAW (Table 4).

Table 3. Demographic profiles of targeted groups (smallholder farmers)

Item		Frequency	Percent
Sex	Male	5	55.6
	Female	4	44.4
Age	18-40	6	66.7
	41-65	3	33.3
Educational level	Illiterate	2	22.2
	Grade 1-8	5	55.6
	Completed highschool	2	22.2
	College or university	0	0.0
Marital status	Single	0	0.0
	Married	9	100.0
	Divorced	0	0.0

Table 4. Responses of farmers about FAW before training

Topics	Numbers of farmers	Responses (%)			
		Enough knowledge/skills	Moderate knowledge/skills	Little knowledge/ skills	No knowledge/ skill
1. Basic biology of FAW	9	0.0	0.0	0.0	100.0
2. Identification	9	0.0	0.0	22.2	77.8
3. Collection methods	9	0.0	0.0	0.0	100.0
4. Management methods	9	0.0	0.0	66.7	33.3

*Fall armyworm

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After training was offered, 33% of farmers responded having acquired enough knowledge or skills to understand the basic biology and 66.7% responded to having acquired moderate knowledge or skills (Table 5). The farmers developed knowledge and skills on identification and collection methods as well as the different techniques of FAW management, including PPT. Farmers who responded to acquiring enough knowledge or skills and moderate knowledge or skills on the identification of FAW were 22.2, 66.7 and 11.1%, respectively (Table 5). The farmers who responded to having acquired enough knowledge or skills and moderate knowledge or skills on collection methods were found 44.4 and 55.6%, respectively. Of the farmers, 66.7, 22.2, and 11.1% responded that they acquired enough, moderate or little knowledge/skills on management methods of FAW, respectively (Table 5).

3.2. Awareness of Farmers about PPT before and after training

As depicted in Table 6, all farmers who were selected for the adoption of PPT had no knowledge of PPT and the companion plants used for push-pull (silver-leaf desmodium and Sudan grass) though they are locally available. Similarly, the farmers had no knowledge on the role of the companion plants for the suppression of the invasive Striga weed (suppression by the silver-leaf desmodium), improvement of soil fertility through nitrogen fixation (in this case the silver-leaf desmodium) and as a source of forage (both silver-leaf desmodium and Sudan grass) (Table 6: response = 100% for no knowledge).

However, after training on the role of PPT for pest management and other extra-benefits obtained from the companion plants, the farmers developed the basic knowledge on the principles of PPT (Table 7: 44.4 and 55.6% of the farmers responded for enough and moderate knowledge acquired, respectively). Similarly, 33.3%, 55.6%, 11.1% of the farmers responded for enough, moderate and little knowledge acquisition, respectively through the training about the function of silver-leaf desmodium and Sudan grass for FAW management (Table 7). Besides, 66.7 and 33.3% of the farmers responded to having gained enough and moderate knowledge, respectively both on the role of the companion plants for improvement of soil fertility and suppression of Striga weed. Results also showed that 66.7, 22.2 and 11.1% of the farmers responded to having enough, moderate, and little knowledge (respectively) after the training regarding the role of the companion plants as a source of forage for livestock (Table 7).

Table 5. Responses of farmers about FAW after training

Topics	Numbers of farmers	Responses (%)			
		Enough knowledge/ skills	Moderate knowledge/ skills	Little knowledge/ skills	No knowledge/ skill
1. Biology of FAW	9	33.3	66.7	0.0	0.0
2. Identification	9	22.2	66.7	11.1	0.0
3. Collection methods	9	44.4	55.6	0.0	0.0
4. Management methods	9	66.7	22.2	11.1	0.0

*Fall armyworm

Table 6. Responses of farmers about PPT before training

Topics	Numbers of farmers	Responses (%)			
		Enough knowledge	Moderate knowledge	Little knowledge	No knowledge gained
PPT for pest management					
1. Principles of PPT*	9	0.0	0.0	0.0	100.0
2. Awareness on silver-leaf desmodium for pest management	9	0.0	0.0	0.0	100.0
3. Awareness on Sudan grass for pest management	9	0.0	0.0	0.0	100.0
Other functions of companion plants used in PPT					
4. Improvement of soil fertility	9	0.0	0.0	0.0	100.0
5. Source of forage for livestock	9	0.0	0.0	0.0	100.0
6. Suppress Striga weed	9	0.0	0.0	0.0	100.0

* Push-Pull Technology

Table 7. Responses of farmers about PPT after training

Topics	Numbers of farmers	Response (%)			
		Enough knowledge	Moderate knowledge	Little knowledge	No knowledge
PPT for pest management					
1. Principles of PPT*	9	44.4	55.6	0.0	0.0
2. Awareness on silver-leaf desmodium for pest management	9	33.3	55.6	11.1	0.0
3. Awareness on Sudan grass for pest management	9	33.3	55.6	11.1	0.0
Other functions of companion plants used in PPT					
4. Improvement of soil fertility	9	66.7	33.3	0.0	0.0
5. Source of forage for livestock	9	66.7	22.2	11.1	0.0
6. Suppress Striga weed	9	66.7	33.3	0.0	0.0

* Push-Pull Technology

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3.3. Adoption of PPT by farmers and infestation of FAW

After the training, PPT was implemented on each farmer's field to compare the status of the FAW population on the novel system with maize monocrop plots. As depicted on Figures 1a and b, the adoption of PPT resulted in a significant reduction of numbers of FAW eggs on maize plants compared to maize monocrop plots both during the 2018 (Fig 1a; t-test: $P < 0.001$) and 2019 (Fig 1b; t-test: $P < 0.001$) experiment seasons. The average numbers of FAW eggs during the 2018 experiment season ranged from 0.14 to 0.89 per plant in the PPT maize plots whereas 0.68 to 4.37 eggs per plant were recorded in the monocrop maize plots (Fig 1a). Similarly, the average numbers of FAW eggs during the 2019 experiment season ranged from 0.14 to 0.65 eggs per plant in the PPT maize plots whereas 2.16 to 3.81 eggs per plant in the monocrop maize plots were observed (Fig. 1b). After mid-September, as the maize plants were approaching the harvesting stage, they might have become less attractive to the adult FAW and consequently resulted in the reduction of eggs and larvae of FAW infestation per plants in the monocrop.

The FAW larvae infestation on the PPT maize plots were significantly lower compared to monocrop maize plots in 2018 (Fig 2a; t-test: $P < 0.001$) and 2019 (Fig 2b; t-test: $P < 0.001$) experiment seasons. During the 2018 experiment season, the FAW larvae infestation ranged from 0.1 to 0.13 per plant in the PPT maize plots compared to 0.18 to 1.09 per plant in the monocrop maize plots (Fig 2a). The FAW larvae infestation in the PPT maize plots ranged from 0.06 to 0.14 larvae per plant relative to 0.77 to 1.09 larvae per plant in the monocrop maize plots during the 2019 experiment season (Fig 2a).

3.4. Proportion of plants damaged by FAW larvae

As depicted in Figure 3, the proportions of plant damage by FAW larvae were significantly higher in the monocrop maize plots with per cent damage ranging from 64.5 to 68.9% and 62.4 to 70.3% during the 2018 and 2019 experiment seasons, respectively. In comparison, PPT maize plots per cent damage ranged from 4.9 to 7.5% and 3.5 to 7.1% during 2018 (t-test = 69.4; $P < 0.0001$) and 2019 (t-test = 66.0; $P < 0.0001$), respectively. The adoption of PPT resulted in a highly significant reduction in proportions of plants damaged by FAW larvae (average proportion of damage reduction = 91.4% and 92.1% in the 2018 and 2019 experiment seasons, respectively) (Fig 3).

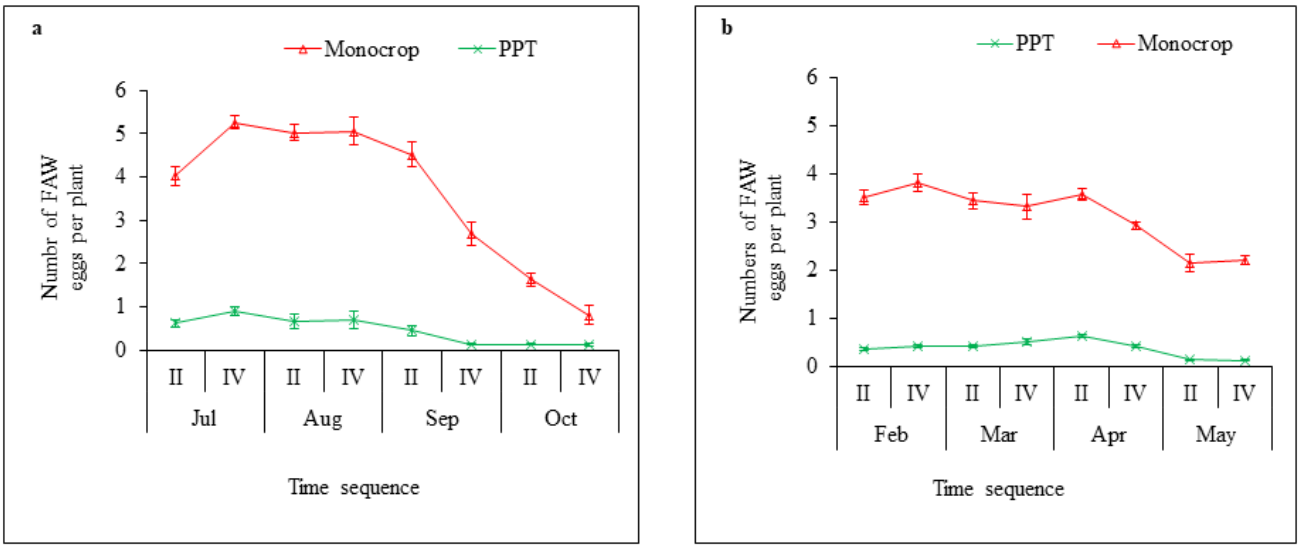

Figure 1. Level of infestation by FAW eggs (number of eggs per plant) on PPT adopted maize field plots and monocrop maize field plots (t-test; n = 9; $P < 0.001$; bars indicate standard errors) (a: 2018 experiment season; b: 2019 experiment season)

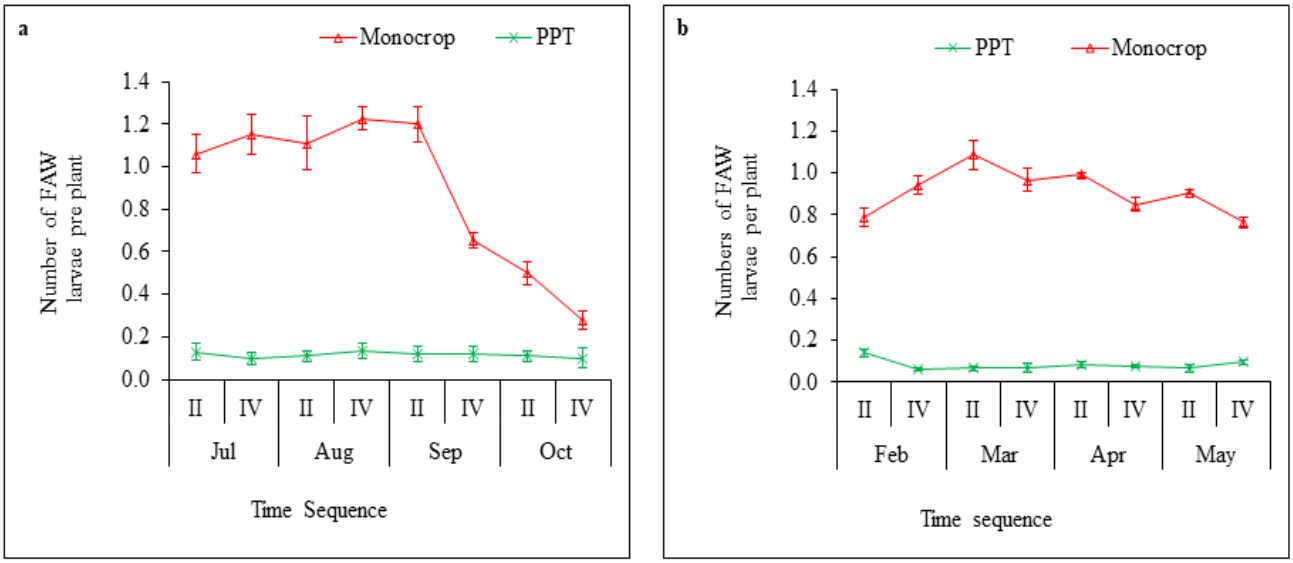

Figure 2. Level of infestation by FAW larvae (number of larvae per plant) on PPT adopted maize field plots and monocrop maize field plots (t-test; n = 9; P < 0.001; bars indicate standard errors) (a: 2018 experiment season; b: 2019 experiment season)

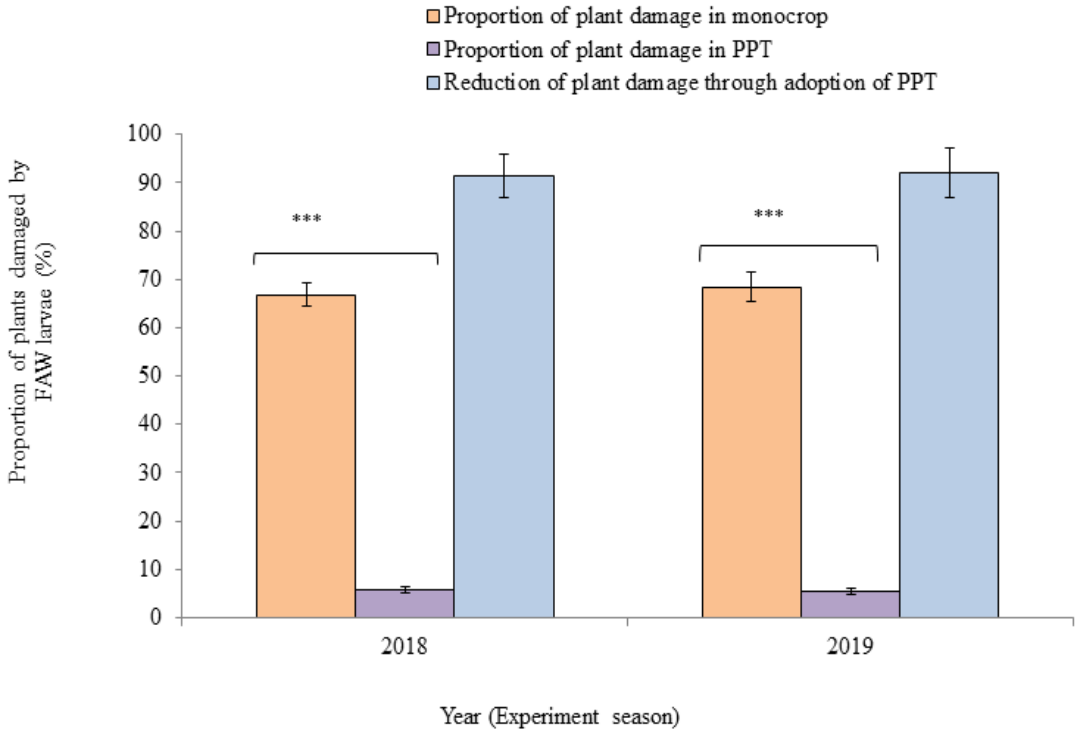

Figure 3. Comparison of proportion of plants damaged by FAW larvae on PPT adopted and monocrop maize plots and proportion of reduction in plant damage through adoption of PPT

4. Discussion

Since the first detection of FAW in Africa in 2016 (Goergen et al., 2016; Day et al., 2017; FAO 2017; Baudron et al., 2019; FAO, 2019; Harrison et al., 2019; FAO, 2020), a plethora of reports and findings have shown its impact on the maize productivity of smallholder farmers mainly in sub-Saharan Africa (Midega et al., 2018; Harrison et al., 2019; Hruska, 2019; Murray et

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al., 2019; Gebreziher, 2020a). Recently, many reports indicated that PPT is suitable, affordable, and friendly for the smallholder farmers for the management of FAW in the region (Midega et al., 2015a, 2015b; Kassie et al., 2018; Midega et al., 2018; Hruska, 2019). For instance, Kassie et al. (2018) reported that the adoption of PPT on smallholder farmer's field led to a significant increase in maize yield and net maize income. In other studies, Midega et al. (2015a, 2015b) found highly significant reductions in Striga (Striga hermonthica) (18 times lower) and stemborer (Busseola fusca Fuller; Lepidoptera: Noctuidae) (6 times lower) damage to maize plants in climate-adapted push-pull plots compared to the maize monocrop plots. In addition, Midega et al. (2018) found that maize plant height and grain yields were significantly higher in PPT maize plots than maize monocrop plots. Similarly, a reduction of 82.7% in an average number of FAW larvae per plant and 86.7% in plant damage per plot were observed in climate-adapted push-pull adopted maize crops compared to maize monocrop plots in Kenya, Tanzania, and Uganda (Midega et al., 2017).

Concurrent to previous findings, the adoption of PPT by smallholder farmers in the current study effectively reduced infestation by FAW both on the rain-fed and irrigated experiments which in turn resulted in a highly significant reduction of damage levels on maize plants. As previous findings indicated, the reduction of pests such as stemborer by a push-pull method is mediated by semiochemicals released from the push- and pull-plants (Pickett et al., 2014; Midega et al., 2015a, 2015b; Midega et al., 2018).

Further, Midega et al. (2011) reported that there was increased abundance, diversity, and activity of predatory arthropods in the push-pull system, further contributing to pest populations reductions. The reduction of FAW eggs and larvae in the current adoption trial might also be due to these mechanisms, as FAW is a noctuidae like the stemborer. However, further investigation is necessary to fully elucidate the mechanisms for the reduction of FAW infestation in the PPT maize plots.

Regardless of the effectiveness of PPT for pest and soil fertility management, the current results depicted that the smallholder farmers where the adoption of PPT was applied in their field had no or little knowledge about FAW and PPT. As a result, the smallholder farmers had been challenged by this severe pest affecting mainly the maize production. The current adoption trial shows awareness creation for smallholder farmers involved in maize production as vital for effective adoption and extension of PPT as a means of integrated pest and soil fertility management and source of forage. After training, the smallholder farmer's perception towards FAW and PPT has significantly improved. In agreement with this, Midega et al. (2018) reported that farmers' perception towards PPT for pest control was improved in an adoption experiment to control stemborer and Striga. They found that farmers rated the PPT significantly superior in reducing Striga infestation and stemborer damage rates, and in improving soil fertility and maize grain yields. As the resistance of FAW to different insecticides (Yu, 1992; Al-Sarar et al., 2016) and Bacillus thuringiensis (BT) has been documented (Storer et al., 2010), adoption and extension of PPT to smallholder farmers are said to be affordable and effective to control FAW. Besides, future projections indicate that FAW might persist and become a lasting threat to smallholder farmers in sub-Saharan Africa. Therefore, adoption and extension of the multi-purpose PPT that suits well with the mixed farming system of the smallholder farmers are vital to manage the pest sustainably.

5. Conclusion

Most smallholder farmers have no or little knowledge about FAW as well as the PPT for pest management. After awareness creation, farmer's perception about the insect pest and PPT were greatly improved and helped for easy adoption of the technology in their fields. The adoption of PPT has reduced infestation and damage to maize by FAW. The current results demonstrate that for the adoption of new technologies such as PPT at the smallholder farmer's level, awareness creation about the pest and PPT is vital for success and extension so that the economic impact of the pests can be reduced to an acceptable level. Therefore, from the current study, it can be inferred that the adoption of PPT along with the awareness creation package significantly reduces the infestation of FAW at smallholder farmer's field levels. This finding highlights the need for expansion of PPT among smallholder farmers (which are financially constrained to purchase expensive insecticides) for the control of FAW and other pests. The potential of the system in controlling pests such as FAW together with a posi-

tive perception of farmers is an opportunity to adopt and expand this ecologically suitable technology in pest-prone regions. However, further study needs to elucidate the details of economic benefits that can be gained from the adoption of PPT.

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Author contributions

Conceptualization, Haftay Gebreyesus Gebreziher, Fissiha Gebreyesus Gebreazgaabher and Yemane Kahsay Berhe; Data curation, Yemane Kahsay Berhe; Formal analysis, Haftay Gebreyesus Gebreziher; Funding acquisition, Haftay Gebreyesus Gebreziher; Investigation, Haftay Gebreyesus Gebreziher; Methodology, Haftay Gebreyesus Gebreziher; Project administration, Haftay Gebreyesus Gebreziher; Resources, Fissiha Gebreyesus Gebreazgaabher; Software, Yemane Kahsay Berhe; Supervision, Haftay Gebreyesus Gebreziher; Validation, Haftay Gebreyesus Gebreziher, Fissiha Gebreyesus Gebreazgaabher and Yemane Kahsay Berhe; Writing – original draft, Haftay Gebreyesus Gebreziher, Fissiha Gebreyesus Gebreazgaabher and Yemane Kahsay Berhe; Writing–review and editing, Haftay Gebreyesus Gebreziher, Fissiha Gebreyesus Gebreazgaabher and Yemane Kahsay Berhe.

Conflict of interest

The authors declare no conflict of interest. Besides, the funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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Research on factors affecting consumer decision on purchasing organic agricultural products in Danang, Vietnam

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The study analyses the factors that influence consumer decisions on purchasing organic agricultural products in Danang. By synthesising previous research, the authors established Ordinal Logistic Regression (OLR) through survey questionnaires for 300 consumers in Danang in March 2019. The empirical model shows that there are eight factors, which have significant positive impacts on the consumer decisions to purchase organic agricultural products, including (i) the quality of products; (ii) trademarks, product labels; (iii) advertising, media, cultural factors; (iv) the understanding of the consumers about products of organic agriculture; (v) the convenience of the point of sale; (vi) income of consumers; (vii) psychological factors (attitudes, interests, taste, age, gender, etc.); (viii) the consumer's career. The research also found two factors negatively affecting consumer decision, including (i) the value-added tax for the import of organic agricultural products; (ii) the age of the consumer. Based on quantitative results, the study proposes recommendations to promote the purchase of organic agriculture products in Danang.

1. Introduction

Safety and quality are two of the most important issues for consumers when choosing food products, especially agricultural products. An abundance of agricultural products is currently offered on the market, many of which are products of unknown origin and production processes that are not controlled. Such products may harm the environment, may not meet food hygiene and safety standards, and may adversely affect consumers' health. Therefore, organic agricultural products are a necessary and timely next step in Vietnam's agricultural development to meet today's consumers' needs.

Eco-products are becoming more popular on the market and are more widely available to consumers. This market is predicted to grow further in the future, especially in Danang. Danang is one of the largest cities in Vietnam and thus faces numerous issues with city development. Food safety plays an essential role in modern life. More and more citizens are concerned about their health in connection to food purchases, especially agricultural foods. It is essential to research factors influencing decision-making for organic food in this city. Since consumers today have an increasing awareness of health and environmental protection, they realise that organic agricultural products (OAPs) bring ecological benefits and provide the body's nutrients. However, there is still a discrepancy between the purchase of organic agricultural products and the purchase of other conventional products, indicating that consumer behaviour does not reflect consumers' growing awareness.

According to the International Federation of Organic

Agricultural Movements (IFOAM), organic agriculture is a production system that sustains soil health, ecosystems and people. It relies on ecological processes, biodiversity, and cycles adapted to local conditions, rather than inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and to promote fair relationships and high quality of life for all involved. For this reason, organic products are also called natural foods or healthy foods.

2. Literature Review

2.1. Organic Product

Following United State Department of Agriculture (USDA) and monitored by the National Organic Program (NOP), Organic products are classified into four types depending on the percentage of contained organic components: (i) "100% organic"; (ii) "Organic" means the product contains more than 95% organic matter; (iii) "Made with organic ingredients" is a product with at least 70% organic matter; (iv) "Some organic ingredients" has less than 70% organic component.

Organic products are often called natural products due to the important role in maintaining a balanced ecosystem and protecting the health of microorganisms in the soil through cropping, processing, distribution and consumption (Lijuan, 2003). Strictly accredited organic products positively affect consumers' health by reducing the risk of poisoning, certain types of cancer or disease. Besides, without additives like unnatural components, artificial preservatives, pesticide residue, and growth stimulants, organic products are safe and nutritious. Moreover, organic agriculture reduces earth and water pollution since chemicals are prohibited (Mishra & Sharma, 2010).

Currently, the production of organic agricultural products in Vietnam have been deployed in the 33 provinces and cities across the country. The area of organic agriculture in 2016 had increased 3.6 times than in 2010 to approximately 77,000 ha. However, this is only a small fraction compared to the 50.9 million hectares of organic agriculture globally and the 11.53 million hectares of agriculture in Vietnam. Therefore, besides organic agricultural products of domestic origination, imported products also tend to increase to meet consumers' needs from Danang city.

2.2. Consumer Behaviour

Theories of consumer behaviour are central factors in establishing a reasonable model for purchase decisions of organic agricultural products. Fishbein and Ajzen (1967) indicated through the Theory of Reasoned Action (TRA) that intention is the most prominent motivation of behaviour. Behaviour is influenced by attitudes (positive or negative) and subjective norms or the awareness of the appropriate manner. Through this research, they proposed the Theory of Reasoned Action model:

In 1991, Ajzen continued completing the TRA and gave birth to the Theory of Planned Behaviour (TPB). He added a factor influencing the intention of consumers: Perceived Behavioural Control, which refers to people's perceptions of their ability to perform a given behaviour. The addition had contributed to complete the TRA, which became the most popular research theory to explain human behaviours (Ajzen, 1991).

Phillip Kotler (1967), with the research "Marketing management" pointed out that the consumers' decision took a 5-step process: (i) Problem recognition; (ii) Information search; (iii) Evaluations of alternatives; (iv) Purchase decision; (v) Post-purchase behaviour.

2.3. Framework of Research Model

The Ordinal Logistic Regression (OLR) model was constructed with a dependent variable Y and independent variables X_i to analyse the factors affecting Danang's consumer purchasing decisions of organic agricultural products. The dependent variable Y (the consumer decisions on purchasing organic agricultural products) is measured with a 5-levelled scale. Y is collected through the observed variables (items) Q1 and Q2 in the questionnaire. The Ordinal Logistic Regression model has accredited the influence of 12 independent variables affecting the decision of purchasing organic agricultural products.

In OLR model, the dependent variable Y is classified into 5 levels according to Likert: (1) Never; (2) Rarely; (3) Sometimes; (4) Often; (5) Always. If Pr is the pos-

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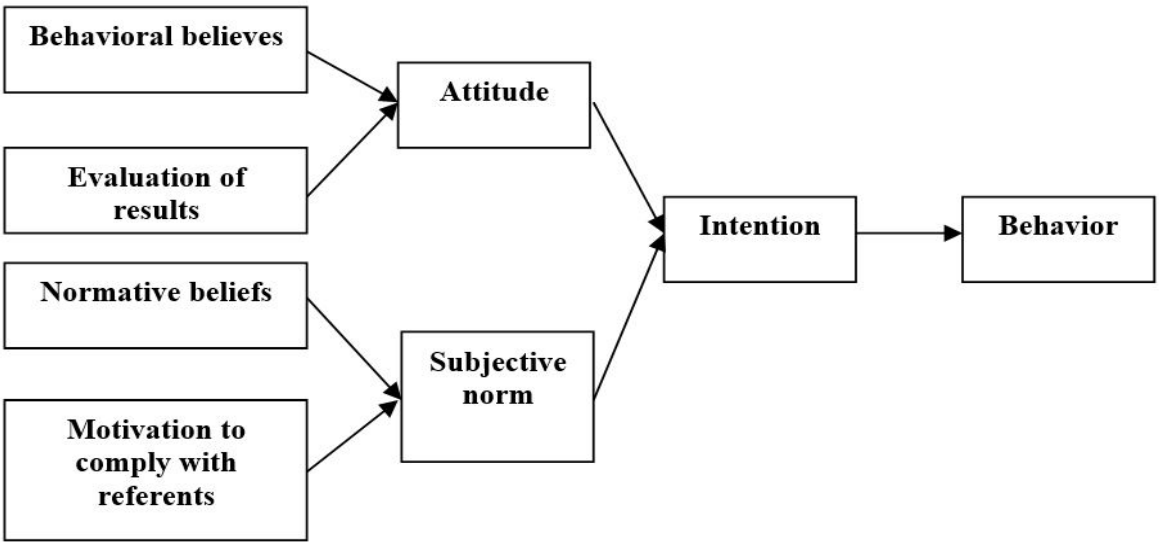

Figure 1. The Theory of Reasoned Action by Fishbein and Ajzen (1975)

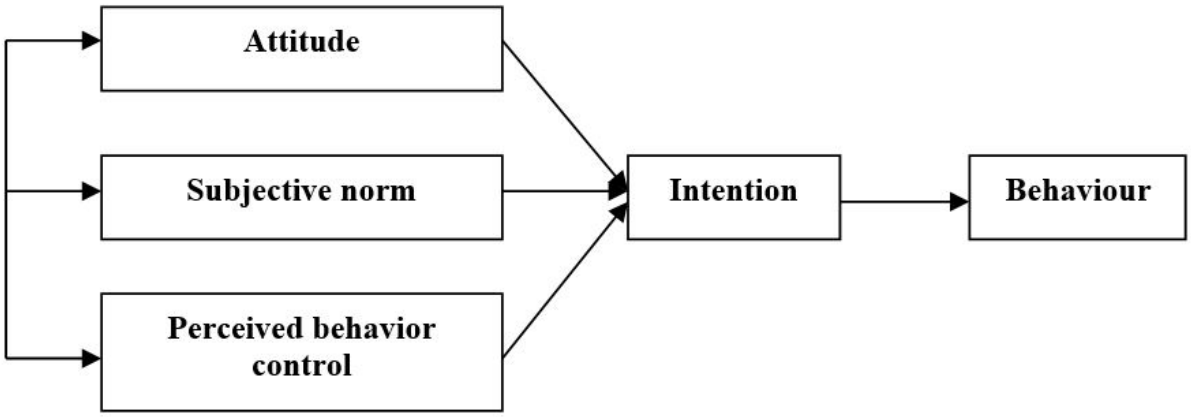

Figure 2. The Theory of Planned Behaviour by Ajzen (1991)

sibility of a specific variable, then Pr ($Y_i \leq j$) is the possibility that $Y_i \leq j$. The Odds coefficient is determined with the following formula:

$$\frac{\Pr(Y_i \leq j|X)}{\Pr(Y_i > j|X)} = \frac{\Pr(Y_i \leq j|X)}{1 - \Pr(Y_i \leq j|X)} \quad (1.1)$$

With $$\Pr(Y_i \leq j|X) = \sum_{m=1}^{j} \Pr(Y_i = m|X) \quad (1.2)$$

And we have the OLR model:

$$\ln\left[\frac{\Pr(Y_i \leq j)}{1 - \Pr(Y_i \leq j)}\right] = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \cdots + \alpha_{12} X_{12} + u_i$$

This model is called the Logistic distribution function. In this function, the model uses the Maximum Likelihood estimations method to estimate the coefficient α_i. The independent variables (from X_1 to X_{12}) are estimated through the items Q3 to Q36 using the Likert scale. The factors affecting the decision of consumers on purchasing the organic agricultural products in Danang are listed in the following sections.

Quality of the product (X_1): Quality is the way consumers perceive a product through quality indicators (Olson, 1977) as basic internal attributes (characteristics, shapes, dimensions) and external attributes (prices, brands, origin, point of sale).. Concepts of quality include several sensory features related to organic products, such as taste, experience and enjoy-

ment (Kulikovski & Agolli, 2010). According to the largest natural food supermarket in the United States, in 2014, WholeFoods conducted a consumer survey of other reasons for buying organic foods. They found that 32% believed that organic food tastes better than conventional counterparts, and 42% believed that organic food has a higher quality than non-organic products. However, in some studies, besides the strong correlation of the intention to buy organic food to the environment, health and safety, the regression results are not statistically disproving the correlation between factors. There are relationship between the quality and intention of buying organic foods at supermarkets and shops in Kluang district, Johor, Malaysia (Wee et al., 2014). The correlation between X_1 and Ln (Odds) is expected positive (+) and coefficient $\alpha_1 > 0$.

Brand and label on the product (X_2): Brand and label are also significant factors to consider when purchasing OAP. Products from famous brands are perceived as more trustworthy, and the label guarantees that the products are organic Hughner et al., 2007). The correlation between X_2 and Ln (Odds) is expected positive (+) and coefficient $\alpha_2 > 0$.

Knowledge about organic products (X_3): People will never buy products without awareness about them. This full awareness of OAPs is determined through certain aspects. Aspects include knowledge about the qualification and process to produce the products and information on its origin and main functions. Consumers need relevant information when deciding to buy products. According to Gracia et al. (2007) quoted by Kristýna Olivová (2011), "Product knowledge is an important factor because it is a way for consumers to distinguish organic foods from conventional foods and thereby form a positive attitude, awareness and quality related to products." Many studies have demonstrated that knowledge of organic foods positively affects consumer intent (Truong et al., 2012; Nguyen , 2011; Olivová, 2011). Therefore, it can be said that knowledge of organic foods positively influences the intention to consume organic foods. The correlation between X_3 and Ln (Odds) is expected positive (+) and coefficient $\alpha_3 > 0$.

Trend of consuming organic products (X_4): Nowadays, trends have become a key factor influencing consumers' mentality, also known as "herd mentality". The effect of trends on consumers' purchasing decision is measured with certain aspects such as people's awareness of the trend; whether the decision depending on trends; whether consumers chose the product regardless of their demand being met; and quality. In Asia, a few studies also highlight this emerging issue.

Shu et al. (2012) used open questionnaires on the attitude of organic food consumers living in Korea and showed that consumers have a positive attitude towards organic food. Interviewees believe that organic food improves health, and they can eat it without fear because organic food is safe for the human body. Research by Ueasangkomsate & Santiteerakul (2016) on attitudes and intentions of organic food consumption in Thailand through 316 questionnaires using random sampling method to find the relationship between food safety and intentions Buy organic food for sustainable development. Hwang (2016) collected data from elderly consumers using online survey methods, and participants of 222 university employees at a university in Midwest, USA, which confirmed the relationship between food safety and the intention to buy organic food. In contrast, a study by Michaelidou & Hassan (2008) that surveyed consumers in supermarkets and retail shops in Scotland concluded that the interest for food safety and hygiene did not directly affect consumers' intention to buy organic products.

Most studies explain the intention to buy organic foods, confirming the main driving force to be food safety. The correlation between X_4 and Ln (Odds) is expected positive (+) and coefficient $\alpha_4 > 0$.

Marketing and advertisement (X_5): This factor directly impacts the consumers' knowledge about OAPs as advertisement provides complete and positive information. Mass media works because it has the potential to spread information quickly. DeFleur et al. (1998) claim that no one can deny the influence of media in changing human behaviour and perceptions. With skilful marketing strategies, advertisements always catch one's interests and create demand for the products. The correlation between X_5 and Ln (Odds) is expected positive (+) and coefficient $\alpha_5 > 0$.

Cultural factors (X_6): Culture is a spiritual value which is deeply rooted in society and is interconnect-

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ed to every thought and behaviour of individuals. The effects of cultural factors are evaluated by how the culture and awareness of protecting the environment also impact the purchasing decision. Environmental factors, such as soil pollution, the use of artificial fertilisers in agriculture, and herbicides and pesticides in agriculture, have been recognised to negatively impact the environment and human health (Suh et al., 2012).

Thai consumers intend to buy organic food, but the level (1.2% is not high enough to encourage companies to invest this industry , a study conducted with more than 300 questionnaires identified five factors of strong attitude. There is a strong correlation with the intention to buy organic foods and environmental concerns preceded by issues of food health and safety (Ueasangkomsate & Santiteerakul, 2016b). Another study investigated the intent-behaviour gap of Malaysian organic food consumers based on TPB behavioural theory and the 5-step decision-making process with 288 questionnaires collected (ratio 96%). They discovered that the intention to buy organic food was affected by perceived food safety, health, environment and animal welfare (Wee et al., 2014). The correlation between X_6 and Ln (Odds) is expected positive (+) and coefficient $\alpha_6 > 0$.

Psychological factors (X_7): Psychology is emphasised as one of the most important factors. It subjectively directs people's point of view. Subjective standards have been shown to positively influence intention and thereby affecting behaviour (Ajzen, 1991). The subjective standard is the pressure that society places on each person when considering whether to perform a behaviour. Other studies have also confirmed there are positive effects between the subjective standard and the intention to buy organic foods (Nguyen , 2011; Effendi et al., 2002; Suh, 2009; Olivová, 2011; Mingyan Yang, 2014). The influence of psychological factors is evaluated with aspects such as consumers' emotion; interests; family and friends' advice; belief in quality and usefulness of the product, and trends. The correlation between X_7 and Ln (Odds) is expected positive (+) and coefficient $\alpha_7 > 0$.

Rate of value-added tax (VAT) on organic agricultural products (X_8): Tax is a government's tool to adjust the macroeconomy, it directly affects the demand-supply of OAPs in the market (Lohr, 2001). For example, VAT will increase OAPs' price in the market, which influences the supply, thus affecting the demand, specifically the consumer purchase decisions of OAP. The correlation between X_8 and Ln (Odds) is expected negative (-) and coefficient $\alpha_8 < 0$.

Price (X_9): Organic agricultural products' prices are usually higher than other products. It is clear that high cost is a reason why consumers choose not to purchase organic agricultural products. Some studies in North America show that consumers are willing to pay a high price for organic products. Buzby & Skees (1994), found that the majority of respondents were willing to pay more to buy grapefruit with low pesticide residue, and about 5% of consumers said they were even willing to pay double the price for a safer grapefruit. Research by Padel et al. (2005) dealt with organic products, mainly vegetables and fruits in the UK. After surveying 181 consumers, they found that price is a barrier but not an absolute barrier, and instead, it is a factor that complicates the buying decision process. They think that consumers consider price to be a problem when buying, but they also perceive it as "any money" (Kulikovski & Agolli, 2010). The influence of price is determined by customers' consideration about OAP prices; an expectation of a reduction in the price of the OAP; the OAP's price stability. The correlation between X_9 and Ln (Odds) is expected negatively (-) and coefficient $\alpha_9 < 0$.

Retail outlets location (X_{10}): This factor affects the cost and time to buy the OAP. The factor is judged by convenience while shopping and spending time to buy the product. Dettmann & Dimitri (2007) explain that supermarkets have noticed the rapid growth of organic products and have included them in their distribution systems. The presence of organic food in supermarket chains and retail stores has increased the accessibility of products to consumers. Yes, organic food is not present continuously; no goods are a major barrier to consumers' purchase intentions. The correlation between X_{10} and Ln (Odds) is expected positively (+) and coefficient $\alpha_{10} > 0$.

Consumers' income (X_{11}): Income directly influences the consumers' ability to afford the OAP and fulfils the consumer demand. While the intention is the prerequisite, the buying ability for a product is the sufficient condition (Jim, 2008). The correlation between

X_{11} and Ln (Odds) is expected positively (+) and coefficient $\alpha_{11} > 0$.

The government's policies (X_{12}): The government has many macro tools to affect the macro and micro economy (Hughner et al, 2007). The correlation between X_{12} and Ln (Odds) is expected positively (+) and coefficient $\alpha_{12} > 0$.

3. Methodology

3.1. Object of research

- The theories about the main factors that affect the purchasing decisions of consumers for organic agricultural products in Danang.
- To estimate regression factors that affect the purchasing decisions of consumers for organic agricultural products in Danang from the OLR models.
- To draw recommendation and propose significant recommendations and solutions to support consumers, who have more knowledge of the organic agricultural products and come to exact decisions in choosing OAPs.

3.2 Subjects and scope of the study

Subjects: Analysis of the factors affecting consumer decisions to purchase organic agricultural products in Danang.

Scope of the study: Consumers that purchase and sell organic agricultural products in large supermarkets of all large districts, such as Hai Chau, Thanh Khe, Son Tra, Lien Chieu, Cam Le, Ngu Hanh Son district in Danang.

The study carries out the estimate, regression, and statistically significant tests for the number of factors impacting the customer decisions on purchasing organic agricultural products in Danang. After that, there are some possible recommendation and solutions are proposed from patterns and findings.

3.2. Research method

In implementing this study, the authors have used qualitative research methods such as dialectical materialism, historical materialism associated with the method of analysis, comparison, synthesis and chemical systems. Specifically, the research bases on the investigation method, a random survey by questionnaire investigation that the research team built, and using the software SPSS20 to analyse, estimate the multivariate regression model and Ordinal Logistic Regression method maximum matching, prediction and statistical hypothesis testing relevant to the model.

The researching method was based on a randomised survey method of 300 consumers who consume organic agricultural products. Through the questionnaire, scientific working groups built and used SPSS20 software to analyse and estimate a regression model and test the statistical hypothesis relevant to the model. The steps of quantitative analysis process include (1) Rudimentary accreditation by the Cronbach's Alpha reliability estimate; (2) the Exploratory Factor Analysis (EFA); (3) Ordinal Logistic Regression Analysis.

3.3. Data of research

The rudimentary research process was done with a quantitative method, including the theoretical model's research, the questionnaires and measure scale for 34 items based on Likert 5-levelled scale. After having modified and completed the questionnaire and experimented on ten consumers, the questionnaire was officially completed.

The authors suggest 34 items according to Likert 5-levelled scale and 4 qualitative questions. The study sample size was 300 (n = 300). Total surveys handed out were 310; the total surveys received was 300. The sample is representative and random for consumers in large districts of Danang, such as Hai Chau, Thanh Khe, Son Tra, Lien Chieu, Ngu Hanh Son, and Cam Le district.

4. Analysis and Results

4.1. Measure scale description and descriptive statistics of the study sample

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Table 1. Measure scale and Descriptive statistics

Group	Question	Scale	Valid percentage	Mean	Standard deviation
Organic products consuming status (Y)	Q1: Purchase and consume imported organic agricultural products	1-Never 2-Rarely 3-Sometimes 4-Often 5-Always	1- 23% 2- 35% 3-24% 4-17% 5- 3%	2.88	1.129
	Q2: Purchase and consume domestic organic agricultural products		1- 11% 2- 25% 3-24% 4-27% 5- 15%	3.33	0.996
Organic products' quality (X1)	Q3: OAP is hygiene and food safety.	1-Never 2-Rarely 3-Sometimes 4-Often 5-Always	1- 8% 2- 20% 3-24% 4-32% 5- 18%	3.93	1.022
	Q4: Quality of OAP meets consumers' demand		1- 04% 2- 22% 3-24% 4-30% 5- 22%	3.89	0.942
	Q5: Believe that the OAPs have been accredited		1- 07% 2- 19% 3- 24% 4-27% 5- 25%	3.85	0.962
Brand, label on the organic product (X2)	Q6: Take into account the brand name and label when purchasing decision.	1-Never 2-Rarely 3-Sometimes 4-Often 5-Always	1- 04% 2- 22% 3-24% 4-30% 5- 22%	3.55	1.064

Continue Table 1. Measure scale and Descriptive statistics

Group	Question	Scale	Valid percentage	Mean	Standard deviation
Brand, label on the organic product (X2)					
	Q7: Trust in the brand and label on the OAPs.		1- 04% 2- 22% 3-24% 4-30% 5- 22%	3.78	0.977
	Q8: The more famous brand, the more influence the OAPs has on the purchasing decisions.		1- 8% 2- 20% 3-24% 4-32% 5- 18%	3.82	1.011
Knowledge about organic products (X3)	Q9: Knowledge about standards and the process of OAPs cropping.	1-Very little 2-Little 3-Average 4-A lot 5-Very much	1- 11% 2- 25% 3-24% 4-27% 5- 15%	3.13	1.074
	Q10: Knowledge about origin of OAPs		1- 11% 2- 25% 3-24% 4-27% 5- 15%	3.13	0.988
	Q11: Knowledge about the functions of the OAPs.		1- 8% 2- 20% 3-24% 4-32% 5- 18%	3.82	1.041
Trend in consuming organic products (X4)	Q12: Awareness of the OAP trend in the market.	1-Never 2-Rarely 3-Sometimes 4-Often 5-Always	1- 11% 2- 25% 3-24% 4-27% 5- 15%	3.08	0.986

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Continue Table 1. Measure scale and Descriptive statistics

Group	Question	Scale	Valid percentage	Mean	Standard deviation
Trend in consuming organic products (X4)		1-Never 2-Rarely 3-Sometimes 4-Often 5-Always			
	Q13: Choose the OAPs depending on trends in the market.		1- 11% 2- 25% 3-24% 4-27% 5- 15%	3.02	1.112
	Q14: Choose the OAPs depending on trends although they do not fulfil consumers' demand.		1- 23% 2- 35% 3-24% 4-17% 5- 3%	2.68	1.333
Advertisement about the products (X5)	Q15: Choose the OAPs because of the advertisement.	1-Never 2-Rarely 3-Sometimes 4-Often 5-Always	1- 04% 2- 22% 3-24% 4-30% 5- 22%	3.17	1.154
	Q16: Believe in the advertisement about the OAPs.		1- 23% 2- 35% 3-24% 4-17% 5- 3%	2.78	1.242
	Q17: The products fulfil the demand as advertised.		1- 23% 2- 35% 3-24% 4-17% 5- 3%	2.74	1.199
	Q18: Aware of the OAPs due to friends and family.		1- 8% 2- 20% 3-24% 4-32% 5- 18%	3.32	1.543

Continue Table 1. Measure scale and Descriptive statistics

Group	Question	Scale	Valid percentage	Mean	Standard deviation
Advertisement about the products (X5)		1-Never			
	Q19: Sales' advice when shopping.	2-Rarely 3-Sometimes 4-Often 5-Always	1- 8% 2- 20% 3-24% 4-32% 5- 18%	3.35	0.982
	Q20: Aware of the OAPs due to studying and research.		1- 23% 2- 35% 3-24% 4-17% 5- 3%	2.78	1.156
Traditional factors (X6)	Q21: Choose the OAPs because of the traditional factors.	1-Never 2-Rarely 3-Sometimes 4-Often 5-Always		2.64	1.300
	Q22: Choose the OAPs due to environmental protection.			3.58	1.231
Psychological factors (X7)	Q23: Make the purchasing decisions due to feelings and interest.	1-Never 2-Rarely 3-Sometimes 4-Often 5-Always		3.49	1.225
	Q24: Make the purchasing decisions due to advices of family and friends.			3.48	1.223
	Q25: Make the purchasing decisions due to belief in quality and functions of the OAPs.			3.53	1.313
	Q26: Make the purchasing decisions due to trends in the society.			3.01	1.100
VAT rate on the organic products (X8)	Q27: VAT rate on the OAPs affecting the purchasing decisions.	1-Never 2-Rarely 3-Sometimes 4-Often 5-Always		3.54	1.57

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Continue Table 1. Measure scale and Descriptive statistics

Group	Question	Scale	Valid percentage	Mean	Standard deviation
VAT rate on the organic products (X8)					
	Q28: Expected VAT rate on the OAPs.	0% 2% 5% 10% 12%		1.307%	1.935
Prices of organic products (X9)	Q29: Consider the prices when choosing the OAPs.	1-Never 2-Rarely 3-Sometimes 4-Often 5-Always		3.74	1.088
	Q30: Expect a reduction in the price of the OAPs.			4.02	1.133
	Q31: The products' price shifts.			3.34	0.991
Retail outlets location (X10)	Q33: Take too much time to buy the products.	1-Never 2-Rarely 3-Sometimes 4-Often 5-Always		2.95	0.942
Income of the consumers (X11)	Q35: How much percentage of income spent on OAPs?	1-Very little 2-Little 3-Average 4-A lot 5-Very much		3.02	1.102
Government policies (X12)	Q36: Choosing the OAPs due to Government policies?	1-Never 2-Rarely 3-Sometimes 4-Often 5-Always		3.66	1.214

Source: Data collected form the SSPS 20 software

4.2. Accredit the scale's reliability by Cronbach's Alpha reliability estimate

The Cronbach's Alpha reliability estimate is used to accredit the reliability of the items groups following independent variables in order to analyse the Exploratory Factor Analysis (EFA). Cronbach's Alpha reliability estimate is calculated and measured by the following scale:

So, the coefficient of Cronbach's Alpha was close to and greater than 0.6 level. There were 31 items with a coefficient of correlation greater than 0.3 level. The items with a coefficient of correlation less than 0.3 were temporary eliminated such as Q18, Q20, Q26, and Q31. Therefore, all 12 factors were evaluated to be reliable and useable. This is the precondition to analyse the Exploratory Factor Analysis (EFA) to group the items into general and significant factors affecting the organic products purchasing decision of consumers in Danang.

4.3. Analyse the Exploratory Factor Analysis (EFA)

Based on the Cronbach's Alpha results, reliability estimate and observable reliability with a coefficient of correlation less than 0.3 level were eliminated. The following 22 items were used to analyse main factors: Q3, Q4, Q5, Q6, Q7, Q8, Q9, Q10, Q11, Q12, Q13, Q14, Q15, Q16, Q17, Q21, Q22, Q23, Q24, Q25, Q29, Q30.

Table 2. The Cronbach's Alpha reliability estimate

Order	Variables	Questions	Cronbach's Alpha	Evaluation
1	**(X1)**	Q3, Q4, Q5	0.74	Useful
2	**(X2)**	Q6, Q7, Q8	0.715	Useful
3	**(X3)**	Q9, Q10, Q11	0.689	Useful
4	**(X4)**	Q12, Q13, Q14	0.594	Useful
5	**(X5)**	Q15, Q16, Q17, Q18, Q19, Q20	0.691	Useful
6	**(X6)**	Q21	1	Useful
7	**(X7)**	Q23, Q24, Q25, Q26	0.762	Useful
8	**(X8)**	Q27	1	Useful
9	**(X9)**	Q29, Q30, Q31	0.669	Useful
10	**(X10)**	Q33	1	Useful
11	**(X11)**	Q35	1	Useful
12	**(X12)**	Q36	1	Useful

Source: Data collected through surveys in March 2019

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- Factors analysis in round 1: with KMO = 0.81 and 4 items are eliminated due to disqualification: Q8, Q11, Q12 and Q15.
- Factors analysis in round 2: with KMO = 0.799 and 2 items are eliminated due to disqualification: Q14 and Q22.
- Factors analysis in round 3: with KMO = 0.772 and all items are qualified, and 16 items (observable variables) are divided into 5-factor groups:

Through analysis, it is implied:

Firstly, Factor Loading, or the relationship of each variable to the underlying factor, is a very important coefficient that assures the EFA level of significance. With 300 observations, the factor loading should be greater than 0.55. Secondly, KMO (Kaiser-Meyer-Olkin) value is a factor used to consider how suited the data is for Factor Analysis; the KMO value should be no larger than 1 but no less than 0.5. The result shows that the KMO value is 0.722, which means the EFA analysis is suitable for observable variables. Thirdly, the Bartlett Test. H0: All population variances are equal to 0. H1: At least two are different. Due to the Chi-square which resulted in 1597.062, Sig = 0.000, the conclusion is that the observable reliability is related to each other.

Following Appendix A, the Average Variance Extracted is 67.122% (>50%), which means the five groups of factors explain 67.122% of the data changes; so that the scales are acceptable. The eigenvalue of the fifth group is 1.056 (≥ 1) and indicates that the changes explained by each factor are acceptable. The Rotated Component Matrix (Appendix B) suggests that among 22 items used to analyse the Exploratory Factor Analysis (EFA), six variables are eliminated (Q8, Q11, Q12, Q14, Q15 and Q22) due to factor loading values of less than 0.55. Therefore, the 16 qualified items divided into five groups that explain 67.122% of the changes of data are as follows:

- FT1 includes: Q3, Q4, Q5, Q7 explains 25.943% of the changes in data.
- FT2 includes: Q13, Q16, Q17, Q21 explains 14.421% of the changes in data.
- FT3 includes: Q6, Q23, Q24, Q25 explains 12.816% of the changes in data.
- FT4 includes: Q9, Q10 explains 7.34% of the changes in data.
- FT5 includes: Q29 and Q30, explains 6.602% of the changes in data.

4.4. Ordinal Logistic Regression (OLR)

Model 1 used the Ordinal Logistic Regression between the dependent variable Q1 (imported organic agricultural products purchasing decision of the consumers) and the following independent variables: FT_1, FT_2, FT_3, FT4, FT_5, Q_{27}, Q_{33}, Q_{35}, Q_{36}, Age, Gender, Work, Number. The Age variable is the variable that describes the age of consumers in 5 levels: Age= 1 means consumers are less than 30 years old; Age= 2 means consumers are less than 40 but older than 30 years old; Age= 3 means consumers are less than 50 but older than 40 years old; Age= 4 means consumers are less than 60 but older than 50 years old; Age= 5 means consumers are older than 60 years old.

Gender is the sex of the consumers with 2 levels: Gender= 1 means the consumer is male; Gender= 0 means the consumer is female. Meanwhile, work is the occupation of the consumers with 4 levels: Work= 1 means that the consumer is an officer; Work= 2 means that the consumer is staff such as accountant, sales, engineer and architect; Work= 3 means that the consumer is freelancer; Work= 4 means that the consumer is student and stay home mom. The number variable is the number of people in the consumers' family.

Table 3. KMO coefficient and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**Sig.**
Bartlett's Test of Sphericity	Approx. Chi-Square	1597.062
	Df	120
	Sig.	0.000

Source: Data collected from SPSS20 software

Firstly, Table 4 shows the final model had a 0.00 significance and a -2 Log-likelihood of 531.103 and a large Chi-square value. The H0 is denied at 1%. Therefore, the interaction between factors and Ln (Odds) exists.

Secondly, the model is suited with the data collected due to the Goodness-of-Fit (Deviance) value of 1.000 and Chi-square value of 515.453, considerably large (Table 5).

Thirdly, Model 1 indicates that the independent variables can explain most of the dependent variable changes (Q1). The Pseudo R-Square of Nagelkerke value of 0.72 means that 72% of the changes of Q1 are explained by the main factors. The Pseudo R-Square of McFadden was 0.384 and shows this is a good model (Appendix C).

Finally, OLR shows that the model is statistically significant with a 0.069 significance value of Q2 at the fourth scale (often), and there are differences in the purchasing decision between the level of Q2. Model 1, which implements the regression with Q1 and independent variables FT1, FT2, FT3, FT4, Age, Work, Q35 affects Ln (Odds) positively. However, Model 2 was not as good as Model 1 due to the smaller R2 value and factors such as Q27 (VAT), FT5 (factors related to price), Q33 (convenience in buying the product), Gender, and Number that do not have any effect on Ln (Odds).

5. Discussion and Recommendations

Based on the survey results of 300 samples and the Ordinal Logistic Regression analysis results, it is clear that the factors that influence the purchase decisions of consumers for organic agricultural products in Danang are statistically significant. These findings suggest it is necessary to enhance management and ensure the quality of organic agricultural products

Table 4. Model Fitting Information

Model	**-2 Log Likelihood**	**Chi-Square**	**Df**	**Sig.**
Intercept Only	877.147			
Final	531.103	346.044	89	.000

Source: Data collected from SPSS20 software

Table 5. Goodness of Fit

	Chi-Square	Chi-Square	Df	Sig.
Pearson	1307.656	895		.000
Deviance	515.453	895	89	1.000

Source: Data collected from SPSS20 software

Table 6. Pseudo R-Square

Cox and Snell	.684
Nagelkerke	.720
McFadden	.384

Source: Data collected from SPSS20 software

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supplied in Danang. Additionally, based on the coefficient of FT1 factor and items Q3, Q4, Q5 and Q7, recommendations should aim to some possible solutions that include coordinating closely to manage, inspect and overlook the OAPs bought in the local supermarkets of Danang by the market management Department of the local Administration, the Health Ministry and the Consumer Rights Protection Association. It has to guarantee and observe the announcement of national standards for such OAPs which were promulgated and came into force on 29 December 2017. Next, the General Customs Department and the Border Management Department should enhance to control and enforce the quality of imported OAPs.

Manufacturers and the OAP Manufacturers Association should be encouraged to commit and undertake organic products' quality with consumers. Agricultural affair department support technology for farmers related to Grow organic vegetable, fruit

Marketing and communication for the usefulness of OAPs in the media and educational programs should be supported. This recommendation is supported by the significant influence of both coefficients of factors FT2 and items Q13, Q16, Q17, Q21. Notably, the introduction of process and manufacturing system of OAPs in the local media and internet network would help in purchase-buying behaviour. In addition, it is necessary to encourage the advertisement for new products in the media and public areas and to communicate the OAPs knowledge of people. One opportunity would be educational programs for students in school and universities could accelerate the distribution of knowledge on organic foods' production and consumption. So, it is significant to improve awareness and shape the culture of fresh organic agricultural products to reflect production and consumption behaviours that protect the natural environment. Various communication instruments such as banners, slogans, and drawings must be applied through public campaigns for educational organisations, student clubs, television advertising, and large social networking sites (i.e., Facebook, Zalo). It is vital to use the media to advertise knowledge, standards and production processes, the effect and usefulness of the product for individuals, and social issues such as protecting the ecological environment. When consumers are fully aware of the benefits of organic agricultural products, they are likelier to change consumer habits and approach organic agriculture products because they recognise their value. Promoting OAPs' supply and demand makes the market more vibrant, expands production, and serves as the basis for the expansion of exports and the development of the national economy. The State should further encourage households without access to organic products to self-cultivate organic agricultural products at home and benefit from the surrounding soil resources. The fact remains that the current price of organic agricultural products is too high. Thus, it is essential to innovate the process and technology of current productions for organic agricultural products.

Public policy-making should promote a brand and label development for organic agriculture products. Based on the coefficient of factors FT3 and items Q6, Q23, Q24, Q25 in the OLR model, specific recommendations are suggested that for public policies to encourage the protection and development of big brands and labels of OAPs through strengthening the efficiency of legal regulations, supporting quality of human resources, prioritising access to credit funds, and stimulating farmers and producers to carry out projects of R&D about the rise of pests and disease resistance organisms, organic fertiliser, biological plant protection and botanical medicine. There are policies and regulations used to encourage the development of theoretical foundations which promotes more sustainable organic agricultural production. It is also useful to establish key organic agricultural products or input caters for organic production, which are implemented by priority policies in encouraging public and private investment in the field of agricultural production and rural development in Danang and northern provinces.

Besides, it is important to enhance the anti-phenomenon of counterfeit goods, counterfeit trademark, infringement of the rights of industrial property on trademarks, and labels to build the confidence of consumers for products of organic agriculture originated in the country. The State should strengthen the communication of the usefulness of organic agricultural products for personal health, eco-environment and sustainable development through the various channels including relatives, friends, colleagues, and neighbourhoods which could expand these distribu-

tion channels, and build and maintain the trust of consumers.

Moreover, it is essential to reform the value-added tax system for organic agricultural products. From our statistical analysis the items Q27 and Q28, the authors can be seen in the framework of the sample with 300 customers, the value of Q28 showed 98,4 % of consumers desire the VAT rate to be lower than 10%, particularly 40.7% of consumers (0% VAT rate), 13.3% consumers (1% VAT rate), 27.7% consumers (the VAT rate of 2%), 5.3% consumers (the VAT rate of 3%), 2.0 % consumers (the VAT rate of 4%), 9.3% consumers (the VAT rate of 5%). VAT policy is a macro-economic tool which manages the critical socioeconomic part of the government and is also a factor with vital influence on production-consumption. A reasonable VAT policy can create economic incentives to promote the production, marketing and consumption of organic agricultural products. So, it is necessary to carry out a policy of tax incentives through reduction of VAT rates in order to encourage investment in the production and consumption of OAPs, in particular, to propose a reduction of the VAT rate on OAPs from 5% to 2%.

This solution encourages the production and consumption of products and reduces the pressure on prices and removes the high price of organic food, which is a current access barrier to OAPs. Simultaneously, reducing or exempting the VAT rate for services and material inputs to manufacture OAPs, such as organic fertilisers, biological fertilisers, and organic microbiological preparations of plant protection can reduce manufacturing costs and product costs. Lower costs can create better conditions and increase consumer demand. In addition to the VAT, a corporate income tax policy which affects the benefits of producers and investors in the field of organic agriculture should also be reformed through a tax base and tax rate following to calculate tax for business activities related to this field and reduce import tax for material input such as: land rent fee, natural components Specifically, the State may apply a rate deduction for the type of corporate income tax in the short term, or accompanied by certain conditions for private organisations specialised in the production of organic agriculture.

Lastly, it is significant to improve consumers' understanding of organic agricultural products. Related to factors FT4 and items Q9, Q10, the authors also support the development of mass media communication to expand the consumer awareness in the field of national and international standards of OAPs, the process of OAPs cropping and origin of OAPs. Producers should enhance the ability to carry out consultancy activities on the nature and benefits of OAPs at the point of sale of organic agricultural products, such as supermarket systems in Hai Chau, Thanh Khe, Son Tra districts, and also implement measures for advertisements, leaflets, customer conferences, agriculture exhibitions to provide useful information about the manufacturing process and consumer benefits of organic agricultural products.

5.5 Conclusion

The research has achieved the target that finds eight significant factors positively affecting consumer decisions on purchasing organic agricultural products in Danang. Based on articles and research papers, this study has established a theoretical model of 12 factors with 36 items impacting consumer decisions on purchasing organic agricultural products. It has used a multivariable regression model of Ordinal Logistic Regression on 300 survey samples and identified eight major factors which have statistically significant effects, including (i) the quality of products; (ii) trademarks, product labels; (iii) advertising, media, cultural factors; (iv) the understanding of the consumers about products of organic agriculture; (v) the convenience of the point of sale; (vi) income of consumers; (vii) psychological factors (attitudes, interests, taste, age, gender, etc.); (viii) the consumer's career. Besides, the research also found two factors negatively affecting consumer decision: (i) the value-added tax for the import of organic agricultural products; (ii) the age of the consumer. In addition, the study proposes recommendations based on four coefficient factors and their relationship to various items derived from the results of the model. However, the regression model should continue to be studied to explain and detect new influencing factors.

Limitation: This study only focuses on Danang city, and therefore future research should expand into other regions of Vietnam.

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Conflict interest

The authors declare no conflict of interest. Besides, the funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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APPENDIX

Appendix A. Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.151	25.943	25.943	4.151	25.943	25.943	2.489	15.555	15.555
2	2.307	14.421	40.364	2.307	14.412	40.364	2.446	15.287	30.843
3	2.051	12.816	53.180	2.051	12.816	53.180	2.418	15.112	45.955
4	1.174	7.340	60.521	1.174	7.340	60.521	1.846	11.537	57.492
5	1.056	6.602	67.122	1.056	6.602	67.122	1.541	9.631	67.122
6	1.774	4.480	71.962						
7	1.704	4.402	76.364						
8	1.577	3.603	79.967						
9	1.559	3.491	83.459						
10	1.493	3.082	86.541						
11	1.473	2.959	89.500						
12	1.390	2.440	91.939						
13	1.368	2.299	94.238						
14	1.339	2.121	96.359						
15	1.303	1.896	98.256						
16	1.279	1.744	100.000						

Source: Date collected from SPSS20 software

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Appendix B. Rotated Component Matrix

	Component				
	1	2	3	4	5
Q3	.745				
Q4	.828				
Q5	.765				
Q6			.633		
Q7	.666				
Q8					
Q9					
Q10				.876	
Q13		.619		.808	
Q16		.705			
Q17		.790			
Q23			.668		
Q24			.662		
Q25			.744		
Q29					.728
Q30					.830
Q21		.769			

Source: Date collected from SPSS20 software

Appendix C. Parameter Estimates

	Estimate	Std. Error	Wald	Df	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
[Q1 = 1]	.346	3.542	.010	1	.922	-6.596	7.289
[Q1 = 2]	3.309	3.546	.871	1	.351	-3.642	10.260
[Q1 = 3]	6.431	3.571	3.244	1	.072	-.567	13.430
[Q1 = 4]	9.332	3.588	6.765	1	.009	2.300	16.363
[FT1=1.50]	.816	2.483	.108	1	.742	-4.051	5.684
[FT1=2.00]	-3.076	2.013	2.336	1	.126	-7.021	.869
[FT1=2.25]	-1.300	1.585	.673	1	.412	-4.407	1.807
[FT1=2.50]	.017	1.027	.000	1	.987	-1.996	2.030
[FT1=2.75]	-634	1.077	.346	1	.556	-2.745	1.478
[FT1=3.00]	177	1.039	.029	1	.865	-1.859	2.212
[FT1=3.25]	-578	.956	.365	1	.546	-2.452	1.296
[FT1=3.50]	033	1.043	.001	1	.975	-2.012	2.077
[FT1=3.75]	2.184	.953	5.252	1	.022	.316	4.051
[FT1=4.00]	3.604	.998	13.033	1	.000	1.647	5.560
[FT1=4.25]	1.254	.907	1.911	1	.167	-.524	3.032
[FT1=4.50]	2.283	.925	6.088	1	.014	.470	4.097
[FT1=4.75]	2.302	.918	6.291	1	.012	.503	4.100
[FT1=5.00]	0a	.	.	0	.	.	.

Continue Appendix C. Parameter Estimates

	Estimate	Std. Error	Wald	Df	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
[FT2=1.00]	5.975	3.691	2.621	1	.105	-.1.259	13.209
[FT2=1.25]	2.569	2.106	1.488	1	.222	-1.558	6.697
[FT2=1.50]	2.929	2.228	1.728	1	.189	-1.437	7.295
[FT2=2.00]	1.239	2.042	.368	1	.544	-2.764	5.241
[FT2=2.25]	2.610	1.888	1.911	1	.167	-1.091	6.311
[FT2=2.50]	3.731	1.912	3.808	1	-051	-.016	7.478
[FT2=2.75]	4.032	1.933	4.352	1	-037	-244	7.819
[FT2=3.00]	3.401	1.912	3.163	1	-075	-.347	7.149
[FT2=3.25]	2.089	1.916	1.189	1	.276	-1666	5.843
[FT2=3.50]	2.652	1.855	2.043	1	.153	-.985	6.288
[FT2=3.75]	1.397	1.956	.510	1	.475	-2.437	5.230
[FT2=4.00]	2.266	2.026	1.251	1	.263	-1.704	6.237
[FT2=4.25]	-146	2.165	.005	1	.946	-4.388	4.097
[FT2=4.50]	3.532	1.923	3.372	1	.066	-.238	7.302
[FT2=4.75]	.744	4.190	.034	1	.853	-7.438	8.987
[FT2=5.00]	0a	.	.	0	.	.	.
[FT3=1.25]	10.887	2.340	21.640	1	.000	6.300	15.473
[FT3=1.75]	4.430	1.565	8.010	1	.005	1.362	7.498
[FT3=2.00]	3.823	1.344	8.092	1	.004	1.189	6.458
[FT3=2.25]	2.986	1.092	7.470	1	.006	.845	5.127
[FT3=2.50]	4.265	1.131	14.226	1	.000	2.049	6.481
[FT3=2.67]	-15.246	.000	.	1	.	-15.246	-15.246
[FT3=2.75]	4.423	1.036	18.223	1	.000	2.392	6.454
[FT3=3.00]	3.517	1.011	12.114	1	.001	1.537	5.498
[FT3=3.25]	4.172	1.012	17.001	1	.000	2.189	6.155
[FT3=3.50]	1.882	1.020	3.404	1	.065	-.117	3.881
[FT3=3.75]	3.068	1.077	8.122	1	.004	.958	5.178
[FT3=4.00]	2.873	1.120	6.576	1	0.10	.677	5.068
[FT3=4.25]	2.298	.971	5.598	1	.018	.394	4.202
[FT3=4.50]	793	.987	.646	1	.421	-1.141	2.278
[FT3=4.67]	0a	.	.	0	.	.	.
[FT3=4.75]	957	.985	.944	1	.331	-.973	2.887
[FT3=5.00]	0a	.	.	0	.	.	.
[FT4=1.00]	-2.445	1.629	2.252	1	.133	-5.639	.748
[FT4=1.50]	-3.735	2.666	1.962	1	.161	-8961	1.491
[FT4=2.00]	-3.229	1.054	9.391	1	.002	-5.294	-1.164
[FT4=2.50]	-2.308	.966	5.372	1	.020	-4.260	-356
[FT4=3.00]	-1.700	.967	3.091	1	.079	-3.596	.195
[FT4=3.50]	-1.125	1.044	1.161	1	.281	-3.172	.921
[FT4=4.00]	-.227	1.054	.046	1	.830	-2.293	1.839
FT4=4.50]	-1.662	1.074	2.394	1	.122	-3.767	.443
[FT4=5.00]	0a	.	.	0	.	.	.

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Continue Appendix C. Parameter Estimates

	Estimate	Std. Error	Wald	Df	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
[FT5=1.50]	1.270	1.581	.646	1	.422	-1.828	4.369
[FT5=2.00]	1.121	.874	1.644	1	.200	-.593	2.835
[FT5=2.50]	.166	.741	.050	1	.822	-1.287	1.620
[FT5=3.00]	-.927	.638	2.111	1	.146	-2.178	.324
[FT5=3.50]	-.649	.673	.929	1	.335	-1.969	.671
[FT5=4.00]	.230	.593	.151	1	.698	-.933	1.394
[FT5=4.50]	.076	.574	.018	1	.895	-1.049	1.202
[FT5=5.00]	0a	.	.	0	.	.	.
[Q27=1]	-1.231	.718	2.939	1	.086	-2.639	.176
[Q27=2]	-.738	.540	1.869	1	.172	-1.795	.320
[Q27=3]	-.1450	.521	7.750	1	.005	-2.471	-429
[Q27=4]	-.273	.531	.261	1	.067	-1.313	.768
[Q27=5]	0a	.	.	0	.	.	.
[Q36=1]	.555	.793	.489	1	.484	-1.000	2.109
[Q36=2]	.070	.567	.015	1	.902	-1.042	1.181
[Q36=3]	-.254	.496	.263	1	.608	-1.226	.718
[Q36=4]	.431	.527	.670	1	.413	-.601	1.464
[Q36=5]	0a	.	.	0	.	.	.
[Gender=0]	-.156	.360	.189	1	.664	-.862	.549
[Gender=1]	0a	.	.	0	.	.	.
[Age=1]	-3.610	1.282	7.931	1	.005	-6.123	-1.098
[Age=2]	-1.756	1.285	1.868	1	.172	-4.275	.762
[Age=3]	-2.645	1.366	3.747	1	.053	-5.323	.033
[Age=4]	-2.131	1.279	2.776	1	.096	-4.639	.376
[Age=5]	0a	.	.	0	.	.	.
[Work=1]	2.720	.624	18.990	1	.000	1.496	3.943
[Work=2]	2.599	.526	24.457	1	.000	1.569	3.630
[Work=3]	3.893	.791	24.210	1	.000	2.342	5.443
[Work=4]	0a	.	.	0	.	.	.
[Number=1]	-.277	2.998	.099	1	.926	-6.153	5.599
[Number=2]	-1.572	2.501	.395	1	.530	-6475	3.330
[Number=3]	-.333	2.439	.019	1	.892	-5.133	4.448
[Number=4]	-.400	2.405	.028	1	.868	-5.133	4.313
[Number=5]	-.278	2.425	.013	1	.909	-5.032	4.476
[Number=6]	.736	2.434	.091	1	.762	--4.034	5.506
[Number=7]	1.677	3.499	.236	1	.627	-5.083	8.436
[Number=8]	0a	.	.	0	.	.	.
[Q35=1]	.056	.828	.005	1	.946	-1.568	1.680
[Q35=2]	.011	.587	.000	1	.985	-1.139	1.161

Continue Appendix C. Parameter Estimates

	Estimate	Std. Error	Wald	Df	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
[Q35=3]	1.629	.526	9.577	1	.002	.579	2.661
[Q35=4]	.432	.553	.611	1	.434	-.651	1.516
[Q35=5]	0a	.	.	0	.	.	.
[Q33=1]	1.181	.882	1.791	1	.181	-.549	2.910
[Q33=2]	1.677	.627	7.159	1	.007	.449	2906
[Q33=3]	1.779	.635	7.858	1	.005	.535	3.023
[Q33=4]	.979	.674	2.108	1	.146	-.342	2.301
[Q33=5]	0a	.	.	0	0	.	

Source: Data collected from SPSS20 software

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Environmental Impacts of Food Loss and Waste: Land Degradation

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food loss; food waste; degradation; land resources; Ukraine; useless use.

Food waste and loss have a negative impact on the environment, namely on water, land, energy and other natural resources used to produce non-consumable products. According to the results of an empirical study, the present study establishes the degree of land resource degradation resulting from food loss and waste and adequately identifies potential environmental benefits from reducing food loss and waste for agricultural land use would be discussed further. Methods: The authors' methodological approach for assessing the impact of food loss and waste on the degradation of land resources is based on the following principles: objectives, unity, systematicity, scientific knowledge, and maximum informativeness. In accordance with the purpose of the study and the above principles, an appropriate system of indicators has been developed. The methodology proposed by FAO in Ukraine was used to calculate food loss and waste. The obtained results are of great importance in the formation of food security policy based on sustainable land use development in Ukraine. First, it is empirically proven that zero food loss and waste on grains, potatoes, vegetables, fruits, meat and milk can significantly reduce the burden on land resources. Secondly, the reduction of food loss and waste has positive economic consequences.

1. Introduction

The Food and Agricultural Organization of the United Nations (FAO) (2020) defined food loss as "the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retailers, food service providers and consumers". In contrast, food waste "refers to the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food service providers and consumers". Food loss and food waste are inter-woven and cross all tiers of the food chain. According to current estimates, worldwide more than 1 billion tons of food loss and waste are produced, while almost 10% of the world's population suffers from malnutrition and food insecurity (Popat et al., 2020). At the same time, the volume of food loss and waste in the world is sufficient to feed 940 million adults (Abbade, 2020), which defines this problem as the main factor in the fight against hunger.

The problem of food loss and waste is extensively investigated by foreign scientists, in particular, in the EU and the US. The opinion of scientists is most divided as to which stage along the food chain, food loss and waste occurs, which affects the choice of the object of

research. Recently, modern researches have become increasingly interested and have made a slight shift in emphasising food loss and waste at the stages of retail trade and food consumption by households. In New Zealand, food waste in the retail sector was 13 kg per capita per year (Goodman-Smith et al., 2020). Sweden also pays special attention to retail (Rosenlund et al., 2020) and is active in finding preventive measures and incentives to reduce food waste at this stage of the food chain. In Italy, research is looking for tools to measure food waste (Amicarelli et al., 2020), in determining the degree of influence of food loss and waste management on the efficiency of retail operators (Alfiero et al., 2019) and in determining the behaviour of farmers concerning unsold food (Bonadonna et al., 2019). According to one study conducted in the United States (Dusoruth & Peterson, 2020), American households throw away a significant amount of food, which could be explained by the rather high standard of living of the average American. However, a similar situation is observed in developing countries. Studies conducted in Lebanon showed that food loss and waste at the household level is 0.2 kg per capita per day. In the world, annual food loss and waste at the household level are 1.3 billion tons (Pellegrini et al., 2019). Practical data shows that not all agricultural producers consider food loss and waste at the harvesting stage quite significant. Simultaneously, scientific research confirms that the volume of such losses is significant (Johnson et al., 2019). Economic losses resulting from food loss and waste at the harvesting stage are evidenced by the results of a study in Mozambique (Popat et al., 2020), which confirmed the loss of corn at a level of 3.7 to 7.9%, or 28 million dollars. That is almost 1% of the national budget, which is higher than the average cost of food aid programs received over the past three years. Losses at the stage of harvesting fruits and vegetables in the United States (North Carolina) amounted to 42% (Johnson et al., 2018). These results indicate a significant underestimation of significant volumes at the harvesting stage, which in some countries significantly exceeds losses at other stages.

Such findings show that the potential benefits of food loss and waste reduction are concentrated in three areas: environmental (rational use of resources to reduce anthropogenic pressure on the environment), social (increasing food availability, poverty and gender inequality eradication, especially in rural areas) and economic (preventing economic losses, saving money and resources). It should be emphasised that all studies, regardless of the object of study (stages in the food chain), focus on the environmental, social and economic consequences of food loss and waste, but rarely simultaneously carry out an actual assessment of such consequences. An exception is the economic component, but it is not always present.

For Ukraine, this issue is of particular importance for several reasons. Firstly, Ukraine has joined other countries in implementing the Sustainable Development Goals 2016-2030 set by the United Nations. Secondly, Ukraine has one of the highest indicators among developed countries on the levels of land development and plots of land with an insufficient level of consumption of animal products. Thirdly, most agricultural producers, for example, during the former Soviet Union, still prefer extensive farming practices that create even more ecological burden on land resources without adequate economic and social returns. At the same time, a somewhat limited number of works are devoted to studies of food loss and waste in Ukraine; they determine the following problems: economic losses as a result of food loss and waste (Kotykova & Babych, 2019a), social consequences of food loss and waste (Kotykova & Babych, 2019b), food consumption by Ukrainian households depending on the affordability of food (Kotykova, Babych, & Pohorielova, 2020), the formation of criteria (Kotykova, Babych, & Yahodzinska, 2020) and a system of food security indicators (Kotykova, Babych, & Krylova, 2020) in accordance with the SDG 2030 criteria.

2. Materials and Methods

Our research focuses on the environmental aspects, particularly the impact of food loss and waste on the degradation of land resources in Ukraine. The study aims to establish the degree of degradation of land resources as a result of food loss and waste and identify potential environmental benefits for agricultural land usage from food loss and waste reduction (according to the results of an empirical study). The object of research is the environmental consequences of food loss and waste for agricultural land usage. The subject of the study includes indicators of land usage, inappropriate usage of crops area and arable land, population density, production volumes and food loss and waste per 100 hectares of agricultural land in the regions of

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Ukraine and types of products (grains, vegetables, potatoes, meat, milk and fruits).

The research is based on empirical methods according to the authors' methodology in the estimation of the influence of food loss and waste on the level of land resources degradation. The methodological approach to assessing food loss and food losses is based on the principles of purpose, unity, consistency, scientific character and maximum information content (Kotykova, 2010). The hypothesis of the study is the assumption that food loss and waste leads to degradation of land resources while reducing food loss and waste has significant potential environmental benefits. The assessment of the agricultural land usage in Ukraine is based on the generally accepted methodology for analysing (Worldbank, 1998) the level of development of land (LDL, formula 1), the share of arable land in the area of agricultural land (SAL, formula 2) and the share of crops in arable land (SS_{ac}, formula 3):

$$LDL = \frac{AAgrL}{AL}, \quad (1)$$

where AA_{grL} – area of agricultural land, ha; AL – total area of land;

$$SAL = \frac{AAraL}{AAgrL}, \quad (2)$$

where AA_{raL} – arable land area, ha;

$$SS_{ac} = \frac{AS_{ac}}{AAraL}, \quad (3)$$

where SS_{ac} – share of crops in arable land, %.

In order to assess the impact of food loss and waste and land degradation, there was used the authors' approach based on the analysis of such indicators: volumes of food loss and waste, thousand tons; useless use of sown area of forage crops, thousand hectares; the proportion of the useless area used for sowing crops, %; useless use of arable land, thousands ha; share of useless arable land, %.

The methodology proposed by FAO (2011, p. 33-35) is used to calculate the total food loss and waste (FLW_{ac}) in Ukraine. The work "Economic Impact of Food Loss and Waste" shows the calculations on losses and waste of milk in Ukraine (2019a. p. 57) as an example.

The "useless use of the crop area" (UVA_{ac}) indicator for food loss and waste and loss for crops (grains, potatoes and vegetables) is determined by the formula 4:

$$UVA_{ac} = \frac{FLW_{ac}}{PAC_{ac}}, \quad (4)$$

where FLWac – amount of food loss and waste and loss on crops or potatoes or vegetables; PAC_{ac} – yield of agricultural crops (grains, potatoes, vegetables), per 1 ha.

Indicator "Useless Use of Square Perennial Plants" (UVA_{pp}) for food loss and waste on fruits is determined by the formula 5:

$$UVA_{pp} = \frac{FLW_{pp}}{PAC_{pp}}, \quad (5)$$

where FLWpp – volume of food loss and waste in terms of types of agricultural crops (grains, potatoes and vegetables); PAC_{pp} – yield of fruits, per 1 ha.

Indicator of "useless use of sown area of forage crops" (UVA_{meet}) for food loss and waste in meat is determined by the formula 6:

$$UVA_{meet} = \frac{FLW_{meet}}{MEEN_{1ha}}, \quad (6)$$

where FLW_{meat} – volume of food loss and waste in meat; $MEAT_{1ha}$ – amount of meat received per hectare of sown area of forage crops, per 1 hectare.

Indicator of "useless use of forage crop area" (UVA_{milk}) for food loss and waste and loss in milk is determined by the formula 7:

$$UVA_{milk} = \frac{FLW_{milk}}{MILK_{1ha}}, \quad (7)$$

where FLW_{milk} – volume of food loss and waste in milk; $MILK_{1ha}$ – amount of milk received per hectare of sown area of forage crops, per 1 hectare.

The official data of the State Statistics Service of Ukraine for 2016 served as the information base in terms of regions and types of products. According to previous studies (Babych, & Kovalenko, 2018), it is unfeasible to make calculations over a longer period, as the level of production and consumption of food

per capita in Ukraine over the past five years has practically not changed (Kotykova, & Babych, 2019a).

3. Results

Predominantly, degradation of land resources in Ukraine is the result of water and wind erosion caused by the high level of land tillage (60.7%) and agricultural land cultivation (85.6%) (Table 1). At the same time, in most regions, these indicators are even higher, in particular in the Volyn (69.4 and 90.7%), Donetsk (68.9 and 94.7%), Zhytomyr (67.0 and 87.8%), Ivano-Frankivsk (78.3 and 88.4%), Luhansk (72.8 and 96.6%), Odessa (72.3 and 92.7%), Poltava (66.3 and 88.9%), Rivne (63.9 and 93.3%), Kharkiv (70.0 and 85.9%), Kherson (69.6 and 84.6%), Khmelnytskyi 62.6 and 93.8%), Cherkasy (71.9 and 82.0%), and Chernivtsi (63.0 and 94.2%) regions. Indicators in the Zaporizhzhia (30.4%), Kyiv (35.4%) and Sumy (39.4%) regions are the closest to the European indicators of land tillage level. By the level of the share of arable land in the area of agricultural land, only the Zaporizhzhia region (49.7%) has a value, which is close to one, common for the countries of the European Union. Thus, among the remaining (23) regions of Ukraine, there is no region where the share of arable land in the area of agricultural land was less than 71%.

Table 1. The level of use of agricultural land in Ukraine in 2016

Region	Area size of agricultural land, million hectares	Area of arable land, million hectares	Sowing area of agricultural crops, million hectares	Level of land tillage, %	Share of arable land in the area of agricultural land, %	Share of crops in arable land, %
Ukraine	34957.6	29931.2	27026.0	60.7	85.6	90.3
Vinnytsa	1838.2	1667.3	1642.2	60.7	85.6	90.3
Volyn	833.0	607.6	552.3	69.4	90.7	98.5
Dnipropetrovsk	2199.6	2082.6	1920.2	41.4	72.9	90.9
Donetsk	1777.1	1561.0	989.6	68.9	94.7	92.2
Zhytomyr	1290.4	1053.4	881.6	67.0	87.8	63.4
Zakarpattia	387.7	192.5	190.2	43.3	81.6	83.7
Zaporizhzhia	2127.1	1880.9	1630.2	30.4	49.7	98.8
Ivano-Frankivsk	493.5	377.7	371.4	78.3	88.4	86.7
Kyiv	1513.6	1280.2	1164.0	35.4	76.5	98.3
Kirovograd	1791.1	1730.3	1692.7	53.8	84.6	90.9
Luhansk	1706.0	1227.3	786.3	72.8	96.6	97.8
Lviv	1009.5	719.0	662.0	63.9	71.9	64.1
Mykolaiv	1777.2	1646.8	1533.4	46.2	71.2	92.1
Odesa	2207.5	1961.8	1846.2	72.3	92.7	93.1
Poltava	1837.0	1713.1	1719.6	66.3	88.9	94.1
Rivne	789.6	614.5	547.8	63.9	93.3	100.4
Sumy	1447.9	1159.7	1122.3	39.4	77.8	89.1
Ternopil	967.3	831.0	812.2	60.8	80.1	96.8
Kharkiv	2187.0	1851.1	1760.4	70.0	85.9	97.7
Kherson	1782.5	1672.6	1351.4	69.6	84.6	95.1
Khmelnytskiy	1484.2	1217.6	1153.2	62.6	93.8	80.8
Cherkasy	1316.8	1242.0	1194.9	71.9	82.0	94.7
Chernivtsi	442.6	322.1	305.7	63.0	94.3	96.2
Chernihiv	1751.2	1319.1	1196.2	54.7	72.8	94.9

Source: Authors computation based on State Statistics Service of Ukraine (2016)

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The usage of arable land under crops is even higher. On average, in Ukraine, this indicator is 90.3%. At the same time, in Volyn (98.5%), Donetsk (92.2%), Zaporizhzhia (98.8%), Kyiv (98.3%), Kirovograd (90.9%), Luhansk (97.8%), Mykolaiv (92.1%), and Odesa (93.1%). Indicators in Chernivtsi (94.2%), Poltava (94.1%), Rivne (100.4%), Ternopil (96.8%), Kharkiv (97.7%), Kherson (95.1%), Cherkasy (94.7%), Chernivtsi (96.2%), and Chernihiv are even higher. Of course, there might be a situation where the arable land was used twice (repeated sowing, for example). However, under such conditions, the volume of production loss and, consequently, the amount of "useless" usage of arable land would be even higher. Under such conditions, large areas of arable land are sown, but the products received for human consumption are not consumed or even lost, which is unacceptable. Thus, according to the calculations, the useless usage of grain sowing area in Ukraine in 2016 amounted to 670.7 thousand hectares, including 102.3 thousand hectares at the production stage, which is 4.7% of the total area arable land (Table 2).

Table 2. The useless use of the arable land in the grain crops production for food loss and waste and loss in Ukraine in 2016

Region	The volume of food loss and waste, thousand tons		The useless use of the sowing area of grain crops, thousand hectares		Share of the sowing area of grain crops in the arable land, %		Share of the useless use of the sowing area of grain crops, %	
	total	**incl. at the stage of the agricultural production**	**total**	**incl. at the stage of the agricultural production**	**fact**	**if removing the useless sowing areas**	**by region**	**total amount in Ukraine**
Ukraine	2548.9	371.6	670.7	102.3	47.9	45.7	4.7	100.0
Vinnytsa	303.0	33.2	56.5	6.2	52.0	48.6	6.5	8.4
Volyn	49.3	4.7	22.0	2.1	48.5	44.8	7.5	3.3
Dnipropetrovsk	37.7	15.8	18.6	7.8	52.5	51.6	1.7	2.8
Donetsk	46.6	9.2	19.6	3.9	34.8	33.6	3.6	2.9
Zhytomyr	133.9	12.9	29.0	2.8	37.1	34.4	7.4	4.3
Zakarpattia	15.6	1.1	9.3	0.7	47.8	42.9	10.1	1.4
Zaporizhzhia	72.1	14.0	32.4	6.3	46.9	45.2	3.7	4.8
Ivano-Frankivsk	35.8	3.4	11.2	1.1	40.1	37.1	7.4	1.7
Kyiv	190.4	21.1	36.5	4.0	44.3	41.4	6.4	5.4
Kirovograd	203.5	21.3	55.2	5.8	46.7	43.6	6.8	8.2
Luhansk	32.0	7.4	11.7	2.7	30.9	30.0	3.1	1.7
Lviv	71.4	6.9	22.3	2.2	42.3	39.1	7.3	3.3
Mykolaiv	59.5	13.5	26.3	6.0	50.7	49.1	3.2	3.9
Odesa	103.7	23.7	37.4	8.5	61.0	59.1	3.1	5.6
Poltava	339.4	34.1	66.4	6.7	54.6	50.7	7.1	9.9
Rivne	35.8	6.3	11.0	1.9	43.9	42.1	4.1	1.6
Sumy	221.7	25.6	40.0	4.6	55.7	52.2	6.2	6.0
Ternopil	85.6	13.7	20.7	3.3	56.0	53.5	4.5	3.1
Kharkiv	96.8	21.6	31.4	7.0	53.1	51.4	3.2	4.7
Kherson	41.9	9.9	20.0	4.7	39.7	38.5	3.0	3.0
Khmelnytskiy	189.6	19.2	37.6	3.8	43.9	40.8	7.0	5.6
Cherkasy	203.3	25.8	37.1	4.7	53.1	50.1	5.6	5.5

Continue Table 2. The useless use of the arable land in the grain crops production for food loss and waste and loss in Ukraine in 2016

Region	The volume of food loss and waste, thousand tons		The useless use of the sowing area of grain crops, thousand hectares		Share of the sowing area of grain crops in the arable land, %		Share of the useless use of the sowing area of grain crops, %	
	total	**incl. at the stage of the agricultural production**	**total**	**incl. at the stage of the agricultural production**	**fact**	**if removing the useless sowing areas**	**by region**	**total amount in Ukraine**
Chernivtsi	3.7	1.3	2.4	0.9	38.0	37.3	2.0	0.4
Chernihiv	87.0	25.5	15.9	4.7	49.6	48.4	2.4	2.4

Source: Authors computation 2019 based on State Statistics Service of Ukraine (2016)

The indicators in Volyn (7.5%), Zhytomyr (7.4%), Zaporizhzhia (10.1%), Ivano-Frankivsk (7.4%), Luhansk (7.3 %), Poltava (7.1%) and Khmelnytskiy (7.0%) regions are higher in one-and-a-half times and more, in comparison with the average data on the volumes of useless arable land in Ukraine. It should be noted that there is a correlation between the regions with the highest levels of food loss and waste of grain and the highest rates of useless usage of grain sown area. At the same time, this correspondence is not established when comparing data of ordinary regions and regions with the highest proportion of grain area useless usage. This is due to two factors: significant differences in the volumes of grain crops by region and different grain yields.

The highest level of useless usage of arable land under the crops is in the Vinnytsa, Kirovograd and Poltava regions, respectively 8.4, 8.2 and 9.9%; the lowest level is in Zhytomyr, Ivano-Frankivsk, Rivne and Chernivtsi, respectively 1.4, 1.7, 1.6 and 0.4%.

In case of the removal of useless areas of grain crops, the share of their crop area will decrease to 45.7%, which is 2.2 % less than actual data. This difference is even higher in Vinnytsa, Volyn, Zhytomyr, Zakarpattia, Zaporizhzhia, Ivano-Frankivsk, Kyiv, Kirovograd, Lviv, Poltava, Sumy, Khmelnytskiy and Cherkasy regions.

Regarding the inappropriate usage of arable land in the cultivation of potatoes, it is established that the total amount of irrationally used area of sowing in Ukraine is 285.3 thousand hectares, including 114.8 thousand hectares at the production stage (Table 3). In terms of regions, the largest areas of the useless area of arable land under potato crops are located in the Vinnytsia and Kyiv regions, and the smallest are in the Zakarpattia, Zaporizhzhia, Mykolaiv and Kherson regions. Thus, the share of uselessly consumed arable land under potato crops in Ukraine was 21.8%, including more than 30.0% in the Dnipropetrovsk, Donetsk, Zaporizhzhia and Luhansk regions and less than 20.0% in the Volyn, Zakarpattia, Ivano-Frankivsk, Lviv, Poltava, Ternopil, Khmelnytskyi and Chernihiv regions. According to the actual data, the share of potatoes in the area of arable land in Ukraine is 4.4%. The share of crops in the Volyn, Zakarpattia, Ivano-Frankivsk, Lviv, Rivne and Chernivtsi regions is much higher than this indicator (more than 10%), and it is twice less for the Zaporizhzhia, Luhansk, Mykolaiv, Odesa and Kherson regions. In case of the removal of useless areas of potatoes, the share of sowing in the total area of arable land will decrease to 3.4% (by 1.0%), while in Zakarpattia, Ivano-Frankivsk, Lviv, Rivne and Chernivtsi regions, the reduction of the share of potatoes in the arable land will be more than 2.0%.

Regarding the inappropriate usage of arable land in vegetable growing, it is established that the total amount of irrationally used area of sowing in Ukraine is 145.2 thousand hectares, including 39.1 thousand hectares at the production stage (Table 4). From a perspective of regions, the largest areas of the useless usage of arable land under vegetable crops are situated in the Dnipropetrovsk, Kyiv and Kherson regions,

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Table 3. The useless use of the arable land in the potatoes production for food loss and waste in Ukraine in 2016

Region	The volume of food loss and waste, thousand tons		The useless use of the sowing area of potatoes, thousand hectares		Share of the sowing area in the arable land, %		Share of the useless use of the sowing area of potatoes, %	
	total	**incl. at the stage of the agricultural production**	**total**	**incl. at the stage of the agricultural production**	**fact**	**if removing the useless sowing areas**	**by region**	**total amount in Ukraine**
Ukraine	4645.4	1903.2	285.3	114.8	4.4	3.4	21.8	100.0
Vinnytsa	375.8	161.7	22.0	9.5	6.5	5.2	20.3	7.7
Volyn	188.6	99.1	12.0	6.3	11.8	9.9	16.7	4.2
Dnipropetrovsk	182.5	52.7	16.2	4.7	2.6	1.8	30.3	5.7
Donetsk	154.6	35.8	13.5	3.1	2.3	1.4	37.8	4.7
Zhytomyr	285.4	115.2	15.1	6.1	6.6	5.2	21.7	5.3
Zakarpattia	104.9	46.8	6.6	3.0	17.6	14.1	19.6	2.3
Zaporizhzhia	82.5	23.1	6.9	1.9	1.2	0.8	31.3	2.4
Ivano-Frankivsk	193.8	85.3	11.8	5.2	15.7	12.6	19.9	4.1
Kyiv	505.3	149.0	28.2	8.3	7.4	5.2	29.7	9.9
Kirovograd	157.7	52.8	10.6	3.6	2.4	1.7	26.1	3.7
Luhansk	99.8	22.1	6.8	1.5	1.4	0.8	39.5	2.4
Lviv	299.5	141.7	17.4	8.2	13.1	10.6	18.5	6.1
Mykolaiv	79.7	23.5	5.6	1.7	1.2	0.8	29.7	2.0
Odesa	137.6	47.3	9.3	3.2	1.9	1.4	25.4	3.2
Poltava	174.1	93.2	8.9	4.7	3.2	2.6	16.3	3.1
Rivne	214.0	109.3	12.0	6.1	11.4	9.4	17.1	4.2
Sumy	227.2	93.2	12.3	5.0	5.0	3.9	21.3	4.3
Ternopil	176.4	86.4	10.5	5.1	7.1	5.8	17.9	3.7
Kharkiv	243.1	94.3	13.9	5.4	3.3	2.6	22.6	4.9
Kherson	75.3	24.5	6.4	2.1	1.4	1.0	26.9	2.2
Khmelnytskiy	235.0	115.5	11.7	5.8	5.4	4.4	17.8	4.1
Cherkasy	178.5	73.4	10.9	4.5	4.1	3.2	21.3	3.8
Chernivtsi	124.0	52.0	7.1	3.0	10.5	8.3	20.9	2.5
Chernihiv	150.4	105.2	9.9	7.0	6.0	5.3	12.5	3.5

Source: Authors computation 2019 based on State Statistics Service of Ukraine (2016)

and the smallest are in the Sumy, Khmelnytskyi and Chernihiv regions. Consequently, the share of uselessly used arable crops in Ukraine was 32.5%, including the Donetsk, Kyiv and Luhansk regions with more than 40%, and the Vinnytsia, Volyn, Dnipropetrovsk, Kirovograd, Poltava, Kharkiv, Kherson and Cherkasy with less than 30%. According to the actual data, the share of vegetables sown in the area of arable land in Ukraine is 15%. Per the given indicator (more than 2%) is the share of crops in the Volyn, Ivano-Frankivsk, Kyiv, Lviv, Kherson and Chernivtsi regions, and smaller than the given indicator (less than 1%) in the Luhansk, Sumy, Khmelnytskyi and Chernivtsi regions. In case of removing the useless areas of vegetable sowing, the share of sowing of the crop in the total area of arable land will decrease to 1.0% (by 0.5%). In contrast, in the Zakarpattia and Kharkiv regions, the reduction of the share of vegetables sown

in the arable land will be more than 1.5%.

Regarding the inappropriate use of farmland in the cultivation of fruits, it has been established that the total amount of irregularly used area in Ukraine is 87.4 thousand hectares, including 17.2 thousand hectares at the production stage. In terms of regions, the largest areas of useless agricultural area used in fruits and vegetable production are installed in the Vinnytsa, Dnipropetrovsk, Kyiv, Lviv and Chernivtsi regions, and the smallest in Zhytomyr, Rivne and Sumy regions. Thus, the share of useless usage of fruit farmland in

Table 4. The useless use of the arable land in the vegetables production for food loss and waste in Ukraine in 2016

Region	The volume of food loss and waste, thousand tons		The useless use of the sowing vegetables, thousand hectares		Share of the sowing area in the arable land, %		Share of the useless use of the sowing area of vegetables, %	
	total	**incl. at the stage of the agricultural production**	**total**	**incl. at the stage of the agricultural production**	**fact**	**if removing the useless sowing areas**	**by region**	**total amount in Ukraine**
Ukraine	3155.3	874.8	145.2	39.1	1.5	1.0	32.5	100.0
Vinnytsa	148.1	44.4	6.3	1.9	1.3	0.9	29.2	4.4
Volyn	82.3	25.3	3.8	1.2	2.2	1.6	28.5	2.6
Dnipropetrovsk	223.1	67.0	10.4	3.1	1.7	1.2	29.1	7.2
Donetsk	164.5	20.0	10.7	1.3	1.0	0.3	72.1	7.4
Zhytomyr	91.6	26.2	3.6	1.0	1.1	0.8	30.6	2.5
Zakarpattia	81.8	23.4	3.9	1.1	6.7	4.6	30.6	2.7
Zaporizhzhia	136.0	38.2	5.6	1.6	1.0	0.7	31.1	3.8
Ivano-Frankivsk	64.4	15.1	3.9	0.9	2.8	1.7	37.4	2.7
Kyiv	259.6	56.1	11.6	2.5	2.2	1.3	40.5	8.0
Kirovograd	75.0	22.4	5.0	1.5	1.0	0.7	29.3	3.4
Luhansk	73.7	15.8	3.8	0.8	0.8	0.5	40.9	2.6
Lviv	169.1	44.2	8.5	2.2	3.5	2.4	33.4	5.8
Mykolaiv	163.1	46.2	5.9	1.7	1.2	0.8	30.9	4.1
Odesa	141.7	33.3	9.1	2.1	1.2	0.8	37.3	6.2
Poltava	150.8	47.8	6.8	2.1	1.4	1.0	27.6	4.7
Rivne	72.3	20.7	3.7	1.1	2.0	1.4	30.6	2.5
Sumy	63.2	18.2	3.2	0.9	0.9	0.6	30.3	2.2
Ternopil	78.0	22.7	3.5	1.0	1.4	1.0	30.1	2.4
Kharkiv	211.5	66.4	8.5	2.7	1.7	1.2	27.9	5.9
Kherson	390.0	131.6	10.6	3.6	2.4	1.8	25.9	7.3
Khmelnytskiy	70.4	20.0	3.4	1.0	0.9	0.6	30.7	2.4
Cherkasy	106.3	32.2	5.9	1.8	1.7	1.2	28.9	4.1
Chernivtsi	76.2	20.8	3.9	1.1	3.8	2.6	32.1	2.7
Chernihiv	62.6	16.8	3.5	0.9	0.8	0.5	32.5	2.4

Source: Authors computation 2019 based on State Statistics Service of Ukraine (2016)

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Ukraine was 44.4%, including in Kiev, Luhansk, Sumy and Chernihiv regions with more than 60%, and in Vinnitsa, Zakarpattia, Lviv, Odessa, Poltava, Rivne, Ternopil, Kherson, Khmelnytskiy and Chernivtsi with less than 40% (Table 5).

According to the present data, the share of fruit and vegetables in fruit-bearing age in the area of agricultural lands in Ukraine is 0.7%. The share of fruit trees in the Zakarpattia and Chernivtsi regions is higher than the corresponding figure (more than 3%) and is smaller (less than 0.3%) in Sumy and Chernihiv. With the exception of the useless usage of planting areas in the fruiting age, the share of plantings in the fruiting age in the total area of agricultural lands will decrease to 0.4% (by 0.3%). In contrast, in the Zakarpattia and

Table 5. The useless use of the farmland in the fruits and vegetables production for food loss and waste in Ukraine in 2016

Region	The volume of food loss and waste, thousand tons		The useless use of the perennial plantings area, thousand hectares		Share of the plantations in the fruiting age in the arable land, %		Share of the useless use of the plantations in the fruiting age, %	
	total	**incl. at the stage of the agricultural production**	**total**	**incl. at the stage of the agricultural production**	**fact**	**if removing the useless sowing areas**	**by region**	**total amount in Ukraine**
Ukraine	984.8	208.7	87.4	17.2	0.7	0.4	44.4	100.0
Vinnytsa	88.7	23.9	7.2	1.9	1.2	0.8	32.5	8.2
Volyn	17.3	3.3	2.2	0.4	0.6	0.3	46.4	2.5
Dnipropetrovsk	62.9	13.5	5.5	1.2	0.6	0.4	40.7	6.2
Donetsk	42.8	7.9	3.1	0.6	0.4	0.2	47.3	3.5
Zhytomyr	18.0	3.7	1.6	0.3	0.3	0.2	43.1	1.8
Zakarpattia	47.4	13.4	3.8	1.1	3.2	2.2	30.9	4.4
Zaporizhzhia	31.3	5.9	3.7	0.7	0.4	0.2	46.6	4.2
Ivano-Frankivsk	22.5	4.3	3.9	0.7	1.7	0.9	45.5	4.4
Kyiv	95.7	6.3	11.6	0.8	0.6	-0.2	133.8	13.3
Kirovograd	15.5	2.7	2.5	0.4	0.3	0.1	50.5	2.8
Luhansk	20.8	2.4	3.6	0.4	0.3	0.1	75.9	4.2
Lviv	43.2	9.5	5.0	1.1	1.2	0.8	39.6	5.7
Mykolaiv	36.8	7.7	2.0	0.4	0.3	0.2	42.1	2.3
Odesa	113.7	27.7	2.9	0.7	0.4	0.2	35.9	3.3
Poltava	28.3	6.9	2.0	0.5	0.3	0.2	35.8	2.3
Rivne	22.8	6.8	1.9	0.6	0.8	0.6	29.3	2.2
Sumy	10.6	1.4	1.9	0.3	0.2	0.1	67.1	2.2
Ternopil	25.8	6.4	2.1	0.5	0.6	0.4	35.0	2.4
Kharkiv	49.5	6.9	3.9	0.5	0.3	0.1	62.6	4.5
Kherson	35.0	8.0	2.8	0.6	0.4	0.3	38.4	3.2
Khmelnytskiy	60.6	17.6	4.2	1.2	1.0	0.7	30.1	4.9
Cherkasy	25.0	4.5	2.6	0.5	0.4	0.2	48.7	3.0
Chernivtsi	61.0	16.7	5.1	1.4	3.6	2.5	31.9	5.8
Chernihiv	9.6	1.3	2.1	0.3	0.2	0.1	64.9	2.4

Source: Authors computation 2019 based on State Statistics Service of Ukraine (2016)

Chernivtsi regions, the reduction in the proportion of fruit plantings in agricultural land area will be more than 1.0%.

Regarding the inappropriate usage of arable land in the production of meat, it has been established that the total amount of uselessly used area of sowings of forage crops in Ukraine is 699.3 thousand hectares, including 61.8 thousand hectares at the production stage (Table 6). In terms of regions, the largest areas of the useless usage of arable land under sowings of forage crops in the production of meat are installed in Zhytomyr, Poltava, Kharkiv and Chernihiv regions, and the smallest in the Zakarpattia, Kirovograd and

Table 6. The useless use of the arable land in the meat production for food loss and waste in Ukraine in 2016

Region	The volume of food loss and waste, thousand tons		The useless use of the forage crops area, thousand hectares		Share of the forage crops area in the arable land, %		Share of the useless use of the sowing crops area, %	
	total	**incl. at the stage of the agricultural production**	**total**	**incl. at the stage of the agricultural production**	**fact**	**if removing the useless sowing areas**	**by region**	**total amount in Ukraine**
Ukraine	816.9	74.3	699.3	61.8	6.5	4.1	36.2	100.0
Vinnytsa	85.7	10.4	36.3	4.4	8.2	6.1	26.4	5.2
Volyn	31.5	3.9	23.0	2.8	14.7	10.9	25.7	3.3
Dnipropetrovsk	87.7	7.7	21.5	1.9	2.8	1.8	36.6	3.1
Donetsk	58.2	2.8	30.1	1.4	2.9	0.9	67.5	4.3
Zhytomyr	16.4	1.7	44.0	4.6	13.6	9.4	30.8	6.3
Zakarpattia	15.5	1.6	13.1	1.4	22.5	15.7	30.2	1.9
Zaporizhzhia	25.1	1.8	21.4	1.5	2.6	1.4	44.0	3.1
Ivano-Frankivsk	23.0	2.6	22.3	2.5	20.6	14.7	28.8	3.2
Kyiv	91.9	6.4	38.9	2.7	6.6	3.5	46.3	5.6
Kirovograd	16.2	1.7	14.2	1.5	2.6	1.8	31.1	2.0
Luhansk	18.3	0.7	22.6	0.9	2.1	0.3	86.3	3.2
Lviv	45.7	3.9	37.2	3.2	13.9	8.7	37.2	5.3
Mykolaiv	12.7	1.0	25.6	2.0	3.8	2.2	41.0	3.7
Odesa	25.1	1.5	33.7	2.0	3.2	1.4	54.3	4.8
Poltava	27.7	2.6	42.7	4.0	7.2	4.7	34.5	6.1
Rivne	17.5	1.8	31.4	3.2	16.0	10.9	31.8	4.5
Sumy	15.2	1.5	26.5	2.6	6.8	4.5	33.4	3.8
Ternopil	18.4	1.7	21.5	2.0	7.4	4.8	35.0	3.1
Kharkiv	39.8	3.0	41.4	3.1	5.3	3.1	41.9	5.9
Kherson	15.3	1.3	26.7	2.3	4.3	2.7	36.9	3.8
Khmelnytskiy	21.2	2.1	34.8	3.4	8.9	6.0	32.1	5.0
Cherkasy	80.2	10.4	23.4	3.0	7.6	5.7	24.8	3.4
Chernivtsi	13.6	1.3	16.3	1.6	15.6	10.6	32.4	2.3
Chernihiv	14.9	1.1	50.9	3.8	9.2	5.4	41.9	7.3

Source: Authors computation 2019 based on State Statistics Service of Ukraine (2016)

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Chernivtsi regions. Thus, the share of inefficient arable land under crop sowings in meat production in Ukraine was 36.2%, including more than 50% in Donetsk, Luhansk and Odesa regions and less than 30% in Vinnytsa, Volyn, Ivano-Frankivsk and Cherkassy. According to the data, the share of crop sowing area in arable land in Ukraine is 6.5%. The share of crops in the Volyn, Zakarpattia, Ivano-Frankivsk, Lviv, Rivne and Chernivtsi regions is higher than in the given indicator (more than 10%), and smaller (less than 3%) in Dnipropetrovsk, Donetsk, Zaporizhzhia, Kirovograd and Luhansk. In case of the removal of useless usage of forage crops areas in the production of meat, the share of sowing of culture in the total area of arable land will decrease to 4.1% (by 2.4%), while in the Zakarpattia, Ivano-Frankivsk, Lviv, Rivne and Chernivtsi regions, decreasing the share of fodder crops sowing in the area of arable land will be more than 5.0%.

Regarding the inappropriate usage of arable land in the production of milk, it is established that the total amount of irrationally used area of sowing of fodder crops in Ukraine is 322.0 thousand hectares, including 70.1 thousand hectares at the production stage (Table 7). In terms of regions, the largest areas of the useless area of arable land under sowing of forage crops in the production of milk are installed in the Kyiv and Kharkiv regions, and the smallest in the Zakarpattia, Kirovograd and Chernivtsi regions. Thus, the share of inefficient arable land under crop sowing in milk production in Ukraine was 16.7%, including more than 30% Donetsk, Kyiv and Luhansk regions, and less than 13% in Volyn, Zakarpattia, Ivano-Frankivsk, Rivne and Chernivtsi. In case of the removal of useless usage of forage crops areas in the production of milk, the share of sowing of culture in the total area of arable land will decrease to 5.4% (by 1.1%), while in Ivano-Frankivsk, Lviv and Chernivtsi regions, the reduction in the share of fodder crops in the arable land will be more than 2.0%.

In general, in Ukraine, taking into account useless

Table 7. The useless use of the arable land in the milk production for food loss and waste in Ukraine in 2016

Region	The volume of food loss and waste, thousand tons		The useless use of the forage crops area, thousand hectares		Share of the forage crops area in the arable land, %		Share of the useless use of the sowing crops area, %	
	total	**incl. at the stage of the agricultural production**	**total**	**incl. at the stage of the agricultural production**	**fact**	**if removing the useless sowing areas**	**by region**	**total amount in Ukraine**
Ukraine	1715.3	376.5	322.0	70.1	6.5	5.4	16.7	100.0
Vinnytsa	120.7	31.0	19.4	5.0	8.2	7.1	14.1	6.0
Volyn	48.5	15.0	10.5	3.2	14.7	13.0	11.8	3.3
Dnipropetrovsk	87.7	11.6	16.1	2.1	2.8	2.0	27.4	5.0
Donetsk	80.8	7.0	18.7	1.6	2.9	1.7	41.9	5.8
Zhytomyr	74.4	20.6	18.8	5.2	13.6	11.8	13.1	5.8
Zakarpattia	40.0	11.6	5.4	1.6	22.5	19.7	12.5	1.7
Zaporizhzhia	51.8	9.4	9.7	1.8	2.6	2.1	20.0	3.0
Ivano-Frankivsk	60.3	16.9	10.0	2.8	20.6	17.9	12.9	3.1
Kyiv	132.7	15.9	25.5	3.1	6.6	4.6	30.3	7.9
Kirovograd	45.7	11.2	6.8	1.7	2.6	2.2	14.9	2.1
Luhansk	39.4	4.5	8.3	1.0	2.1	1.5	31.8	2.6
Lviv	85.8	19.7	15.8	3.6	13.9	11.7	15.8	4.9
Mykolaiv	55.7	12.4	10.2	2.3	3.8	3.2	16.3	3.2

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Continue Table 7. The useless use of the arable land in the milk production for food loss and waste in Ukraine in 2016

Region	The volume of food loss and waste, thousand tons		The useless use of the forage crops area, thousand hectares		Share of the forage crops area in the arable land, %		Share of the useless use of the sowing crops area, %	
	total	**incl. at the stage of the agricultural production**	**total**	**incl. at the stage of the agricultural production**	**fact**	**if removing the useless sowing areas**	**by region**	**total amount in Ukraine**
Odesa	66.0	13.2	11.3	2.3	3.2	2.6	18.2	3.5
Poltava	115.6	28.9	17.9	4.5	7.2	6.2	14.5	5.6
Rivne	52.7	15.9	11.9	3.6	16.0	14.1	12.1	3.7
Sumy	62.7	15.0	12.0	2.9	6.8	5.8	15.1	3.7
Ternopil	60.0	16.4	8.1	2.2	7.4	6.4	13.2	2.5
Kharkiv	114.4	19.2	21.4	3.6	5.3	4.2	21.6	6.6
Kherson	46.8	10.7	11.4	2.6	4.3	3.6	15.8	3.5
Khmelnytskiy	77.2	21.4	14.2	3.9	8.9	7.7	13.1	4.4
Cherkasy	83.2	18.8	15.2	3.4	7.6	6.4	16.0	4.7
Chernivtsi	36.9	10.4	6.5	1.8	15.6	13.6	12.9	2.0
Chernihiv	76.4	19.9	16.9	4.4	9.2	7.9	13.9	5.3

Source: Authors computation 2019 based on State Statistics Service of Ukraine (2016)

arable land usage in the production of crops, potatoes, vegetables, fruits, meat and milk, the total area of irrational used arable land is 2122.4 thousand hectares (7.1% of the total area of arable land) (Table 8). Almost half of this area is inappropriately used arable land of eight regions: Vinnytsa, Zhytomyr, Kyiv, Lviv, Odesa, Poltava, Kharkiv and Khmelnytskiy. The lowest rates (less than seventy thousand hectares) of useless arable land usage were established in six regions: Zakarpattia, Ivano-Frankivsk, Luhansk, Rivne, Ternopil and Chernivtsi. It should be noted that if the Zakarpattia region in the absolute value has the least value of useless arable land (38.5 thousand hectares), then in relative terms it prevails in all other regions of Ukraine with 20% of arable land of inefficient use. More than seven regions (Volyn, Zhytomyr, Zakarpattia, Ivano-Frankivsk, Kiev, Lviv, Rivne, Chernivtsi) have more than 10% of arable land, which is uselessly used, and only five regions (Dnipropetrovsk, Zaporizhzhia, Luhansk, Mykolaiv, Kherson) have an indicator less than 5% of irrationally used area of crops from in the total area of arable land.

Table 9 calculations confirm the hypothesis that the negative impact of food loss and waste on arable land usage is significant. Thus, removing useless arable land usage will decrease the share of arable land in agricultural area by 6.0% – from 85.6 to 79.6%. In 13 regions, this difference will be even greater, and in the Zakarpattia, Lviv and Ivano-Frankivsk regions the decrease will be respectively 10, 10 and 12%. It is logical to assume that in those regions where the population density is higher, food loss and waste will be greater, such as in Zakarpattia, Ivano-Frankivsk, Lviv and Chernivtsi regions. At the same time, Zakarpattia and Chernivtsi regions have one of the smallest indicators of production per 100 hectares of agricultural land.

However, such a conclusion is not always reliable, as the provision of the regions with agricultural land is different. In addition, the level of yield and structure of crops are also significantly different, as evidenced by the data of Donetsk region, which, according to the population density, ranks 4th among the regions of Ukraine and, 23rd in loss of food loss and waste per 100 hectares of agricultural land. At the same time, the Donetsk region occupies the penultimate position among Ukraine regions by volume of production per

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100 hectares of agricultural land. Similarly, in the regions with the lowest population density the lowest food loss and waste per 100 hectares (Mykolaiv and Kherson regions) or the smallest share in the total amount of losses in Ukraine (Kirovograd and Chernihiv regions) are observed in the regions with the lowest population density).

The calculations confirm the thesis of the significant potential benefits of reducing food loss and waste, particularly as a strategy to meet the food deficit, which is projected to occur in 2050 with 9.3 billion people. The main potential environmental benefits of reducing land degradation by reducing food loss and waste in Ukraine are shown in Figure 1.

4. Discussion

Domestic scientists devote insufficient attention to this problem: Ukraine does not have full-scale studies of food loss and waste at the regional or national level. Undoubtedly, scholarly works deal with certain aspects of the problem under the study, but they are local and unsystematic. There is no study of the impact of food loss and waste on the level of degradation of land resources in Ukraine. Consequently, the over-

Table 8. The useless use of the arable land for food loss and waste in Ukraine

Region	The usage of the arable land in the production of the agricultural products			Share of the arable land in the agricultural land, %	
	Actually – total, million hectares	**The useless use of the arable land, thousand hectares**	**Share of the useless use of the arable land, %**	**Fact**	**If removing the useless arable land**
Ukraine	29931.2	2122.4	7.1	85.6	79.6
Vinnytsa	1667.3	140.5	8.4	90.7	83.1
Volyn	607.6	71.2	11.7	72.9	64.4
Dnipropetrovsk	2082.6	82.8	4.0	94.7	90.9
Donetsk	1561.0	92.6	5.9	87.8	82.6
Zhytomyr	1053.4	110.4	10.5	81.6	73.1
Zakarpattia	192.5	38.5	20.0	49.7	39.7
Zaporizhzhia	1880.9	75.8	4.0	88.4	84.9
Ivano-Frankivsk	377.7	59.3	15.7	76.5	64.5
Kyiv	1280.2	140.6	11.0	84.6	75.3
Kirovograd	1730.3	91.8	5.3	96.6	91.5
Luhansk	1227.3	53.3	4.3	71.9	68.8
Lviv	719.0	101.2	14.1	71.2	61.2
Mykolaiv	1646.8	73.7	4.5	92.7	88.5
Odesa	1961.8	100.6	5.1	88.9	84.3
Poltava	1713.1	142.7	8.3	93.3	85.5
Rivne	614.5	69.9	11.4	77.8	69.0
Sumy	1159.7	93.9	8.1	80.1	73.6
Ternopil	831.0	64.3	7.7	85.9	79.3
Kharkiv	1851.1	116.6	6.3	84.6	79.3
Kherson	1672.6	75.1	4.5	93.8	89.6
Khmelnytskiy	1217.6	101.7	8.4	82.0	75.2
Cherkasy	1242.0	92.5	7.4	94.3	87.3
Chernivtsi	322.1	36.2	11.2	72.8	64.6
Chernihiv	1319.1	97.2	7.4	75.3	69.8

Source: Authors computation 2019 based on State Statistics Service of Ukraine (2016)

whelming majority of scientific works studying food loss and waste one way or another belong to a foreign scientific school. However, in the global food loss and waste calculations conducted by FAO, Ukraine does not appear to be a separate country but classified as "Europe". It is quite evident that the averaged indicators of this group are not close to the realities of Ukraine. Therefore, proposals for reducing food loss and waste developed based on such analytical data, cannot fully represent our country, which requires the corresponding calculations according to actual data (Babych, 2018).

5. Conclusions

The study concluded that the loss of food loss and waste has significant negative environmental consequences on land use. Thus, the amount of inadequately expended area of sowing of agricultural crops is 670.7 thousand hectares of grain crops; 285.3 thousand hectares of potatoes; 145.2 thousand hectares of vegetable crops; 87.4 thousand on plantations of perennial

Table 9. The volume of production and food loss and waste per 100 hectares of agricultural land in Ukraine in 2016

Region	Estimated per 100 hectares of agricultural land:						
	population density		produced products		food loss and waste		
	million people	in % in relation to the data in Ukraine	thousand kcal	in % in relation to the data in Ukraine	thousand kcal	in % in relation to the data in Ukraine	in% to the volume of production in the region
Ukraine	113.4	100.0	657.2	100.0	12.2	100.0	1.9
Vinnytsa	86.5	76.3	1109.4	168.8	19.7	161.5	1.8
Volyn	125.0	110.2	472.0	71.8	16.1	131.5	3.4
Dnipropetrovsk	146.9	129.5	451.8	68.7	8.6	70.4	1.9
Donetsk	238.8	210.6	317.6	48.3	5.6	45.5	1.8
Zhytomyr	96.1	84.8	650.4	99.0	14.2	116.3	2.2
Zakarpattia	324.7	286.3	389.5	59.3	20.2	165.2	5.2
Zaporizhzhia	81.8	72.1	384.3	58.5	5.7	46.3	1.5
Ivano-Frankivsk	279.6	246.6	615.8	93.7	22.3	182.3	3.6
Kyiv	114.6	101.1	888.3	135.2	18.2	148.9	2.0
Kirovograd	53.9	47.5	677.7	103.1	9.2	75.0	1.4
Luhansk	128.7	113.5	253.9	38.6	3.9	32.0	1.5
Lviv	251.0	221.4	569.6	86.7	19.6	160.7	3.4
Mykolaiv	64.7	57.1	447.7	68.1	7.0	57.5	1.6
Odesa	108.1	95.3	621.3	94.5	9.1	74.4	1.5
Poltava	77.7	68.5	1076.1	163.7	15.5	126.9	1.4
Rivne	147.3	129.9	605.0	92.1	18.5	151.1	3.1
Sumy	76.3	67.3	1017.8	154.9	14.7	120.3	1.4
Ternopil	109.5	96.6	880.9	134.0	16.8	137.4	1.9
Kharkiv	123.5	108.9	603.2	91.8	10.9	88.8	1.8
Kherson	59.2	52.2	376.9	57.4	9.3	76.3	2.5
Khmelnytskiy	86.6	76.4	799.7	121.7	15.0	122.4	1.9
Cherkasy	93.5	82.5	1160.2	176.5	17.3	141.6	1.5
Chernivtsi	205.2	180.9	376.7	57.3	18.9	154.5	5.0
Chernihiv	59.0	52.0	847.8	129.0	12.7	104.0	1.5

Source: Authors computation 2019 based on State Statistics Service of Ukraine (2016)

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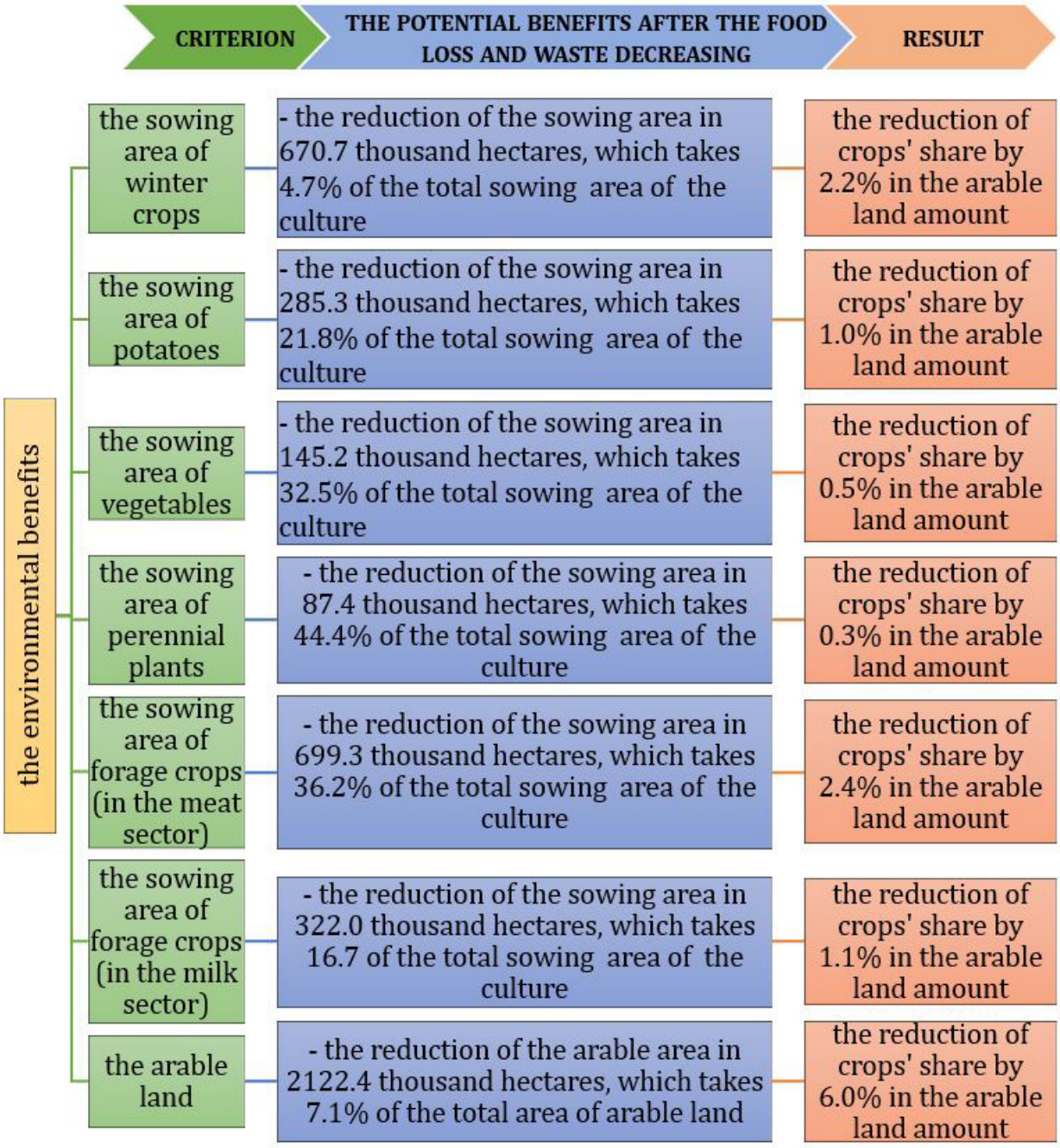

Figure 1. The potential environmental benefits on the reduction of land degradation after decreasing the food loss and waste in Ukraine. (*Source: Authors work*)

herbs; 699.3 and 322.0 thousand hectares of fodder crops for the production of meat and milk respectively. Thus, the total area of inefficient arable land is 2122.4 thousand hectares (7.1% of the total area of arable land). Under the condition that the useless areas of arable land are removed, the share of arable land in agricultural lands will decrease by 6.0%.

The obtained results are of great importance in forming food security policy based on sustainable land use development in Ukraine. First, it is empirically proven that zero losses of food loss and waste on grain, potatoes, vegetables, fruits, meat and milk can significantly reduce the pressure on land resources. Secondly, reducing food loss and waste has positive economic consequences. Reducing crop areas means cutting crop costs while preserving production volume for implementation, which adds value-added. This conclusion is especially important for agricultural producers, the vast majority of whom believe that additional

profit can be obtained using extensive (through the expansion of cultivated areas) or intensive (through increasing the usage of mineral fertilisers and plant protection products) methods of farming.

Taking into account the experience of developed countries that have achieved certain successes in food loss and waste problems, Ukraine will benefit from the practice of special digital platforms (Cane & Parra, 2020); resource efficiency and food waste reduction in the food chain (Messner et al., 2020); food donation (Busetti, 2019); reducing the volume of a portion and, accordingly, its cost (Zhao & Manning, 2019); development of highly efficient technologies for production and deep processing of products, the introduction of algorithms for structuring logistics, storage and processing of food products and waste disposal, increasing the energy efficiency of production processes (Galstyan et al., 2019).

Conflict of interest

The authors declare no conflict of interest. Besides, the funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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https://tporganics.eu

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UniKassel & VDW, Germany-February 2021

BIOFACH - World´s Leading Trade Fair for Organic Food

https://www.biofach.de/en

BIOFACH - World´s Leading Trade Fair for Organic Food

The trade fair duo BIOFACH and VIVANESS took place from 17 - 19 February 2021 completely digital. Organic is more being more and more related to the aspect of quality and conscious attitude towards nature's resources. BIOFACH in the world-leading event focusing on organic foods. It usually takes place at the Exhibition Centre Nuremberg where people from all around the world gather since 1990 to share their passionate interest in organic food, get to know each other and exchange view. BIOFACH is the perfect opportunity for meeting professionals and organic producers from the organic market and be inspired by the sector's latest trends.

For more information about the events and activities that happened at BIOFACH please see visit: https://www.biofach.de/en

For more news please refer to our website

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BIOFACH balance sheet

https://www.biofach.de/de/news/presseinformationen/2020-biofach-kongress-shaping-transformation-jgpqt8ook2_pireport

The organic sector as a strong community - even in times of crisis

Nuremberg / Berlin, February 22nd, 2021.
BIOFACH attracted 13,800 trade visitors and 1,442 exhibitors from all over the world to the eSPECIAL of BIOFACH, the world's leading trade fair for organic products.
In the three days of the fair, the international organic industry discussed hundreds of sessions of the in-house congress.
Current topics from organic law to market and trade issues to new products. Of the Bund Ökologische Lebensmittelwirtschaft (BÖLW) is the German, non-material sponsor of the fair. Peter Röhrig, Managing Director of the Organic Top Association, takes stock:
"With many guests from research, politics, authorities and civil society the international organic movement discussed how a sustainable future could be achieved with organic. The eSPECIAL of BIOFACH was very lively, innovative, committed and international. They do that 400,000 chat messages, over 10,000 bilateral video meetings and 775 conference contributions and Exhibitor presentations on three days of the event more than clear!"

At its 32nd edition and digital premiere, BIOFACH presented itself once more than trade fair top runner and diverse industry meeting point for the international organic food industry. The organic sector was also shown in the digital format of the world's leading trade fair as the driving force for the necessary restructuring of agriculture and nutrition. From the field to the shelf presented eco-companies such as economy and ecology successfully hand in hand walk. Thousands of congress participants discussed the main topic "**Shaping Transformation. Stronger. Together**" and many other issues that affect Germany's organic movement and the Organic Business World.

Organic food boomed at the checkout in 2020 like never before. 14.99 billion euros in sales show that people are increasingly relying on healthy and environmentally friendly food and are therefore in favour of deciding on organic food.

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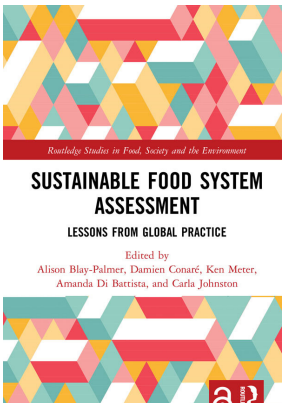

Sustainable Food System Assessment: Lessons from Global Practice

A review by Nayram Ama Doe

Author: Blay-Palmer Alison, Conaré Damien, Meter Ken, Di Battista Amanda, and Johnston Carla
Publisher: Routledge Taylor and Francis Group
Published year: 2020
Language: English
ISBN: 9780429439896
Length: 282 pages

Sustainable Food System Assessment: Lessons from Global Practice provides ideas about the increasing interest and measurement of food system sustainability. This assessment resulted from workshops and seminars organised by partners of the Laurier Centre for Sustainable Food Systems (LCSFS) work. Sustainability is built on a three-pillar approach used by several authors, including the United Nations 2030 Agenda for Sustainable Development Goals (SDGs). This book is one of the recent books that presents an overview of sustainable food systems' assessment with lessons from a global practice. This book is divided into three different chapters to enable easy reading and understanding by readers.

The book begins with a definition of sustainability as considered in three overlapping areas, namely social, environmental and economical. Social considerations in the context of food systems are associated with consumers' rights such as the right to food, food democracy, just labour practices and gender equity. Environmental dimensions include the environmental and ecological method of food production, while the economic consideration deals with keeping impartial economic activity at the local level that nurtures collaborative and commercial networks.

The first book chapter deliberates on theoretical and conceptual foundations that discuss an evolving user-led participatory methodology and gives an overview on how to assess the impact of urban-driven innovations on sustainability through mainly quantitative evaluation methodologies and the various dimensions of sustainability. The book also discusses an interdisciplinary community-based approach to taking care of the land and discussing issues on community-driven food system metrics. Besides it reflects on the well-being of an ecosystem by deliberating on the health of a food system in a changing environment and the instabilities and disturbances caused by climate change such as drought, wildfire, fish, water, pests and contaminants. This chapter also presents an overview of how to set up a food system assessment making the purpose and audience explicit, defining geographic boundaries, using the community capitals framework and finally making a connection to sustainable food systems work.

The second chapter of this book deals with the operationalisation of a sustainable food system assessment. This section talks about the existing gaps in data, data politics, and the generation of appropriate data for a food system. This chapter further provides a case study on the study of Cape Town's food system and food security, presenting issues such as the causes of the city-scale data gap and the challenges the government faces. Some data challenges faced include food security data, food system data, lack of relevant indicators from local government data, refusal to appreciate the limitations of data collection, and finally, data control in the private sector.

Chapter three, the concluding chapter of this book, discusses the impacts and outcomes of a sustainable food system assessment. Some interesting outcomes presented were structuring a foundation to grow food policy by developing a measurement tool. This chapter also talks about instruments for change in food systems developed from the City Region Food System (CRFS) assessment, planning and policy. Three case studies from three different countries were presented in this chapter. The first case study was conducted in two regions in Zambia, analysing the role of the CRFS approach. The second case study was done in Colombo, Sri Lanka, focusing on poverty and health issues. The final case study was on Medellin's approach to city-region

food systems and the outcomes from certain policies set in different regions in the city. This chapter further discussed the assessment of responsible food consumption in three different city-regions in the Ecuadorian vicinity, discussing the dimensions of responsible consumption. Three specific dimensions were stated: purchasing directly from producers, selecting agri-environmental products, and consuming Andean grains.

Overall, this book was very informative and educative as it discusses and enlightens readers on the assessment of the sustainability of food systems. It provides detailed information on the basic tools and dimensions one needs to know in assessing food systems' sustainability and can be recommended as a useful resource.

About the author:

Nayram Ama Doe is a master' student at the University of Kassel and Fulda University of Applied Sciences, Germany, studying International Food Business and Consumer Studies. Her research focuses on food sustainability, international food legislation, agriculture and food systems, and is very passionate about food security and food supply chain issues.

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THE FUTURE OF FOOD JOURNAL
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Climate-smart agriculture

Scope:

Climate-smart agriculture involves farming practices that improve farm productivity and profitability, help farmers adapt to the negative effects of climate change, and mitigate climate change effects, e.g., by soil carbon sequestration or reductions in greenhouse gas emissions. It is a pathway towards development and food security built on three pillars: increasing productivity and incomes, enhancing the resilience of livelihoods and ecosystems, and reducing and removing greenhouse gas emissions from the atmosphere. Climate-smart practices include practices with an explicit focus on adaptation and practices with a broader scope on reducing production risks and reducing emissions.

The proposed issues will focus on climate-smart approaches that include, but not limited to, increasing diversity, improving sustainable soil and land management, increasing energy use efficiency, and promoting sustainable mechanization.

Publication time: this issue is planned to be published during the **1st quarter of 2022**

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THE FUTURE OF FOOD JOURNAL
JOURNAL ON FOOD, AGRICULTURE & SOCIETY

Agro-based Bioeconomy

Scope:

The bioeconomy is defined as the production, utilization, conservation, and regeneration of biological resources. It is an economic sector primarily based on biogenic instead of fossil resources, and which is increasingly prevalent in policymaking across the globe. Agriculture is one of the essential fields of bioeconomy as it brings together various sectors of food systems, including agriculture, forestry, fisheries , and aquaculture, as well as food and feed manufacturing occupy the biggest niche of the bioeconomy.
The proposed issue will focus on topics that include, but not limited to, the integrated approach for sustained innovation in various areas of agro-based bioeconomy, production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy, agriculture, forestry, fisheries, food production, as well as parts of chemical, biotechnological and energy industries.

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THE FUTURE OF FOOD JOURNAL
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Marketing and consumers behaviour

Scope:

Consumers' behaviour has been the core of attention of researchers in food marketing. The power of companies economy is built on their ability to sell products and services and understand consumers' motivations to purchase products and services. However, consumers differ in their purchase motivations, susceptibility to marketing attempts, and decision-making strategies. Much research nowadays ignores this fact.

Studying consumer behaviour is essential for marketers to understand what influences consumers' buying decisions and final choices. By understanding how consumers decide on a product, they can fill in the gap in the market and identify the products that are needed and the products that are obsolete.

The proposed issue will focus on topics that include, but not limited to, how people make decisions about what they buy, want, need, or act in regards to food or agricultural products or services, factors that affect consumers' behaviour ', including psychological, personal and social factors, behaviour of consumers while researching and shopping, the influence of the environment on consumer behaviour, how marketing campaigns can be adapted and improved to more effectively influence the consumer.

Publication time: this issue is planned to be published during the **3rd quarter of 2022**

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THE FUTURE OF FOOD JOURNAL
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Sustainable nutrition systems

Scope:

A sustainable nutrition system is a key to reforming our global food system. As studies and statistical projections have shown, in 2050, the world population is estimated to reach approximately 9.8 billion people, and therefore the question is always: How can we feed them all? Our current diet will not answer the previous question. The current diet depends largely on increasing production, ignoring all other factors. Whereas, we must rethink the method of cultivation used, the amount of production, distribution, and household consumption.

The proposed issue will focus on topics that include, but not limited to, promote an effective, sustainable nutrition system that reduces environmental impacts, confronts the environmental challenges, and improves health and nutritional outcomes, and helps produce nutrient-rich foods

Publication time: this issue is planned to be published during the **4th quarter of 2022**

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