FRUITS AND VEGETABLES PRODUCTION AND ITS EFFECT ON CONSUMPTION WITH SPECIAL REFERENCE TO SELECT COUNTRIES

Management Insight
13(2) 86-98
https://doi.org/10.21844/mijia.v13i02.11274

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ABSTRACT

India is a land of agriculture diversity with 66 percent of its population still dependent on agriculture and contributing about 20 percent to the Indian GDP. Value addition of food products is expected to increase from 8 per cent to 35 per cent by 2025. Fresh Fruit and vegetable processing is also expected to increase from the current level of 2 per cent to 25 per cent of total production by 2025. This study is basically a secondary data analysis on certain international production and consumption of fruits and vegetables. The article deals with comparative study of certain select countries with respect to their fruits and vegetable production. The analysis shows that there is overwhelming evidence in support of the hypothesis that the study regions are significantly different in terms of their fruits and vegetable production and consumption but interestingly such differences are not able to help to group the countries with respect to fruits and vegetable production. There is also evidence in support of other hypothesis that the production and export level differences exists towards surplus.

Keywords : Vegetables market, vegetable production, vegetable consumption, exports.

1 INTRODUCTION

The fruits and vegetables (F and V) sector is always critical for stimulating a healthy growth trend in Indian agriculture. Given the rising share of high value commodities in the total value of agricultural output and their growth potential, this segment is likely to drive agricultural growth in the years to come (ASSOCHAM, 2013). Rural income majorly depends on horticulture and it plays a unique role in India's economy. Cultivation of these crops is labour intensive and as such they generate lot of employment opportunities for the rural population. Fruits and vegetables sector is perhaps the most profitable venture of all farming activities as it provides ample employment opportunities and scope to raise the income of the farming community. It also has tremendous potential to push the overall agriculture growth. India has been bestowed with wide range of climate and physio-geographical conditionsand as such is most suitable for growing various kinds of F&V. This has placed India among the foremost countries in F&V production just behind China. F&V together constitute about 92% of the total horticultural production in India (ASSOCHAM, 2013). During 2012-13, India's contribution in the world production of F&V was 12.6 % and 14 % respectively (NHB, 2013).China's share has been highest with 21.2% in world's fruit production and 49.5% in world's vegetables production followed by India and Brazil. The world production and percent share of F&V is shown in Table 1.

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Table 1 : World production and percent share in 2012-13

	Fruits			Vegetables	
Country	**Production**	**Share**	**Country**	**Production**	**Share**
China	137066750	21.2	China	573935000	49.5
India	81285334	12.6	India	162186567	14
Brazil	36368678	5.9	Brazil	35947720	3.1
USA	26548859	4.1	USA	27818918	2.4
Indonesia	17744411	2.7	Indonesia	23485675	2
Philippines	16370976	2.5	Philippines	19825388	1.7
Mexico	15917806	2.5	Mexico	16084372	1.4
Turkey	14974561	2.3	Turkey	13599497	1.2
Spain	13996447	2.2	Spain	12531000	1.1
Italy	13889219	2.1	Italy	12297645	1.1
Others	270594597	41.8	Others	261467661	22.6

India is a land of agriculture diversity with 2/3 of its population still dependent on agriculture and contributing about 20% to the Indian GDP. Value addition of food products is expected to increase from 8 per cent to 35 per cent by 2025. Fresh Fruit & vegetable processing is also expected to increase from the current level of 2 per cent to 25 per cent of total production by 2025. Development of the vegetable industry is constrained by poor marketing arrangements; there is a large gap between farmers and retail prices. The traditional retailing of vegetables is not very much organized, amounts to 97% of the total market, is extremely localized and highly fragmented with large number of intermediaries.

India's diverse climate ensures availability of all varieties of fresh fruits & vegetables. It ranks second in fruits and vegetables production in the world, after China. As per National Horticulture Database published by National Horticulture Board, during 2014-15 India produced 86.602 million metric tonnes of fruits and 169.478 million metric tonnes of vegetables. The area under cultivation of fruits stood at 6.110 million hectares while vegetables were cultivated at 9.542 million hectares.

India is the largest producer of ginger and okra amongst vegetables and ranks second in production of potatoes, onions, cauliflowers, brinjal, Cabbages, etc. Amongst fruits, the country ranks first in production of Bananas (22.94%), Papayas (44.03%) and Mangoes (including mangos teens,and guavas) (37.57%). The vast production base offers India tremendous opportunities for export. During 2015-16, India exported fruits and vegetables worth Rs. 8,391.41 crores which comprised of fruits worth Rs. 3,524.50 crores and vegetables worth Rs. 4,866.91 crores. Mangoes, Walnuts, Grapes, Bananas, Pomegranates account for larger portion of fruits exported from the country while Onions, Okra, Bitter Gourd, Green Chillies, Mushrooms and Potatoes contribute largely to the vegetable export basket.

The major destinations for Indian fruits and vegetables are UAE, Bangladesh, Malaysia, Netherland, Sri Lanka, Nepal, UK, Saudi Arabia, Pakistan and Qatar. Though India's share in the global market is still nearly 1% only, there is increasing acceptance of horticulture produce from the country. This has occurred due to concurrent developments in the areas of state-of-the-art cold chain infrastructure and quality assurance measures. Apart from large investment pumped in by the private sector, public sector has also taken initiatives and with APEDA's assistance several Centres for Perishable Cargoes and integrated post-harvest handling facilities have been set up in the country. Capacity building initiatives at the farmers, processors and

exporters' levels has also contributed towards this effort (APEDA, n.d.).

Globally, majority of people consistently are consuming less than the daily recommended F and V requirement. Even in developed nations e.g., Australia, Canada, Europe, UK and USA, researchers have concluded that there is large gap between actual and recommended consumption of both F and V despite decades of concern and publicity while resultant outcomes were short-lived. In a study from 52 low and middle-income countries 77.6% of men and 78.4% of women consumed less than the minimum recommended servings of F and V. Same study reported 74% low F and V consumption amongst adults in India(Hall JN, et al 2009). The following table shows the details of vegetable production in India during 2010 – 11.

Table 2. Vegetable production in India (2010–11)

Vegetables	**Cultivation**	**Vegetables**	**Cultivation**
Brinjal 2009-10 Production (in '000 Tonne)	10561.8	Tomato 2009-10 Production (in '000 Tonne)	12433.1
Brinjal 2010-11 Production (in '000 Tonne)	11895.8	Tomato 2010-11 Production (in '000 Tonne)	16526
Cabbage 2009-10 Production (in '000 Tonne)	7281.7	Onion 2009-10 Production (in '000 Tonne)	12158.7
Cabbage 2010-11 Production (in '000 Tonne)	7948.9	Onion 2010-11 Production (in '000 Tonne)	15117.7
C.Flower 2009-10 Production (in '000 Tonne)	6569	Potato 2009-10 Production (in '000 Tonne)	36577.3
C.Flower 2010-11 Production (in '000 Tonne)	6744.9	Potato 2010-11 Production (in '000 Tonne)	42339.4
Okra 2009-10 Production (in '000 Tonne)	4803.2	Sweet Potato 2009-10 Production (in '000 Tonne)	1094.6
Okra 2010-11 Production (in '000 Tonne)	5784	Sweet Potato 2010-11 Production (in '000 Tonne)	1046.6
Peas 2009-10 Production (in '000 Tonne)	3029.4	Tapioca 2009-10 Production (in '000 Tonne)	8059.8
Peas 2010-11 Production (in '000 Tonne)	3517.4	Tapioca 2010-11 Production (in '000 Tonne)	8076
Summary Statistics			
Maximum			42339.4
Minimum			1046.6
Average			11078.265
Standard Deviation			10633.858

Source: https://data.gov.in/keywords/horticulture

The above table shows the details of vegetable cultivation in 2010 – 11. The maximum cultivation seems to be Potato (42339.4 tonnes) and the least is Sweet Potato (1046.6). Onion and Brinjal are close to the average.

2 LITERATURE REVIEW

de Lorgeril M., et al (1994) shows that Mediterranean diet is rich in terms of F & V and they suffer relatively low level of incidence of myocardial infarction (MI). The results of Indian Experiment of Infarct Survival (IEIS) showed that consumption of low-fat diet enriched with F and V, compared with a standard low-fat diet, was associated with about 40% reduction in cardiac events and 45% reduction in mortality

after one-year (*Singh RB, et al, 1992)*. A study carried out in south India too observed higher F and V intake explained 48% of protective effect against CVD risk factors in the studied population(Radhika G, et al 2008). While results from the Dietary Approaches to Stop Hypertension (DASH) trial suggested that changes in dietary fats do not necessarily accompany automatic increase in F and V intake (Conlin PR, et al 2000).

Sachdeva, S., and et al, (2013) did research titled "increasing fruits and vegetable consumption – challenges and opportunities". Authors mentions that "Overall it is estimated that low F and V intake is attributable to approximately 2.7 million (4.9%) annual deaths and 26.7 million (1.8%) daily and causes about 31% of ischaemic heart diseases (IHD), 11% of stroke and 19% of gastro-intestinal cancers and still significantly associated (protective) with lung/pharyngeal/laryngeal/oral cancer, type-2 diabetes mellitus, bone-health, vision/cataract and micronutrient deficiency state. Low F and V intake is considered as the sixth main risk factor for mortality in the world."

Arvind Singhal (2010), the first part of the report lists down the factors contributing to a dynamic economy. The study forecasts the consumption pattern for the year 2014. The food and grocery spending continues to be a major component and it continues to top the categories of consumption. The consumers will shift from 'low-price' platform to 'price-plus' platform. There will be a strong increase in the trend of going shopping as a 'family', the study opines.

A report of NCAER (2014) shows that India's average per capita calorie and protein intake has grown only modestly, although the per capita fat consumption has registered a higher growth. Calorie and protein source in the Indian diet is diversifying with fruit/vegetable and animal-based food share increasing and cereal and pulses declining. The report also explores further showing as with the rising level of income, per capita fat consumption is growing rapidly and the share of vegetable oil in the overall calorie intake is increasing necessitating large imports. Unless domestic production increases the import requirement will continue to grow with rising per capita income.

Peltzer, K., Pengpid, S (2012) did research on fruits and vegetable consumption in South East Asian Countries. The aim of the study was to assess the prevalence of fruits and vegetable consumption and associated factors among Southeast Asian in-school adolescents. Data were collected by self-report questionnaire from nationally representative samples (total 16,084) of school children aged 13 to 15 years in five Southeast Asian countries. Overall, 76.3% of the 13 to 15 year-olds had inadequate fruits and vegetables consumptions (less than five servings per day); 28% reported consuming fruits less than once per day and 13.8% indicated consuming vegetables less than once per day. In multivariable analysis, lack of protective factors and being physically inactive were associated with inadequate fruits and vegetable consumption, and sedentary behaviour and being overweight was protective of inadequate fruits and vegetable consumption. The results stress the need for intervention programmes aimed at increased consumption of fruits and vegetables, targeting proximal factors such as the family environment and distal factors by aiming at integrating other risk factors such as physical activity into health promotion among adolescents.

Prakash, J., et al (2015) did a study on consumption pattern of fruits and vegetables among medical students in private hospitals. The study finds that the average daily consumption of fruits was 155 gm/day and vegetables 190gm/day. Mean consumption of fruits and vegetables was 345 gm/day which is less than 400 gm/day as recommended by WHO, 27.8% respondents consumed 400 gm or more of fruits and vegetables. It was observed that most frequently consumed fruits by the medical students were banana, orange, apple, & mangoes while the most popular vegetables were potatoes, tomatoes, carrots, & beans. Maximum Doctors have good nutritional knowledge i.e. interns 85% and PGs 91%. The research used logistic regression and shown that category of medical students, age and

income have positive relationship with consumption of fruits and vegetables of 400 gm or more. The mean consumption of fruits and vegetables was 345 gm/day which included most commonly consumed fruits and vegetables.

Epuru. S., et al (2014) did a study on fruits and vegetable consumption among university students in Saudi Arabia. The study basically a cross sectional survey. The article mentions that a total of 200 females (mean ± standard deviation (SD): age: 21.49 ± 1.72 years; height: 160.93 ± 7.68 cm; weight: 64.30 ± 12.52 kg; and BMI: 24.81 ± 4.51 kg/m2) participated. The percentage of subjects who likes fruits (86 %) is significantly higher (÷2= 31.999; p <0.0001) as compared to the percentage of subjects who likes vegetables (71 %). There was two times higher risk for obesity for study population with low vegetable consumption as compared to high vegetable consumption (÷2= 6.123; p =0.013; OR=2.176 (CI- 1.169- 4.051)). Results from this study highlight the importance of early identification of the health risk behaviours in young adults and the need to promote healthy dietary awareness and interventions.

Deaton, A., Drèze, J., (2009) wrote an essay on food and nutrition status in India. The paper is basically a review article and explores nutrition intake in India. The article mentions about certain hypothesis that calorie requirements have declined due to lower levels of physical activity or improvements in the health environment." The article concludes by mentioning that there is strong evidence of a sustained decline in per capita calorie consumption during the last 25 years or so.Arlappa, N., et al (2010) wrote certain research paper titled Consumption pattern of pulses, vegetables and nutrients among rural population in India. At the end of the article the authors try to discuss about importance of vegetables and pulses and they mention that majority of pre-school children, adolescents, adults, pregnant and lactating women were not consuming even 50% of the recommended amounts of vitamin A, iron, riboflavin, vitamin C, free folic acid and calcium. This was reflected in the NNMB study carried out in same villages during 2003 where high prevalence of iron deficiency anemia and vitamin A deficiency was reported.

3. RESEARCH METHODOLOGY

From the review of literature it is clear that the reasonable intake of fruits and vegetables helps keeping health well. There are certain studies in support of this view and show lot of quantitative evidence. There are also literature that the less intake of reasonable amount of F and V pose health problems. These observation in fact provide certain inputs for this research such as what influences consumption is it alone production or any other factor? Is it possible to observe consumption driven by surplus depends on production, exports? If so what is the empirical evidence? Is it possible to any level of evidence in support of theoretical relationships in between surplus, production and exports? While there is lot of literature in support of the views that individual health depends on nutritious food *ala* F and V, but the same on certain factors which influence consumption driven by surplus at global level is scarce. This research try's to explore relationships in between these factors of study i.e. surplus, production and exports, so that any evidence in support of hypothesis might help researchers involving in this domain of operations.

This paper deals with the study of fruits and vegetable production and consumption. Production is the process of converting tangible and intangible inputs into goods and services that are suitable for exchange. The word consumption, in business parlance, can be defined as the utilization of economic goods that might result into fulfilment or satisfaction. The word utilization is perhaps is critical for the very act of consumption. For instance, maize can be used to produce ethanol or eateries for human consumption. The first activity is utilization but the second activity is consumption due to the fact that the very definition for the word consumption emphasize fulfilment or satisfaction. So, these two words consumption and utilization might not be used in the same parlance. Now the

question is, in which way this word consumption can be understood from the surplus point of view for in the best interest of availability of goods and services. While it is not extraneous to state that the very act of consumption depends on availably but what determines the availability might be point that need to be brought under the focus of discussion. For instance, Ranum P., and et al, (2014) in their study discuss the effect of utilization of maize for ethanol production affects prices for animal and human consumption. So the price paid by the consumers to fulfil their needs (through maize) determines the availability of maize for such consumption. Hota, S., (2014) in her research mentions that the human consumption of water pretty much determines the utilization and consumption of water. She also suggest the policy makers and metropolitan authorities to optimize the existence in the best interest of low income groups which utilize scarce comparatively compared to high income groups living in urban areas. So based on the evidence in the earlier research this study assumes that the consumption pretty much depends on the surplus with due respect to exceptions.

The research is descriptive and exploratory in nature, which means this study seek to identify certain issues, dilemmas or any ambiguity in the field by merely providing summary of the statistics so collected in support of the objectives. The data sets were obtained from certain international repositories like US Department of Agriculture, European data portal, portals from other NGOs. The data sets were analysed with the help of certain statistical tests in order to find the uncertainties in the field of agriculture with special reference to fruits and vegetables. The original data which have been obtained from the repositories is a data matrix of 6 X196 order. The original data set provides description of vegetable production and export of 196 countries. But for the feasibility only few countries were selected namely India, China, United States of America and United Kingdome. The comparisons were made with the help of Karl Pearson Correlation Coefficient and certain tests like *t test* were done along with *f test* in order to verify if these countries are significantly different with respect to their production and export of vegetables. The data is available only for few vegetables like Asparagus, Broccoli, Cabbage, Onion, Carrot and etc. The details were provided in analysis section of this paper. The following serves as objectives to the study.

1. To know the present condition of production of fruits and vegetables with respect to select countries.

2. To know about the status of the countries in comparison to each other with respects to fruits and vegetables.

3. To find out if the countries are different with respect to their production of fruits and vegetables.

4. To find and evaluate the evidence in support of study proposition that the countries are significantly different with respect to their production of vegetables.

5. To find and seek if thereexist any possibility to identify groups through any differences that can be found in the data.

6. To find and evaluate that whether any evidence is available in support of study proposition that the consumption driven by surplus significantly depends on exports and imports.

As mentioned before, certain statistical techniques like to Karl Pearson Correlation along with T Test of independent samples were chosen to realize the above mentioned objectives. The Karl Person Correlation Coefficient is parametric measure that seek to explain relationship between any two or more variable of the study. Karl Person Correlation Coefficient for population can be expressed as below:

And for sample

$$r \quad \frac{\sum_{i\ 1}^{n}(x_1 \quad \bar{x})(y_i \quad \bar{y})}{\sqrt{\sum_{i}^{n}(x_1 \quad \bar{x})}\sqrt{\sum_{i}^{n}(y_i \quad \bar{y})}}$$

The T Test for independent samples can be defined and expressed as following.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{S_p\sqrt{\frac{n_1 \quad n_2}{}}}$$

Where $\bar{x}_1$ the mean value of the first is sample and $\bar{x}_2$ is the mean value of the second sample. S_p is the pooled sample. The hypothesis for the T Test is that the difference between sample statistics is not significant. In other words:

$H_0 : \bar{x}_1 \quad \bar{x}_2 = 0$

The alternative hypothesis is that the difference is significant i.e. $H_0 :$ = 0. Hence, the following could serve as study hypothesis :

H_1=The differences among sample countries are significant with respect to the production of fruits and vegetables.

H_2=The surplus dependent consumption depends on production, exports and import status of fruits and vegitables in these countties

H_3= The countries can be grouped with respect to vegitable production and consumption and such groups are certain

The substantiation or opposition of the second hypothesis requires multivariate regression. The multivariate regression can be defined as below:

$$y=\beta_0 + \beta_1x_1 + \beta_2x_2 +.....+\beta_nx_n + \varepsilon$$

In this case the expression for multiple regression will turns out to be

$$surplus_{f\&V}=\beta_0 + \beta_1(production)_{f\&V} + \beta_2(exports)_{f\&V} + \varepsilon$$

The test of hypothesis is going to be $H_a : \beta_1 =0$ or $H_a : \beta_1=\beta_2=0$ In fact, as per simple linear regression the ideal expression must be $\beta_0= 0$ and β_1 to explain perfect relationship between dependent and independent variables i.e. surplus and other variables of study. But there is lot of evidence in support of H_a the way it is define here through literature review. Anyway, this study try to test H_a as it is defined above through multiple regression. The following section provide description to the study analysis.

Above methods helps to realize first two hypotheses whereas the third hypothesis might need certain multivariate statistical technique. There are number of techniques to fulfil the needs of this part of research. Some of them are correspondence analysis, principal component analysis, factor analysis and cluster analysis. The study found cluster analysis as suitable technique to evaluate the third hypothesis. R language is used to perform cluster analysis through certain package known as mclust. Mclust is a special package that allows model based clustering through uncertainty and density estimations. For instance, mclustassumes a normal or Gaussian mixture model, such as :

In the above equation x represents the data, G is the number of components $_k$ is the probability that the observation belongs to the k^{th} component. The model is selected based on BIC value i.e., BIC - 2loglik (x,θ) - (no. of params.)* log (n). The following section provides sufficient interpretation to all these methods through output taken from respected tools.

$\bar{x}_1^n \bar{x}_2^p$ $(x / \quad)$

$_{t\ 1\ k\ 1}$

5 ANALYSIS

As mentioned in the previous section this article deals with the study of certain select countries with respect to production, export and surplus for consumption. The aim of the study is to find and evaluate the evidence in support of the study proposition that the study regions or countries are significantly different with respect to production, export and consumption of vegetables. The consumption is studied with respect to surplus available. As it was mentioned in the methods the consumer surplus is the difference between consumption value and price paid by the consumer or buyer. So this study assumes that the surplus effectively address the consumption of the region willy-nilly of the facts. The following table shows the summary statistics for the study data sets.

Table 3. Vegetable Production (in Metric Tons)

Table of Contents	India	China	USA	UK
Artichoke	0	150	45	0
Asparagus	0	14,503.1	38	5.1
Broccoli and Cauliflower	6,745.0	17,960.3	302	180.6
Cabbage and Other Brassica	7,949.0	64,084.0	960	279.4
Carrots	514.9	32,334.6	1,299	694.1
Corn	21,760.0	3,85,685.2	3,13,949	0.0
Cucumbers	161.0	94,667.8	773	0.0
Eggplant	11,896.0	55,423.4	62	0.0
Garlic	1,057.8	38,390.1	191	0.0
Green Bean	617.9	31,416.6	39	0.0
Lettuce	1,059.9	26,864.5	4,071	0.0
Mushroom	514.9	32,334.6	1,299	694.1
Okra	5,784.0	0.0	8	0.0
Onions	17,511.1	44,064.8	38	300.9
Potatoes	42,339.4	1,76,644.3	38	0.0
Spinach	0.0	1,76,644.3	409	0.0
Squash	4,695.5	13,870.2	814	0.0
Sweet Potato	1,046.6	1,50,929.9	1,223	0.0
Tomato	16,826.0	97,022.9	12,526	0.0
Average	7393.627368	76473.1912	17793.8514	113.3757
Variance	111957940.2	8227320204	4880461017	48449.83
Std Dev	10870.96251	93190.0936	71774.6316	226.1448

Table 3 shows the summary of the vegetable production. China appears to be top in the list of production followed by USA, India and the least of which is UK. The following tables shows the details clearly.

China tops the list with an average production of 76 billion tons, which is followed by USA (17 bl), India (7 bl) and UK (0.1 bl). The production in UK appears to be very low. India stands at third position in terms of production.

Table 4 : Country wise summary statistics

Country	Average	Variance	Std Dev	T Stat	P Value
China	76473.19116	111957940	10870.9625	30.66324	2.72368E-17
USA	17793.85142	8227320204	93190.0936	0.832294	0.208074517
India	7393.627368	4880461017	71774.6316	0.449018	0.329389045
UK	113.3756842	48449.833	226.144844	2.185295	0.021164783

Table 2 shows the P Values obtained through multivariate correlation. The analysis shows that the China's production is significantly different from the rest of the countries. The study has the evidence in support of hypothesis that the differences among the countries with respect to

production is rather significant. Interestingly Indian production of fruits and vegetables appears to be significantly different from both China and UK but not from USA. USA and India appears to have same patterns of production. Fig 1 show the production status of the vegetable by country along with a trend line. However, since the data is not a time bound data the trend line doesn't assume importance. The following table shows the statistical diagnosis for two sample T Test.

Table 5 : Correlation analysis

Country	China	USA	India	UK
China	NA	0.03632031	0.002796	0.001029943
USA	0.00146352	NA	0.536246	0.290085583
India	0.00279567	0.53624576	NA	0.006028753
UK	0.00102994	0.29008558	0.006029	NA

Table 6 show the output for multiple regression analysis, the F Statistic (6.32454E+32) along with its P Value (3.1796E-291) shows that there is overwhelming evidence in support of study hypothesis. The consumption driven by surplus rather explained by both production and exports. The differences perceived significantly different from their expected values. That means, the T Statistics (1.49957E+16, -1.05376E+15) and P Values (5.594E-266, 2.2519E-246) shows that the estimates are significant for the study, which means that the estimates are significantly different from the expected values hence providing evidence or substantiating study hypothesis that the consumption driven by surplus in these countries are significantly different from each other. Moreover the way production and exports explains the surplus is rather seems to be opposite from each other. The values are same with opposite signs, which of course empirically true. For instance, while production increases surplus, exports decreases the same. This observation shows the veracity of technique. Hence, providing validity of inferences drawn through other measures.

Table 6 : Multiple Regression

Variables	Estimates	Std Error	T Value	P Value
Surplus	-3.45608E-11	5.70808E-12	-6.054718427	1.28765E-05
Production	1	6.66859E-17	1.49957E+16	5.594E-266
Exports	-1	9.48985E-16	-1.05376E+15	2.2519E-246
F Value	6.32454E+32	SS_{reg}	4.13865E+11	Dof
P Value	3.1796E-291	SS_{resid}	4.13865E+11	16

Cluster Analysis

As it was described in the methodology the data was analysed through model based cluster analysis by Using R language. Please find the code written in R to perform aforementioned analyses as in the form of script in Annexure. The following is the output taken from the R console as a matter of output for summary for the model or fit.

```
>summary(fit, parameters = TRUE)
————————————————————Gaussian finite mixture model fitted by EM algorithm
————————————————————Mclust EII (spherical, equal volume) model with 9 components:
log.likelihood      ndf          BIC          ICL
-331.4581           22 54        -829.8325    -829.8776
```

Clustering table:

1	2	3	4	5	6	7	8	9
12	2	1	1	2	1	1	1	1

Mixing probabilities:

1	2	3	4	5	6	7	8	9
0.54466463	0.09169901	0.04545455	0.04545455	0.09090909	0.04545455	0.04545455	0.04545455	0.04545455

Means:

	[,1]	[,2]	[,3]	[,4]	[,5]	[,6]	[,7]	[,8]	[,9]
X	1.358734e+01	1.580288	4.0	5.0	9.5	15.0	3.0000	22.00	19.0000
India	8.337102e+00	1.040788	16.0	18.0	15.0	10.0	19.0000	7.00	5.0000
China	8.745305e+00	5.555884	7.0	15.0	11.0	13.0	16.0000	17.00	18.0000
USA	9.837211e+00	9.975533	7.0	19.0	2.0	8.0	4.0000	13.00	15.0000
UK	4.502086e-04	2.525360	180.6	279.4	694.1	300.9	113.3757	48449.83	226.1448

The above numerical data is the output from R for cluster analysis. The log likelihood value is -331.4581for 54 DoF and the BIC is -829.8325 these values are useful while comparing the models whereas here there is only one model and the information so obtained from the analysis is not that useful to assess the model. The above output is saved in the form of a table below where there is certain information regarding mixing probabilities and means values for the study variables. For instance the mixing probability for first cluster is approximately 54 % and which falls drastically to 9 % that shows that the model is not able to explain consistent number of clusters, but there are differences among means of the clusters.

The following is the profile plots for cluster analysis performed in R

Figure 2 : Profile plots for cluster analysis

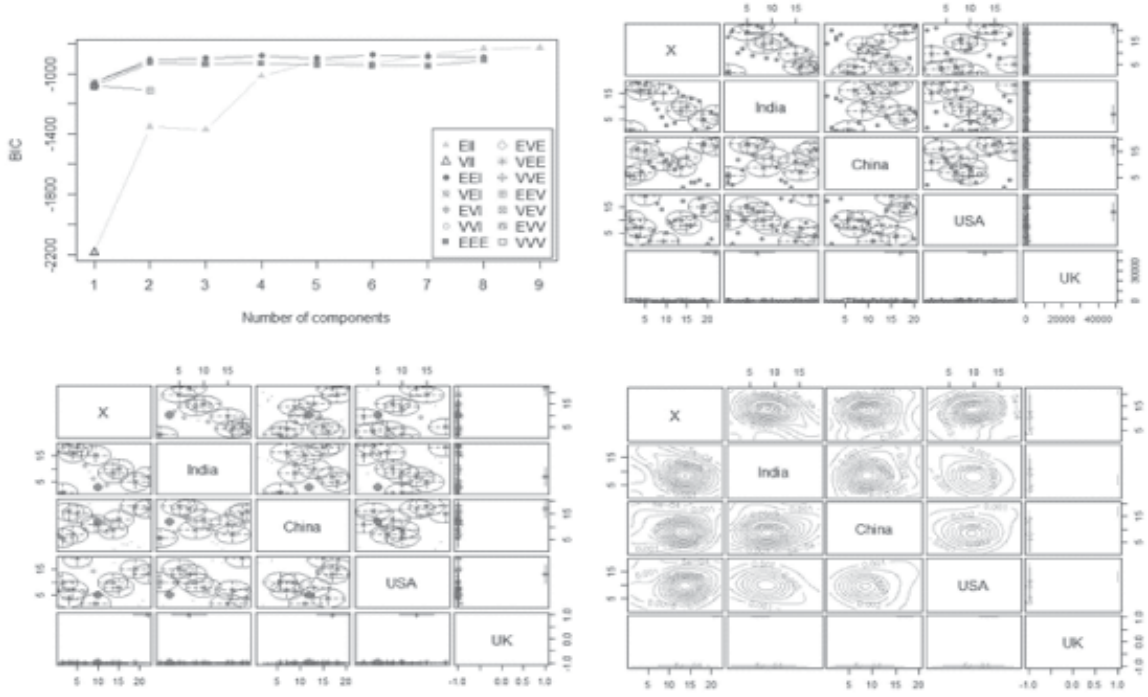


Figure 2 adds pictorial representation to numerical output from R for cluster analysis. The first plot is BIC vs. Number of Components which shows that the covariance models (shown in the legend) the graph shows that all models converge at cluster number nine, which is the solution of the analysis. The second graph is classification plot which depicts the number of clusters along with respective points. The third plot is the uncertainty plot that shows the points that are noisy or outliers. The final plot is the density plot which shows the cluster solution with the help of kernel density estimation. All these plots adds visualization to numerical solution. The following table (table 7) is shows only necessary information from the output.

Table 7. Summaries of clusters in the data

Cluster	Probability	X	India	China	USA	UK
1	0.544665	13.58734	8.337102	8.745305	9.837211	0.00045
2	0.091699	1.580288	1.040788	5.555884	9.975533	2.52536
3	0.045455	4	16	7	7	180.6
4	0.045455	5	18	15	19	279.4
5	0.090909	9.5	15	11	2	694.1
6	0.045455	15	10	13	8	300.9
7	0.045455	3	19	16	4	113.3757
8	0.045455	22	7	17	13	48449.83
9	0.045455	19	5	18	15	226.1448

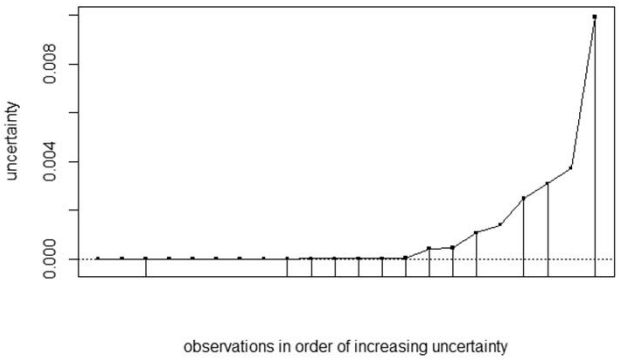
Table 8 shows the information related to uncertainties across the clusters. Uncertainty deals with the mergence of observations across the clusters which is also known as distinctness of clusters. Left column in the table shows the percentage of uncertainty whereas the right column shows the concerned P Value. The P values shows that the uncertainty across the clusters increases and unsteady. Figure 3 is visual representation to the table 6.

Table 8 : Uncertainty of clusters

Percentage	x
0%	0
25%	4.17E-14
50%	1.70E-06
75%	0.000901
100%	0.00992

The cluster analysis fail to show evidence in support of the third hypothesis i.e. the differences across the countries with respect to production are not valid for grouping. So it is not possible for the study to group the countries through dissimilarities.

Figure 4 : Uncertainty in the model



CONCLUSION

Vegetable production in China seems to be unexpectedly high. Though UK production is also unexpectedly high but appears to be usual while compared to USA. USA production is also usual when compared with China. Interestingly, the vegetable production of UK is significantly different from India but not with USA. USA vegetable production is significantly different from China but not from UK and India. Though there appears to be apparent differences statistical diagnosis helped in proving that the

countries are different in terms of their fruits and vegetable production. So this shows that in terms of vegetable production of India is significantly different from UK and China but not with USA. So the null hypothesis rejected and there is overwhelming evidence in the data in support of study hypothesis. The countries are significantly different from each other in terms of their production and consumption. There is also overwhelming evidence in support of second hypothesis that the consumption driven by surplus is significantly different among these countries for they depend on exports and production. There is also evidence in the study that while production increases the surplus but exports decreases the surplus. Production and export level differences to surplus are significant in the study. The study fail to find evidence in support of third hypothesis which means the study is not able to group countries with respect to vegetable production and consumption. So the way vegetables produced and consumed are strictly different across these countries.

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