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RESEARCH ARTICLE

Strategic dimensions of the nutritional and economic value of Cereal crops

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Abstract

Cereals are popular food for human society. It conquers poverty and hungers of global population. It provides significant nutritional and economic value even in the global humanitarian crisis like COVID-19. Cereals are the focal point for improvising numerous goals of UN-SDGs. The present study has focused on the essence of cereals as primary component of staple food augmented with adequate nutritional value. The research work has also attempted to understand the contribution of cereals across the world. The study may emerge as a policy paper on nutritional and economic perspective of 'cereals' based on innovative models and empirical arguments.

Keyword: Nutrition; Economic Value; Cereals; Strategy; SDGs; COVID-19

1. Introduction

The history of human civilization is vast, and the journey of development started with the ignition of fire. Food had been the vital necessity for the very existence of living beings. The art of interdependence through increasing human socialization process had triggered momentum for achieving and overcoming all these menaces. Food, clothes, and shelter had been the prime constructs as basic human needs. The importance of food had been equally consistent both in pre-historic era as well as in the modern 21st century (Alt et al., 2022). The universal policy document of United Nations consistently targeted on the subjects like food, poverty, and hunger as the epitome of global concern which have been reflected in the MDGs and SDGs. This has evidenced that despite achieving landmarks success in technology, advancement of sciences and pyramids of intellectual acumens; the issues of food remain an unaccomplished mission.

The kingdom of living creatures on earth can be categorized as plants, animals, fungi, Protista and Monera. Protista and Monera are the unicellular living organism are called microbes or micro-organism. The 'microbes' consist of bacterium which either survive on the lifestyle of symbiotic or saprophytic practices. The other three dominant living creatures are plant, animal and fungi. Fungi are the representative of eukaryotic organisms separated from plants and animals as well as members of several other smaller living kingdoms. Plants are the only producer of primary foods (Bennett, 2010) that stores energy by the process of photosynthesis. The primary food and energy are transferred from plant to herbivores, from herbivores to carnivores and finally to omnivores following the sequence of food chain to form food pyramid. This food web maintains the synergy of eco-system. So, the bottoms of the pyramid are the plants which are responsible for food solution for the living creatures on earth.

Food is the most essential component for the survival and growth of human life. It provides various nutrients that help the cognitive as well as somatic development in human body. Food is the source of all nutrients and energy which are vital for regular growth, good health, and life span activities. In fact, the structural and functional compositions of the human body cannot be imagined without the supply of five basic nutrients which are protein, carbohydrate, fat, vitamins, and minerals. The requirement of nutrients varies with respect to age, gender, and health conditions. The recommended dietary reference comprising of amount of nutrients, water, fiber, and energy etc. for each segment of population has been depicted in Table 1. It is estimated that out of 350 thousand of plant species available on earth, a mere 80 thousand are proved to be edible by human body even though a miniscule of 150 species are globally ploughed as a food solution for human race or as animal feed. Most surprisingly a latent of one-fifth of largely cultivated species across the globe contribute almost 95 percent of total protein and calories demand of the *Homo sapiens* (Füleky, 2016).

The growing challenges of nutritional demand and issues of food security have become one of the largest threat perceptions for the very existence of our civilization. The concurrent and contemporary agricultural policies have measurably failed to adequately focus and address these challenges in national and international level. Demand vector of food varies with diversified range. The economically marginalized people run after food stuff to eradicate hunger compounded with the affinity to acquire necessary proteins, calories, micronutrients, and vitamins to struggle for basic livelihood. The economically vibrant middle class and creamy layer are concerned for their high health quotient entangle with quality of life, lifestyle disorder (obesity and overweight etc.) and high expectancy by consuming superior quality and balanced diet (Pingali, 2015). Diet diversity can be the holistic solution for each stratum of the population. Diet diversity may be influenced by multidimensional variables such as strategic fit, community beliefs and practices, taste and preferences, availability, adaptability, and price. This can be evidenced by observing diversified food habits across the basis of segmenting population (i.e., geographical, income level, image etc.).

All the dietary combinations are formulated by the considerable presence of cereals. However, cereals are composed of different variety of species like maize, rice, wheat, barley, sorghum, millets etc. In fact, the cereal-umbrella essentially belongs to the *Gramineae* family colloquially popular as grasses. In fact, cereals yield high amount of food with respect to cultivable area. Generally, the agriculture produces (e.g., vegetables, fruits etc,) are highly perishable in nature and lost for very tiny period hence, it cannot be used as per the discretion of future requirement and most importantly cereals can be stored for long period which can be deployed for future use (Saldivar, 2016). It is observed that most of

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the nation assumes food security as the function of self-efficiency in cereals production. This shows the degree of dependency on cereal by a considerable section of global population. However, the agricultural policy has been dominated by three cereal crop - maize, rice, and wheat (Pingali, 2015).

Most of the literatures on cereals are focused on nutritional dimension as a subset to its food value. A section of agriculture economists has attempted to understand the efficacy of farming eco-system with economic implications. However, these approaches are crop specific, region specific or time specific which the agriculture system desperately need the support of big data analytics in a truly representative manners based on real time data inputs and on holistic endeavors. This paper has attempted to address three specific issues i.e., the spectrum of cereals in terms of production and consumption globally, necessary nutritional value and a brief understanding of the scope and contributions of each variety of cereals on the society. In the second stage, the study has focused on possible value creation for each of the cereals using diversification of multiplier both in related and unrelated areas along with its core produce. This has enabled economic value proposition of each of the cereals with present and potential benefits. Finally, the study has encompassed sustainable issues i.e., the economy of land use to achieve the desired production at present as well as ensure the potentially desired requirement in future without any damage or posing threat to the environment. Present research aims to analyze the importance of cereal crops in human life and explore its contribution to the world economy; and to assess the impact of cereals by developing crop wise nutritional and economic value added (EVA) analysis.

2. Methodology

In the present study, secondary data were collected, collated and analyzed from various sources such as, substantive reports, reports of domain knowledge body, articles published in relevant journal and study notes from the pioneer research book. In fact, the nature of the paper essentially demands logical arguments and rational approach using both empirical analysis as well as qualitative explanations. In course of addressing issues a model framework approach has been instituted using classical and applied models of strategic management. The descriptive and inferential statistics have been used for performing empirical analysis. Appropriate statistical packages like MS-Excel, SPSS were used.

3. Analysis and interpretation

3.1. Analysis-I and observation

Cereals have vivid impact on human. Particularly it essentially meets the desired nutrient and other sub-components like protein, fat, carbohydrate, fiber, water etc. The cereals also provide substantial energy for leading day to day life. For instance, oat, millets, maize provide significant energy support for adult person. Oat is rich source of protein followed by rice and triticale. In fact, oat contributes almost all major nutrients in substantial proportion. The details of nutrient matrix of all forms of cereal are canvassed below.

3.1.1 Cereals as the staple food of the world

Cereals are produced and consumed across the world. However, Triticale and Fonio have little presence as staple food. Details of production and consumption of each variety of cereals along with earmarking the amount of nutrients, fiber, water, and energy etc. in each of the selected food largely popular across the globe is presented in Table 2.

The world has been transforming through series of developmental stages. The massive, urbanization, industrialization, infrastructure development and increasing growing demand of habitat have forced the shirking of land primarily agricultural land throughout the globe. In addition to loss of soil fertility, contamination of heavy metals, solid chemical and other pollutants are detrimental to high yielding of crop. In this catch-22 situation it is amazing and fascinating to observe the overall production of cereals have produced in manifolds over a period. The production of cereals has been on increasing order globally except barley, sorghum oats, and rye. This is evidenced by data from 1987 to 2019 as depicted in the Table 2.

It is noted that the maize production has been more than doubled from 1987 to 2019 followed by increase in production of rice and wheat by 50 percent. It may be interpreted that the influx of population has forced us to achieve such an increase of production of cereals to wipe out the issues of hunger and basic livelihood. As the growth in population has been intensified in developing and underdeveloped nations higher production and consumption of cereals signifies that this set of crops essentially act as principal food solution to the respective population and economy.

Table 1. Recommended nutrients requirements in Human Body - Quantitative Approach

Age Group (Month or Years)	Total Water [a] (Litre/day)	Carbohydrate (gm/day)	Total Fiber (gm/day)	Fat (gm/day)	Protein (gm/day/kg of body weight)
Infants					
0–6 m	0.7*	60*	ND	31*	9.1*
6 m-12 m	0.8*	95*	ND	30*	11.0
Children					
1–3 y	1.3*	130	19*	ND	13
4–8 y	1.7*	130	25*	ND	19
Males					
9–13 y	2.4*	130	31*	ND	34
14–18 y	3.3*	130	38*	ND	52
19–30 y	3.7*	130	38*	ND	56
31–50 y	3.7*	130	38*	ND	56
51–70 y	3.7*	130	30*	ND	56
> 70 y	3.7*	130	30*	ND	56
Females					
9–13 y	2.1*	130	26*	ND	34
14–18 y	2.3*	130	26*	ND	46
19–30 y	2.7*	130	25*	ND	46
31–50 y	2.7*	130	25*	ND	46
51–70 y	2.7*	130	21*	ND	46
> 70 y	2.7*	130	21*	ND	46
Pregnancy					
14–18 y	3.0*	175	28*	ND	71
19–30 y	3.0*	175	28*	ND	71
31–50 y	3.0*	175	28*	ND	71
Lactation					
14–18 y	3.8*	210	29*	ND	71
19–30 y	3.8*	210	29*	ND	71
31–50 y	3.8*	210	29*	ND	71

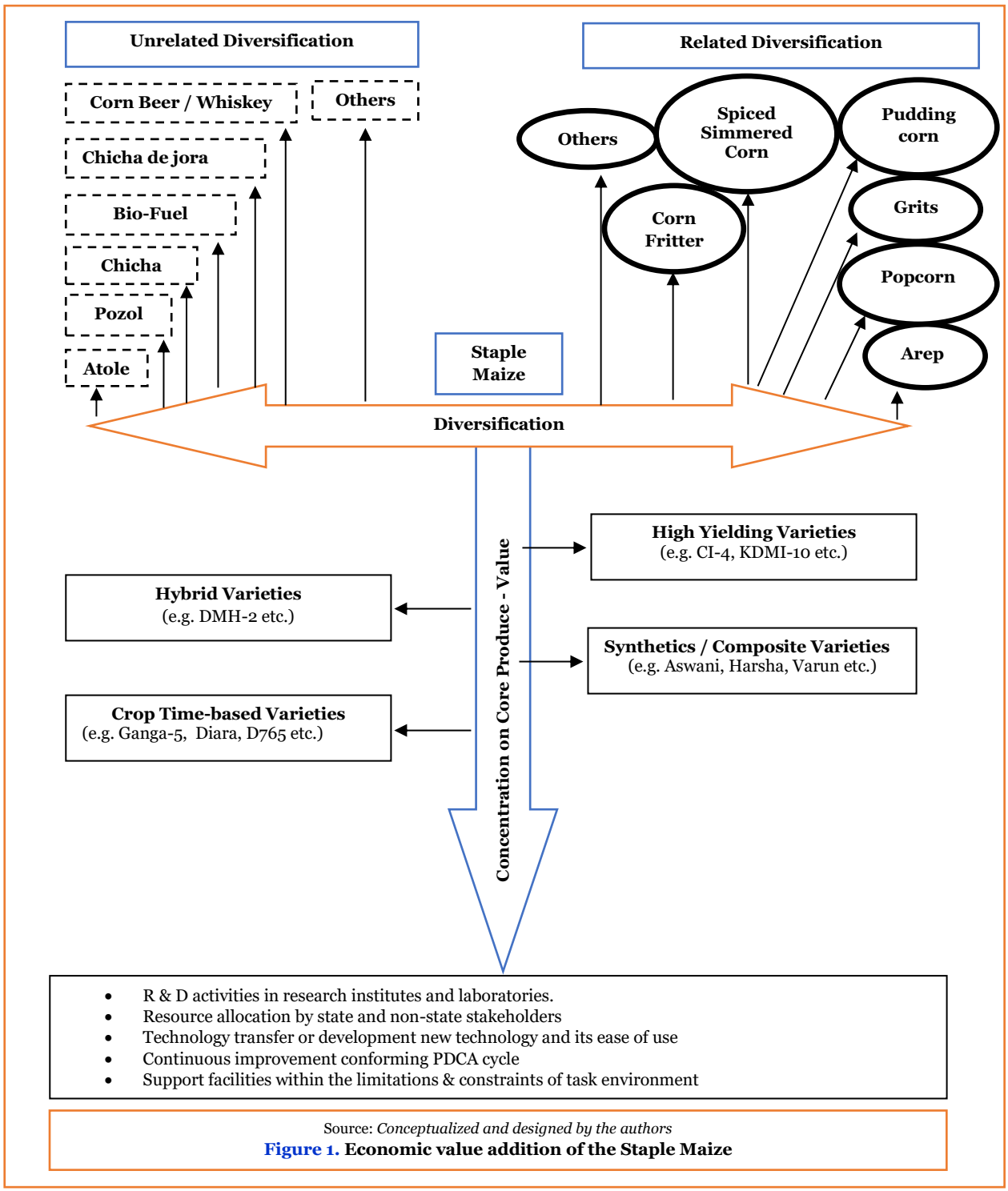
Source: Food and Nutrition Board, Institute of Medicine, National Academies
Derived from DRI reports that presents RDA (bold) and Adequate Intakes (AI) in ordinary type with an asterisk (*).
a. Total water includes all water contained in food, beverages and drinking water.
ND. Not determined.

Table 2. Staple foods with Key Cereals - Content Mix: Cereals - Global Production and Consumption

Content of Nutrients, Water & Energy etc. in 10 Selected Staple Foods / 100 gm												
	Content in gm except KJ for energy	Maize	Rice	Wheat	Potatoes	Cassava	Soybeans	Sweet Potatoes	Yams	Sorghum	Plantains	RDA[ψ]
Content Mix	Water	10.83	7.76	12.42	83.29	59.68	67.5	77.28	69.6	12.4	65.2	3000
	Energy	1523	1493	1389	243	669	615	360	494	1377	510	8368 - 10460
	Protein	8.75	14.73	9.61	2.57	1.36	12.95	1.57	1.53	10.62	1.3	50
	Fat	5.09	1.08	1.95	0.1	0.28	6.8	0.05	0.17	3.46	0.35	-
	Carbohydrates	73.89	74.9	74.48	12.44	38.06	11.05	20.12	27.88	72.09	31.89	130
	Fiber	8.4	6.2	13.1	2.5	1.8	4.2	3	4.1	6.7	1.7	30
	Sugar	0	2.5	1.02	0	1.7	0	4.18	0.5	2.53	17.51	-
Global Production & Consumption of Cereals												
		Maize	Rice	Wheat	Barley	Sorghum	Millets	Oat	Rye	Triticale	Fonio	
WP^		1409.44	966.88	899.37	159.88	61.50	30.67	23.60	13.31	14.51	0.70	
Major Producing Countries		USA, China, Brazil, Argentina, Mexico, Ukraine, India, Indonesia, Russian Federation, Canada.	China, India, Indonesia, Bangladesh, Vietnam, Myanmar, Thailand, Philippines, Brazil, Pakistan.	China, India, Russian Federation, USA, Canada, France, Ukraine, Pakistan, Germany, Australia.	Russian Federatio, Germany, France, Ukraine, Australia, Canada, Spain, Turkey, UK, USA.	USA, Nigeria, Sudan, Mexico, Ethiopia, India, Argentina, China, Niger, Australia	India, Niger, China, Mali, Nigeria, Sudan, Burkina Faso, Ethiopia, Chad, Russian Federation.	Russian Federation, Canada, Poland, Australia, Finland, USA, Spain, Brazil, UK, Argentina	Germany, Russian Federation, Poland, Belarus, Denmark, China, Ukraine, Canada, USA, Spain.	Poland, Germany, Belarus, France, Russian Federation, Hungary, Spain, China, Lithuania, Austria.	Guinea, Nigeria, Mali, Burkina Faso, Niger, Senegal, Benin.	
Major Consuming Countries		USA, China, Brazil, Mexico, India, Egypt, Japan, Canada, Vietnam, South Africa.	China, India, Indonesia, Bangladesh, Vietnam, Philippines, Burma, Thailand, Japan, Brazil.	China, India, Russia, United State of America, Pakistan, Egypt, Turkey, Iran, Brazil, Indonesia.	Russian Federation, China, Saudi Arabia, Turkey, Canada, Iran, United State of America, Ukraine, Australia, Morocco.	Nigeria, Mexico, China, United State of America, India, Sudan, Ethiopia, Argentina, Brazil, Niger.	India, Niger, China, Mali, Nigeria, Burkina Faso, Sudan, Ethiopia, Chad, Senegal.	Russian Federation, United State of America, Canada, China, Brazil, Australia, Chile, Argentina, Belarus, Ukraine.	Russian Federation, Belarus, United State of America, Ukraine, Turkey, Canada, Argentina, Norway, Kazakhstan.	–*	–*	

^World Production as on 2016 (in MT) * Information not available ψ Recommended Dietary Allowances (RDAs)

Source: *Nutrient Data Laboratory, Department of Agriculture, USA and Food and Agriculture Organization (FAO)*



Source: *Conceptualized and designed by the authors*

Figure 1. Economic value addition of the Staple Maize

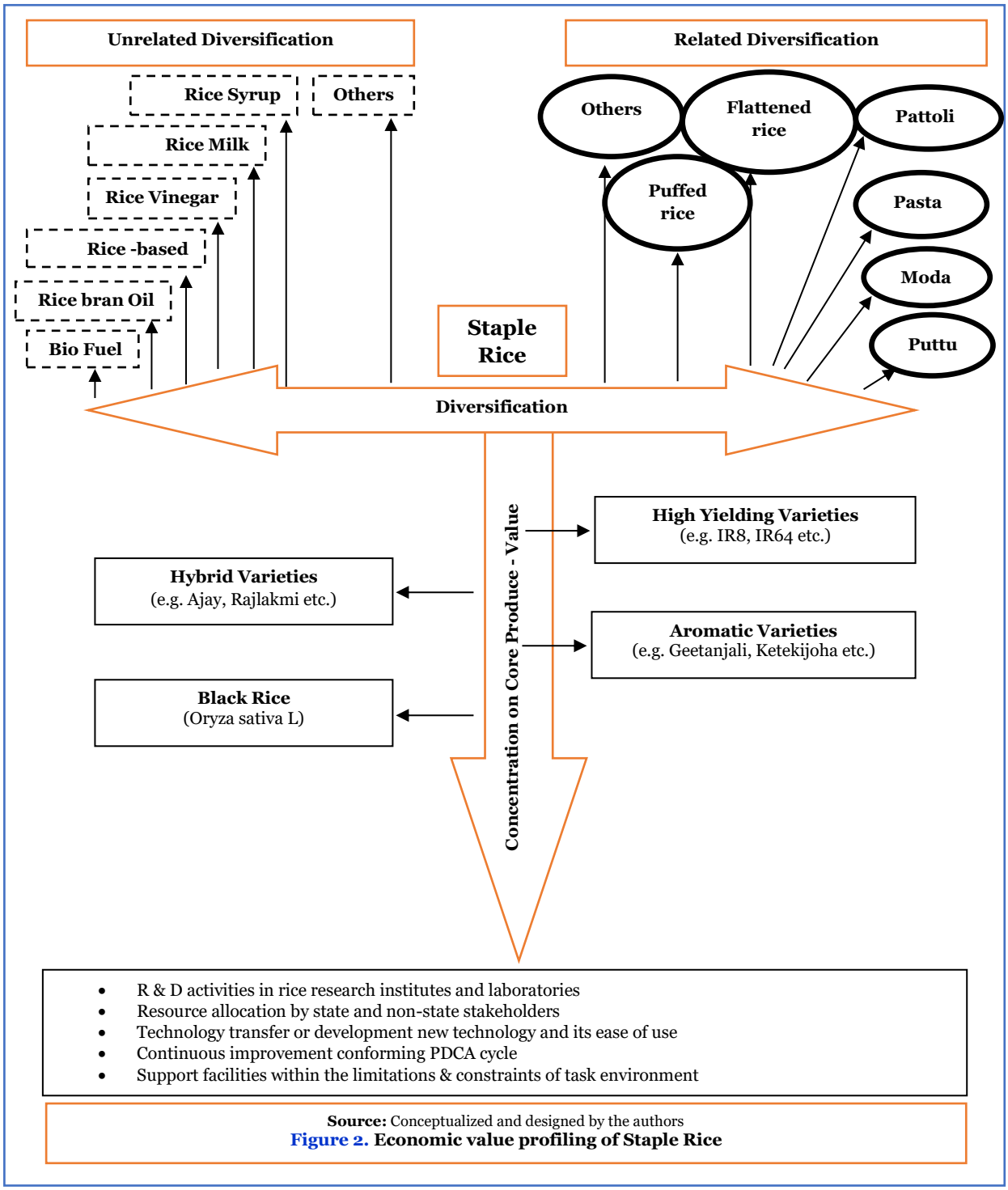


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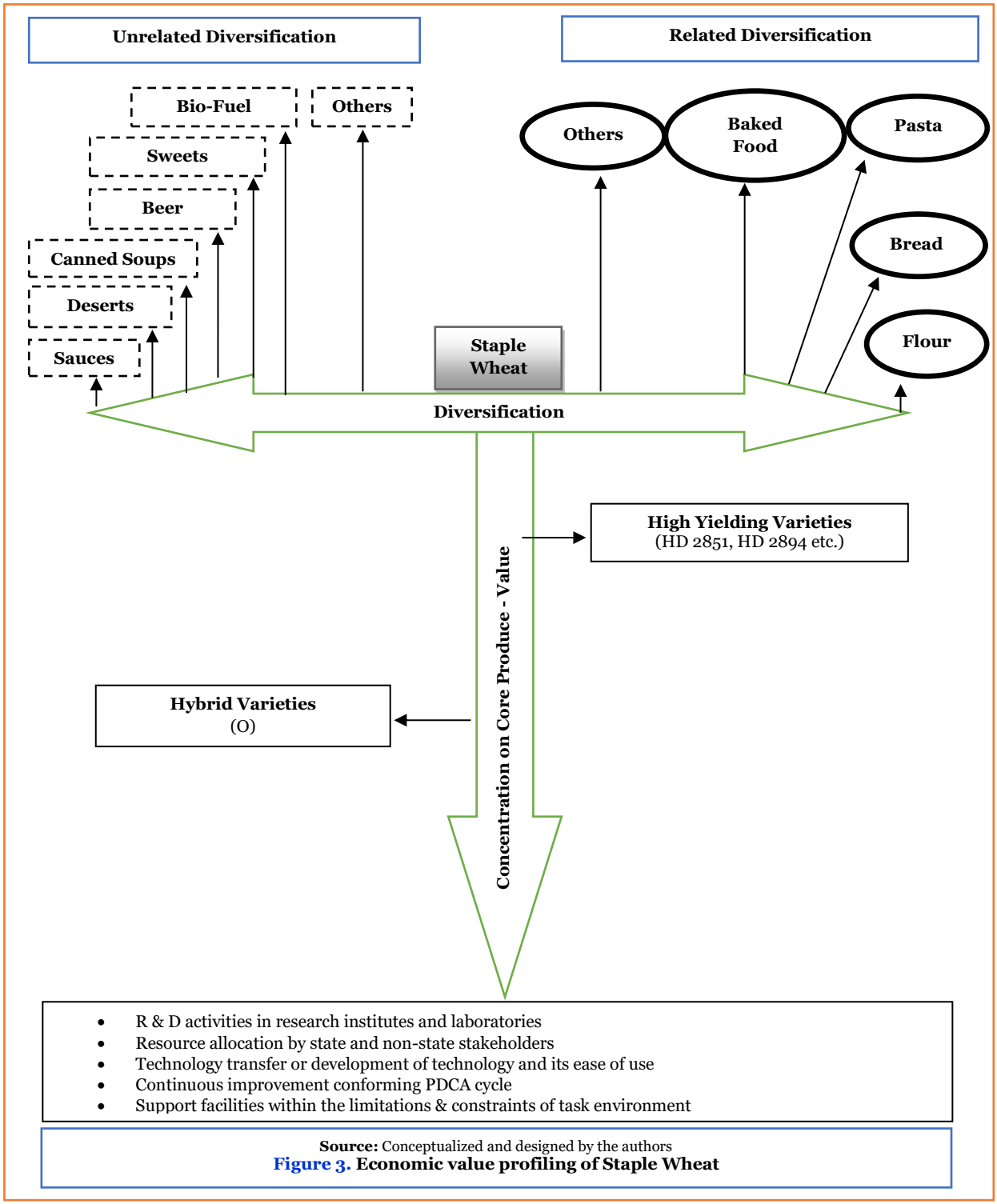
Figure 2. Economic value profiling of Staple Rice



Source: Conceptualized and designed by the authors

Figure 3. Economic value profiling of Staple Wheat

Table 3. Relationship Matrix between GDP and Cereal Production of Selected Countries

Continent	Country	WEO Code	Association between GDP and Cereal Production (r value)
	China	924	0.929**
Asia	India	534	0.933**
	Japan	158	-0.730**
	Indonesia	536	0.990**
	Saudi Arabia	456	-0.757**
	Islamic Republic of Iran	429	0.501**
	Thailand	578	0.838**
	Turkey	186	0.724**
	Russia	922	0.559**
Europe	United Kingdom	112	-0.008
	France	132	0.636**
	Italy	136	0.409*
	Germany	134	0.745**
	Spain	184	0.284
South America	Brazil	223	0.948**
North America	Canada	156	0.194
	USA	111	0.845**
	Mexico	273	0.913**
Australia	Australia	193	0.612**
Africa	Nigeria	199	0.417*
	South Africa	694	0.279
	Mauritius	684	-0.436*

Prepared by the authors. **Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed). WEO code is used to specify the country as mentioned (International Monetary Fund, World Economic Outlook, April 2018) and widely used in standard literature.

To understand the impetuous of cereal production and consumption across the country multistate sampling method was adopted. In the first stage continents are tabulated. In the second stage countries are selected in such a way that each continent be represented. The Table 3 depicts the relationship between GDP of the nation with corresponding magnitude of cereal production on a panel data from the year 1987 to 2016.

It is of high interest of the researchers particularly economists or agro-economists to understand the contribution of cereals towards country's GDP. Few countries have been selected that represent each continent of the world. Respective correlation values were calculated to understand association between GDP of a nation and its corresponding cereal production (quantity) using 30 years panel data which is presented in Table 3.

It shows that majority of the countries have high correlation coefficient which signify that over a period of time cereal production have been impacting significantly on their respective GDPs. This becomes the testimony of the fact that cereals play a pivotal role in the country's economy and as a vital food solution to those countries where 'r' value is above 0.6. The country with negative 'r' value signifies that the production of cereals has inverse relations with corresponding GDP. It means that the country with smaller geographical area essentially lacks agricultural production and thus adds less contribution towards economy. These countries are having or evolving through massive industrialization and automation, the cultivable land is encroached by the secondary or tertiary sector. So, the growth trajectory of the country has negative relationship with the production of cereals.

3.2. Analysis-II and observation

From Table 4, it is depicted that oat is a very important cereal in terms of higher composite nutritional benefits i.e., energy, protein content, fat, carbohydrate, and fiber followed by maize. In terms of protein content, rice stands second after oat followed by triticale. For energy content, oats stand first among the cereal's family followed by millets and maize. It shows that cereals have substantial contribution on human body because of its rich and mixed nutritional content. The detailed nutrition profiling for all the cereals has been enveloped in table 3 along with crop and economic value profiling for three cereals in Figure 1, 2 & 3.

Maize [*Zea mays* L.]

Maize is preferably grown in topical and warm weather condition. However, the grain is adoptable to diversified farming conditions. According to (FAOSTAT, 2020), total production of maize was globally recorded 1310.16 million tones. Research indicates that around 14% of total production is directly used for human food while around 10% is for industrial purposes for generating oil and starch. A section of African population considers maize as a staple food (Saldivar, 2016). Maize isimportant crops in India after rice and wheat. It is equally used for human food and animal feed (Khatkar et al., 2016). Maize is one of the important cereals which have been preferred across the distribution of world population. The EVA of staple maize as cereal commodity can be described as mentioned in Figure 1.

New species of maize like high yielding, hybrid and 'crop time-based varieties' are developed through research & development activities. However, this has been the aspiration of researchers' community to innovate new varieties to fulfill the objective of 'Concentration on Core Produce - Value'. In the commercial market, other popular food stuffs are prepared using maize which reflects the essence of relative diversification strategy. The world has been moving towards high end research to develop innovative value creations using maize and its residues (e.g., straw, grass etc). This may be coined as unrelated diversification. The synergy of related and unrelated diversification accompanied by excelling the core produces with the intervention of advanced Science & Technology which could be further value added by forward integration, effective supply chain management and marketing excellence. This can bring sustainable crop economy for maize.

Rice [*Oryza sativa* L.]

Archeological evidences have depicted rice was cultivated and consumed at least year 4000 B.C. (Saldivar, 2016). It contributes 20% of calories consumed worldwide. Around half of the world population considers rice as staple food. Above 90% of world rice is consumed in Asia. Good number of poorest and developing countries have been depending on rice for centuries ahead. The population of these regions repose confidence and trust on the versatility of rice, availability of protein and high calorific value. It has been observed that there is a growing tendency of high-income consumers in some countries to shift from rice and grain to other high-priced food items with the increasing pattern of wealth. However, such decline for choice of rice has not been witnessed in the countries where population in on increasing pattern. According to FAOSTAT (2020), the world rice production was 788.48 million tones which are projected to grow to the extent of 1.5 times by 2030 (Jones and Sheats, 2016). Black rice is a type of the rice species Oryza sativa L. which is glutinous, packed with high level of nutrients and mainly cultivated in Asia (Pratiwi and Purwestri, 2017). Rice is highly preferred in the Asian countries thus exhibits eccentric distribution over the global population. The usage of rice is manifold as the combination of staple and allied food stuff which has gained immense popularity in the region. Moreover, the allied food stuff represents ethno cultural preference and legacy of the people at large to consume rice or rice-based food product.

Rice is primarily consumed as staple food. The EVA of rice as cereal commodity is portrayed in Figure 2. There are new species of rice like high yielding, hybrid aromatic and black rice varieties. However, this has been the aspiration of applied scientists' community to innovate new varieties with the objective of 'Concentration on Core Produce - Value'. Many other popular food stuffs are prepared commercially using rice which may be considered as a generic form of relative diversification strategy. On the contrary, the world has been witnessing that high end researches are being carried out to develop new products using rice and the residues (e.g. straw, grass etc). This is known as unrelated diversification. The combination of related and unrelated diversifications along with the development to core produces through the frontiers of Science & Technology embedded with the forward integration, supply chain and marketing. This would be sustainable solution for rice driven commodity market.

Wheat [*Triticum aestivum* L.]

From historical researches, it is found that wheat was one of the first cultivated plants in the world. It is assumed to be vital cereal with reference to supply of energy to human body and it essentially possesses functional gluten. With taxonomy essentially contained three species with varying CN that is deployed (cn-14), tetraploid (cn-28), and hexaploids (cn-42). However, hexaploids and tetraploid species widely cultivated for commercial purpose. It is used for preparing bread, cookies, cakes and other bakery items. According to FAOSTAT (2020), the world wheat production in 2016 is merely 881.16 million tons out of which around 70% is used for human food (Saldivar, 2016). It is considered as principal cereals (staple) in all regions except Asia. Even in Asia in certain pockets/region wheat has been predominantly produced and consumed like northern part of India (Khatkar et al., 2016).

Wheat constitutes a large amount of fiber, carbohydrates, and water content. It has moderate amount of energy and protein. The fat and sugar content are low which make wheat as special dietary supplement for certain category of illness. Wheat is widely used as staple food. The EVA of wheat as cereal commodity is elaborated in Figure 3. The innovative species of wheat like high yielding (HD 2851, HD 2894), hybrid wheat varieties are gaining popularity among its consumers. In fact, the aspiration of applied scientists' community remains to develop new species in order to 'concentrate on core produce-value'.

Many other favorite food items are prepared commercially using wheat which represents as sign of relative diversification strategy. On the other hand, the world is committed to developing new generation product categories in the unrelated areas with the use of wheat and the residues (e.g. straw, grass etc). This is called unrelated diversification. The fusion of related and unrelated diversifications along with the development to core produces would the sustainable economic model of wheat for the future. Appropriate forward integration, supply chain and marketing strategies may need to be devised so that the wheat driven value creations could contribute for the welfare of the people.

Barley [*Hordeum vulgare* L.]

Historically barley is also conceived to be cultivated since the evolution of farming. From historical discourse the ancient Egypt, preferred barley than wheat as food grain. The consumption of barley propagated in many other countries from ancient Egypt. According to FAOSTAT (2020), the world productions of barley in 2016 was 143.05 million tones and occupy the 4th position among the cereal basket that essentially contribute to world food supply for human being significantly. It is used both as human food and animal feed. It is estimated that around 64% of world barley is used

Table 4. Cereals-wise Nutrient Content (per 100 gm portion)

	Nutrient	Unit	1Value per 100 g								
			Maize	Rice	Wheat	Barley	Sorghum	Millet	Oats	Rye	Triticale
Proximates	Carbohydrate, by difference	g	73.89	74.90	74.48	77.72	72.09	72.85	66.27	75.86	72.13
	Energy	kcal	364	357	332	352	329	378	389	338	336
	Fiber, total dietary	g	8.4	6.2	13.1	15.6	6.7	8.5	10.6	15.1	-
	Protein	g	8.75	14.73	9.61	9.91	10.62	11.02	16.89	10.34	13.05
	Sugars, total	g	-	2.50	1.02	0.8	2.53	-	-	0.98	-
	Total lipid (fat)	g	5.09	1.08	1.95	1.16	3.46	4.22	6.90	1.63	2.09
	Water	g	10.83	7.76	12.42	10.09	12.40	8.67	8.22	10.60	10.51
Minerals	Calcium, Ca	mg	05	21	33	29	13	8	54	24	37
	Iron, Fe	mg	1.74	1.96	3.71	2.5	3.36	3.01	4.72	2.63	2.57
	Magnesium, Mg	mg	110	177	117	79	165	114	177	110	130
	Phosphorus, P	mg	263	433	323	221	289	285	523	332	358
	Potassium, K	mg	381	427	394	280	363	195	429	510	332
	Sodium, Na	mg	5	7	3	9	2	5	2	2	5
	Zinc, Zn	mg	2.24	5.96	2.96	2.13	1.67	1.68	3.97	2.65	3.45
Vitamins	Folate, DFE	µg		95	28	23	20	85	56	38	73
	Niacin	mg	2.60	6.733	5.347	4.604	3.688	4.72	0.961	4.27	1.43
	Riboflavin	mg	0.23	0.262	0.188	0.114	0.096	0.29	0.139	0.251	0.134
	Thiamin	mg	0.16	0.115	0.297	0.191	0.332	0.421	0.763	0.316	0.416
	Vitamin A, IU	IU	-	19	9	22	0	0	0	11	0
	Vitamin A, RAE	µg	-	1	0	1	0	0	0	1	0
	Vitamin B-6	mg	0.470	0.391	0.191	0.260	0.443	0.384	0.119	0.294	0.138
	Vitamin E (alpha-tocopherol)	mg	-	0.82	0.53	0.02	0.50	0.05	-	0.85	0.9
	Vitamin K (phylloquinone)	µg	-	1.90	1.90	2.20	-	0.90	-	5.90	-
Lipids	Fatty acids, total mono-unsaturated	g	-	0.159	0.283	0.149	1.131	0.773	2.178	0.208	0.211
	Fatty acids, total poly-unsaturated	g	-	0.676	1.167	0.56	1.558	2.134	2.535	0.767	0.913
	Fatty acids, total saturated	g	-	0.156	0.430	0.244	0.61	0.723	1.217	0.197	0.366
	Fatty acids, total trans	g	-	-	-	-	0.005	-	-	0	-

Source: USDA National Nutrient Database for Standard Reference 1 April 2018

for animal feed industry. It is also commercially utilized for beer and food processing sector. It is a winter crop and considered the most drought resistance small grain (Saldivar, 2016). Barley is of highest source of carbohydrate and fiber in the among cereals umbrella. However, it also constitutes moderate levels of energy, water, and protein. Fat and sugar content of barley is less. From the ancient time barley is prescribed to consume during feverish syndrome.

Sorghum [*Sorghum bicolor* (L.) Moench]

Historical study indicated that sorghum has been cultivated for the past 2000 years. According to FAOSTAT (2020), the world productions of sorghum in 2016 was 66.33 million tones and out of which it is estimated that around 42% is used as food and eventually it is highest in Africa. Traditional crop in Africa and India provides substantive calories and protein to its users. High end sorghums can replace maize to be used as input material for industrial production like bioethanol (Saldivar, 2016). Sorghum constitutes large water content carbohydrate and natural sugar. However, it has moderate levels of energy protein, fat, and fiber. Sorghum is consumed during the period of ritual fasting particularly among Asian community.

Proso Millets [*Panicum miliaceum* L.]

According to FAOSTAT (2020), the world productions of millets in 2016 was 30.35 million tones and out of which around 77% is used as food. There are at least 9 species of millets of which pearl millet occupies around 50% of total production. Millets is considered as a staple food in some African countries like Niger, Burkina Faso, Mali, and Gambia (Saldivar, 2016). Millets has been considered as a dietary staple with balance nutrients. The energy content, carbohydrate, protein, fat and fiber content are pretty high. However, sugar content is null in millet.

Oat [*Avena sativa* L.]

Historically it is explored that the origin of oats did exit in 2000 B.C. in the Middle East region. It is a winter crop. It is highly nutritional that is availability of best protein, high content of fat and fiber and least calorie make these cereals as unique and thus it is positively influencing human consumption / demand pattern of oats over a period. It is used for nutrition bars, cookies, and composite bread. According to FAOSTAT (2020), the world productions of oats in 2016 was 23.44 million tons (Saldivar, 2016). Oat is regarded as a magic cereal. It constitutes highest energy, protein and fat content. It has moderate levels of fiber, carbohydrate, and water. The sugar content is null. Oats become transnational breakfast diet among the global population.

Rye [*Secale cereale* L.]

According to FAOSTAT (2020), the world productions of rye in 2016 was 13.47 million tons of which approximately 38% is used for food. Rye's flour is used to make bread crispy. It prefers to produce sour bread. It contains higher level of protein, pentosans, and minerals as compared with wheat flours (Saldivar, 2016). Rye contains higher amount of carbohydrate with a lower level of glycemic index (GI) than most other grains. However, it also constitutes higher level of fiber. Water, energy, fat, protein and sugar content of rye are less.

Fonio [*Digitaria exilis* (Kippist) Stapf]

Fonio has very microscopic existence in the global food basket. However, adequate data is required to be retrieved to analyze its nutritional and economic benefit.

4. Discussion

This study is a synthesis of various approaches drawn from diversified areas such as agricultural, food nutrition, socio-economic and operations management etc. Based on the understanding and the analysis of the study, following recommendations can be specified:

Globally integrated research and development works should be initiated with sharing of inputs and research outcomes for all the agriculture produces. This would enable multidimensional information flow for soil fertility, cereal productivity, demand pattern and ease of uses. The research and development support will bring new varieties that can be used by the global population with the essence of welfare economy as food and hunger has been the focal point of erstwhile MDGs as well as SDGs.

The augmentation of core cereal competency by generating new variety of crop is the frontiers of agro research. Apart from that, related and unrelated diversifications of the cereals are becoming new generation sustainable economic model. It can be used across all variants of cereals and other agriculture produces throughout the global community based on multi-dimensional decision criteria like dynamics of economic priorities, tastes, preferences, feasibility and viability issues.

This research work is manifested primarily on cereal crops from the global point of view. It suffers from concurrent and real time data set for each crop for every nation. For the sake of convenience, the secondary information has been retrieved from multiple reliable sources. Adequate information has not been found for two cereal variants (*Triticale* and *Fonio*) which have made a conservative approach in minuscule of observations. The strategy for model framework may be modified and tailor made by the future researchers using cross functional and representative data set drawn at regular intervals or real time basis in order to ensure optimum strategic fit.

The study is conceived to open diversified areas for the future researchers. The future study may concentrate on identifying the percentage contribution of cereals on average food consumption by every individual in comparison with other food items / categories across different nations or communities. The study has noted that cereals contribute as useful animal feed which in turn maintain ecological balance. Hence in-depth study is needed for estimating the contribution of cereals as feed for the entire animal universe and also for the domestic pets. The contribution of related and unrelated products in the economy which are generated from the bi-products and residues of cereals has not been adequately estimated for the entire world and even specific to each country on each variety of cereals. Further study may be conducted on two cereal variants (*Triticale and Fonio*) in terms of food and nutritional value and farming techniques in order to popularize the food grains.

5. Conclusion

The study on cereals has been carried out by the botanists, agricultural scientists and nutritional experts throughout the globe. It was either confined to stereotype food and nutritional value proposition or extensively committed to advanced scientific pursuits. The present study has given impetus of the cereal crops from different perspectives i.e., food and nutritional value dimensions, economic perspectives, and sustainability. With the growing complexities of problems and criticality of issues, it is imperative to understand that neither scientific acumen nor economic modeling alone can unearth the gravity and scope of this subject. The interdisciplinary approaches can address the aspirations of multifaceted issues of cereals in a cohesive and collaborative manner. The present research has noted that the contribution of cereals has been evergreen which is not bounded by timelines. This is evidenced during COVID-19 pandemic situation when the global population has survived with the major contribution from cereal crops (Business Wire, 2020). The prolonged lock down, self-quarantine and social distancing have miserably devastated the civilizational momentum. The fundamental ideology is that the lines of developmental policies should not intersect each other. The locus of farming and green policy should be in corollary with a mutually rewarding and interactive manner otherwise, the civilization would cease to exist.

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Author's contribution

All the authors have equally contributed in concept, research design, data mining, manuscript writing and proof editing.

Declaration of conflict of interest

Authors have no conflict of interest.

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