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Data intensive study of accessibility of edible species across the globe

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Abstract

Variety of accessibility to edible species in different regions has climatic and historical roots. In the present study, we try to systematically analyze 28,064 records of relationships between 11,752 edible species and 228 geographic zones by hierarchical clustering. 228 geographic regions were classified into 11 super groups named as A to K, which were divided into 39 clusters (CLs). Of them, at least one member of each of 28 CLs is associated to 20 or more edible species according to present information of KNApSAcK DB (http://kanaya.naist.jp/KNApSAcK_World/top.jsp). We examined those 28 CLs and found that majority of the members of each of the 27 CLs (96%) has specific type of climate. Diversity of accessibility to edible species makes it possible to separate 8 geographic regions on continental landmasses namely Mediterraneum, Baltic Sea, Western Europe, Yucatan Peninsula, South America, Africa and Arabian Peninsula, Southeast Asia, Arctic Ocean; and three archipelagos namely, Caribbean Islands, Southeast Asian Islands, and Pacific Islands. In addition, we also examined clusters based on cultural exchanges by colonization and migration and mass movement of people and material by modern transportation and trades as well as biogeographic factors. The era of big data science or data intensive science makes it possible to systematically understand the content in huge data and how to acquire suitable data for specific purposes. Human healthcare should be considered on the basis of culture, climate, accessibility of edible foods and preferences, and based on molecular level information of genome and digestive systems.

Key words：

Data intensive science, accessibility, hierarchical clustering, KNapSAcK Database, healthcare

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Chapter 1

Introduction

1.1 What is Data Science?

In 2009, Microsoft Research published online a paper “The Fourth Paradigm” on the arrival of data intensive science era. This paper summarized a vision of American pioneering computer scientist Jim Gray about the fourth paradigm on data intensive scientific discovery, and suggested how to realize it. A paradigm is special concept of in the history of science that began being advocated by science historian Thomas Kuhn in 1960s, briefly speaking, it means “a framework of scientific research method that represents a certain era and time in the history of science”. Jim Gray advocates that “a fourth paradigm” in place of paradigm until now in this paper. In other words, he sees that humanity has passed through three paradigms so far. First of all, “the first paradigm” is a complication of Aristotle, a philosopher of ancient Greece, it is a paradigm of classical Greek naturalism with influence up to the Middle Ages. In a typical example, as “the sky appears to turn around the North Star”, it is a paradigm of era as typified by “Ptolemaic theory” which understood nature by “experimental descriptive scientific method”. Next, as “the second paradigm”, it is a paradigm of times represented by “dynamics” and “astronomy”, which describe and understand nature by “theoretical constructive scientific method” that incorporated mathematics represented by “differential integration” discovered and invented by Leibniz and Newton. It started from around Newton’s “Principia” to consider “dynamics” and “astronomy” analytically using differential and integral formulas. “the third paradigm” is called “scientific method by computing”, it is a paradigm that computes a nonlinear equation which cannot obtain an analytical solution by using a computer, reproduces calculation result with a table, a diagram, a graph or CG, and then see and understand the calculation result. And, “the fourth paradigm” was proposed aiming to develop science with a statistical inference model based on a large amount of data. That is, “the fourth paradigm” is a paradigm of a new scientific method that pursuit theory by interpretation based on analysis of big data (Hey, T et al., 2009).

1.2 Natural food and human beings' evolution concerning to Data Science

In the era of big data science or data intensive science, emphasis is given on how we systematically understand the content in huge data and how we acquire suitable data for specific purposes. Human healthcare should be considered on the basis of their own culture governed by climate, geographical accessibility of edible foods and preferences, and own molecular constitution based on genome information including digestive systems. Information on diet patterns based on individual heredity can be obtained by anthropological data, the study of various aspects of humans within past and present societies, and archaeology, the study of human activity through the recovery and analysis of material and culture. Such techniques can provide information of traditional diets which leads to ideas for solving how to make an effective diet system in a particular geographic region. Reviving traditional products and ancestral knowledge associated with national/regional cooking make it possible to expand the food base, improve nutritional conditions and food security. Without doubt these crops are of great nutritional value, are highly adaptable to severe environmental conditions, and greatly enhance the value of family farming, especially in the case of indigenous peoples. In this context it is important to help recover and promote traditional prepared foods based on these crops, incorporate them into food assistance program, and develop innovative forms of consumption on a greater scale. In the present study, we focused on accessibility of edible species across the globe because the accessibility is the most important factor in the history of acquisition for examining health condition in human history.

Human beings evolved in Africa with acquisition of variety of natural foods including animals, plants, fungi and bacteria associated with fermentation process. The australopithecines emerged in the Plio-Pleistocene (from about 5-12 million years ago; Sponheimer and Lee-Thorp, 1999). The incorporation of animal tissue into the diet occurred in the late Pliocene (2,580,000 years ago). It is almost certain that human were much better scavengers than hunters because early humans were smaller and less muscled than modern adults and they didn't have any effective weapons (Blumenschine and Cavallo, 1992). From 1.9 million to 200,000 years ago, human tripled their brain mass relative to body mass. In terms of the encephaloisation quotient, a relative brain size measure that is defined as the ratio between actual brain mass and predicted brain mass for an animal of a given size, which was estimated to be 1.23-1.92 for the predominantly vegetarian Australopithecines and

1.41 - 4.26 for Homo genus (Broadhurst et al. 1998). Brain expansion needs not only energy for its growth and maintenance but also the availability of building block such as arachidonic acid (AA), Docosahexaenoic acid (DHA) and many other factors referred to as brain-selective nutrients (Broadhurst, 1998). Together with the brain expansion, aquatic and maritime adaptations played a significant role in the demographic and geographic expansion of anatomically modern humans after about 150,000 years ago (Erlandson, 2001).

The expensive tissue trade-off hypothesis argues persuasively that, as mostly plant-eating australopithecines evolved into frequently-meat-eating later *Homo* species via sometimes-meat-eating early *Homo* species based on an evolutionary trade-off between bowel and brain, both of them being very energy-intensive organs (Wheeler and Aiello, 1995). Fully modern humans, *Homo sapiens* emerged from the Africa ancestral line of all living humans between 100,000 and 60,000 years ago. Later, between 60,000 and 50,000 years ago, a small group of these fully human hunter-gatherers left Africa. Seafood had been a significant component of the Paleolithic diet and the modern human brain probably would have evolved with the diet (Cunnane and Crawford, 2003; Cunnane, 2005).

One of the greatest achievements of human being was the domestication of plants and animals. Just as the earliest *Homo sapiens* of 90,000 to 60,000 years ago coped with different environments as they spread across Africa so did their descendants who scattered the rest of the globe after 60,000 years ago. The African emigrants encountered diverse new environments and discovered edible plants and new animal food sources. Some ten thousand years ago the process of plant and animal domestication was simultaneously underway, in several parts of the world in Africa and Europe. During much of human evolution there has been selection for increased dietary flexibility (Lenard et al, 2010). In contrast to the Neanderthals, Upper Paleolithic humans appeared to forage on broader and more geographically variable range of plants and animals.

About 11,000 years ago hunter-gatherer diet was changed to diet with agriculture and animal husbandry. Intentional fermentation of fruit, rice or honey beverages has been carried out since close to 10,000 years ago which was indicated by the chemical content with ancient Neolithic vessels (McGovern et al., 2004). When milk of cattle was utilized in food and beverage by the domestication of dairy cattle during last 7500 and 9000 years ago, lactase persistence trait was occurred in pastoralist population in Europe and Africa (Deng et al., 2015). The lactase persistence trait made it possible to use milk products for foods.

Currently, there are many factors for increasing accessibility of foods in individual geographic zones, for example, natural causes involving climate, geographical limitation, and artificial causes for example transportation including import and export among countries. The shift from a "Paleolithic" to modern diet was clearly characterized by a reduction in the protein content of the diet and a marked increase in carbohydrates. Economic activities and globalization make it possible to spread edible species across countries using transport systems.

Food culture arises from the place of a people's origin, whether they still live there or not, is characterized by several causes associated with natural conditions such as climate, land soil and water, human cultural factors involving religion, education, literacy and communication, ethnicity, technological factors involving hunting gathering, agriculture, horticulture, aquaculture, fishing, food processing and storage, transport, cooking, and human health status and genetics (Kaplan et al., 2000; Wahqvist et al., 2007).

Biodiversity especially diversity of edible species represents the strength of ecosystems, and is regional theme of nutrition and healthcare based on diet (Wahlqvist, 2003) and nutrition science and food policy should apply an integrative approach to understanding health-optimizing diets based on ecological systems of achieving effective, sustainable, food production (McMichael, .2005).

In the present study, we try to systematically classify geographical areas based on natural food accessibility regardless of whether or not foods such as crops, animals, and fishes are cultivated in the targeted area based on hierarchical clustering. Then, we discuss inherent healthy diets of geographic regions extracted by the hierarchical clustering, eight food cultures across continents as follows, Mediterraneum, Baltic Sea, Western Europe, Yucatan Peninsula, South America, Africa and Arabian Peninsula, Southeast Asia, Arctic Ocean; and food culture of three archipelagos i.e. Caribbean Islands, Southeast Asian Islands, and Pacific islands. In addition, we also examine cross-cultural communications concerning food between geographic regions.

1.3 Purpose of this work

We have accessed on (1) edible species, (2) healthcare systems (3) culture including colonialization (4) geographic properties concerning climate (5) other natural phenomena including ocean current and (6) human genetics via published papers in internet. This information makes it possible to comprehensively understand healthcare specificity in individual regions.

Several researchers on food in the world have studied focusing on the culture of each region as examples, Rozin et al. (2005); Nobayashi et al. (2004) but none of them have not carried out to systematize food variety around the world and the viewpoint of cultural anthropology. The present study aimed to unveil comprehensively understand of variety of foods around the world based on "Big-data Science", including a cultural anthropological viewpoint such as cultural and geographic difference, by analyzing accessibility of edible species across the world. This study is expected to contribute to medical science by summarizing merits and demerits of food in each region of the world, and economic efficiency by a new finding associated with it.

Chapter 2

Materials and Methods

2.1 Clustering of geographic zones based on edible species

Accessibility of edible species is defined as those being consumed as food by people of a targeted geographic zone. Wild species, cultivated species, species imported from other geographic zones are included in accessible edible species of a targeted geographic zone. In the present study, we examined the pattern of diversity of edible species across geographic zones.

We accumulated 28,064 pairs of relations between edible species and geographic zones comprising 11,752 edible species and 228 geographic zones from references. Among the accumulated edible species 44% are plants, 25% are fish, 12% are insects, 10% are mushrooms, and 6% are other species associated with meat. All of the data is available in "KNApSAcK from around the world DB" (http://kanaya.naist.jp/KNApSAcK_World/top.jsp; Afendi, 2012).

In the present work we represent individual geographic zones as 11,752 dimensional binary vectors. Here, if *i*th species is present in *j*th target geographic zones, the *i*th element is set to 1; otherwise, the *i*th element is set to 0. A Tanimoto distance matrix for geographic zones has been applied to hierarchical clustering by Ward's method (Ward, 1963). The distance based on edible species patterns between geographic zones *s* and *t* is represented by *Eq*. (1).

$$r_{st} = 1 - \frac{N(s \cap t)}{N(s \cup t)} \quad (1)$$

Here, $N(s \cap t)$ and $N(s \cup t)$ represent respectively the interaction set and union set of edible species of zones s and t. When a new cluster W is made by merging cluster T and U, the distance between cluster T and W is represented by *Eq.* (2).

$$D_{WT} = \frac{1}{n_U + n_V + n_T}\{(n_U + n_T)D_{UT}^2 + (n_V + n_T)D_{VT}^2 + n_T D_{UT}^2\} \quad (2)$$

Here, *n* represents a number of data in the cluster. And *D* represents the distance between corresponding pair of clusters.

2.2 Classification of geographic zones based on Köppen climate classification

In the present study, 228 geographic zones were classified based on Köppen climate classification. Although various authors published enhanced Köppen classifications or developed new classifications, the climate classification originally developed by Köppen (here referred to as Köppen-Geiger classification) is still the most frequently used climate classification (Kettok et al., 2006).

Combining the three letters depicted in **Table.1.a** and **Table.1.b** leads to at most 34 possible different climate classes. Three of these classes cannot occur by definition since a warm temperate climate (C) needs a temperature of the coldest month T_{min} above –3 °C while a third letter climate (d), extremely continental, needs a temperature of the coldest month below –38 °C. Therefore warm temperate climates (Csd), (Cwd) and (Cfd) cannot be realized and 31 climate classes remain. Köppen and Geiger recognized that not all of the remaining types occur in a large areal amount and therefore not all of these types may be of climatological importance (Kettok et al., 2006).

Table 1.a. Key to calculate the climate formula of Köppen and Geiger for the main climates and subsequent precipitation conditions, the first two letters of the classification. Note that for the polar climates (E) no precipitation differentiations are given, only temperature conditions are defined. This key implies that the polar climates (E) have to be determined first, followed by the arid climates (B) and subsequent differentiations into the equatorial climates (A) and the warm temperate and snow climates (C) and (D), respectively. The criteria are explained in the text. (collected from Kottek et al., 2006)

Type	Description	Criterion
A	**Equatorial climates**	$T_{min} \geq +18$ °C
Af	Equatorial rainforest, fully humid	$P_{min} \geq 60$ mm
Am	Equatorial monsoon	$P_{ann} \geq 25\,(100-P_{min})$
As	Equatorial savannah with dry summer	$P_{min} < 60$ mm in summer
Aw	Equatorial savannah with dry winter	$P_{min} < 60$ mm in winter
B	**Arid climates**	$P_{ann} < 10\,P_{th}$
BS	Steppe climate	$P_{ann} > 5\,P_{th}$
BW	Desert climate	$P_{ann} \leq 5\,P_{th}$
C	**Warm temperate climates**	-3 °C $< T_{min} < +18$ °C
Cs	Warm temperate climate with dry summer	$P_{smin} < P_{wmin}$, $P_{wmax} > 3\,P_{smin}$ and $P_{smin} < 40$ mm
Cw	Warm temperate climate with dry winter	$P_{wmin} < P_{smin}$ and $P_{smax} > 10\,P_{wmin}$
Cf	Warm temperate climate, fully humid	neither Cs nor Cw
D	**Snow climates**	$T_{min} \leq -3$ °C
Ds	Snow climate with dry summer	$P_{smin} < P_{wmin}$, $P_{wmax} > 3\,P_{smin}$ and $P_{smin} < 40$ mm
Dw	Snow climate with dry winter	$P_{wmin} < P_{smin}$ and $P_{smax} > 10\,P_{wmin}$
Df	Snow climate, fully humid	neither Ds nor Dw
E	**Polar climates**	$T_{max} < +10$ °C
ET	Tundra climate	0 °C $\leq T_{max} < +10$ °C
EF	Frost climate	$T_{max} < 0$ °C

Table 1.b. Key to calculate the third letter temperature classification (h) and (k) for the arid climates (B) and (a) to (d) for the warm temperature and snow climates (C) and (D). Note that for type (b), warm temperature value of +10℃ has to occur for at least four months. The criteria are explained in the text.(collected from Kettok et al., 2006)

Type	Description	Criterion
h	Hot steppe / desert	$T_{ann} \geq +18$ °C
k	Cold steppe /desert	$T_{ann} < +18$ °C
a	Hot summer	$T_{max} \geq +22$ °C
b	Warm summer	not (a) and at least 4 $T_{mon} \geq +10$ °C
c	Cool summer and cold winter	not (b) and $T_{min} > -38$ °C
d	extremely continental	like (c) but $T_{min} \leq -38$ °C

Chapter 3

Results

The 11,752 species involved in the present analysis are much more than 7,000 species reported as commonly eaten (Myers, 1983) and one third of the reported edible plants (Samuels, 2015). Furthermore 28,064 records of relationships between edible species and 228 geographic zones is significant information concerning utilization corresponding to individual geographic zones. Though, in the scientific references, information of edible species is very limited for several geographic zones, we applied a hierarchical clustering method to systematize the relationships among 228 geographic zones and constructed a dendrogram (**Figure 1).** We tentatively classified 228 geographic zones into 39 clusters (CL1 - 39) included in 11 super groups (A-K). **Table 2** shows geographic zones classified into 39 CLs. Of them, we examined 28 CLs for which at least one geographic zone of each cluster is associated with 20 or more edible species according to KNApSAcK DB. In **Table 2** the geographic zones associated with more than 20 species are written in black characters.

Food accessibility depends on several factors, that is, climate, agricultural development, transportation, fish cultivation, geography, and national boundaries (Wahlqvist, 2003). Climate influences are fundamentally important for availability of edible species in the natural resources. German scientist Wladimir Köppen has proposed the five vegetation zones as follows: (i) equatorial, (ii) arid, (iii) warm temperature, (iv) snow and (v) polar (Köppen, 1900), which has been updated by Kottek et al. (2006).

Table 3 shows relationships between clusters (CLs) generated by the present study and the vegetation zones defined by Kottek et al. (2006). Based on similarity of geographic zones, our clusters can be associated with 5 major vegetation zones as follows.

(c1) 11 clusters with equatorial climate; CL1-3, 6, 7-9, 14, 16, 17, 19 and 21.

(c2) 1 clusters with arid climate; CL23.

(c3) 6 clusters with warm temperature climate; CL11, 24, 26, 31, 34 (c4) 1 cluster with snow climate; CL30.

(c5) 1 cluster with polar climate; CL32.

Clusters associated to multiple vegetation zones are as follows.

(c6) 1 cluster with equatorial and arid climate; CL18

(c7) 2 clusters with equatorial and warm temperature climate; CL11 and 16

(c8) 1 cluster with warm temperature and snow climate; CL19.

In conclusion, accessibility of edible species can be characterized by the climate of a region, that is, specific climate can be assigned to 26 CLs (92%) based on similar climate of the majority of the members included in a cluster.

The cultures related with climates also affects food accessibility. For example, fat intake can be quite varied from fish, meat, grain involving soy beans, seeds involving sesame, cotton, red palm, coconut, avocado, and fruits involving olive (Walhlqvist, 2003). The Mediterranean diet is collection of similar eating habits traditionally followed countries bordering the Mediterranean Sea (Sofi et al., 2010). So we examined whether or not geographic zones assigned to identical clusters (CLs) are spatially closed to each other.

By taking the relation among geographic zones for individual CLs in **Figure 1** into consideration, 22 CLs can be characterized by specific geographic locations on earth as indicated by maps of the countries in **Figure 2.** Detail geographic zones in individual clusters are also presented in Appendix Figure.A.1-A.29. In the present study, we tentatively examined two types of levels for the clusters, comprehensive level corresponding to super groups A to H and precise level corresponding to clusters CL1 to CL39. Below we briefly discuss the clusters in the context of geographic locations.

(g1) Geographic zones in Caribbean Islands are clusterized in CL1-3 and those three are the most separated by the other geographic zones (Super group **A** in Figure 1).

(g2) Geographic zones in Mediterranean are clusterized in CL4 and 5 and those two CLs are closely related (**B** in Figure 1).

(g3) Geographic zones in Southeast Asian Islands are clusterized in CL6 (**C** in Figure 1).

(g4) Geographic zones in Yucatan Peninsula are clusterized in CL7. Though geographically very near to each other but in terms of accessibility of edible species Caribbean Islands (CL1-3) and Yucatan Peninsula (CL7) are distantly related indicated by the dendrogram where CL1-3 (**A** in Figure 1) and CL7 (**D** in Figure 1) are highly separated.

(g5) Geographic zones in South America (CL8-10) are assigned to 3 CLs and those three CLs are closely related (**D** in Figure 1).

(g6) Geographic zones in Africa are clusterized into CL14, CL16, and CL19. CL14 (**E** in Figure 1) is separated from CL16 and CL19 (**F** in Figure 1).

(g7) Two clusters (CL17 and CL27) related with Indian subcontinent are distantly related with each other in terms of food. The former is assigned to F in Figure 1, whereas, the latter is assigned to **G** in Figure 1.

(g8) Geographic zones in Arabian Peninsulate and East Africa are clusterized in CL18 (**F**).

(g9) Geographic zones in the Pacific islands are clusterized in CL21 (**F**).

(g10) Geographic zones in Western Europe are clusterized in CL24 (**G**).

(g11) Geographic zones in Arctic Ocean are clusterized in CL32 (**G**).

(g12) Geographic zones related with Scandinavia and Baltic Sea are clusterized in CL26, CL30, and CL34. The former two geographic zones (CL26 and CL30) belong to **G** in **Figure 1**, whereas CL34 is separated from those two (belong to **H**).

Of 28 CLs in Table 2, 22 CLs can be characterized by specific geographic locations. Of remaining 6 CLs, five CLs (CL11, 23, 28, 29, 31) can be characterized by climate. Therefore, 27 CLs can be explained at least by either climate or by geographic location. Human have a strikingly diverse species in diet. The intensification and extensification of global trade have greatly increased the diversity of accessible edible species for human. Rapid economic and income growth, urbanization, and globalization lead to a dramatic shift of Asian diet (Pingali, 2007). Several clusters comprise of geographic zones which are distantly separated with each other, reflects the similar accessibility to edible species by globalization. For example, the geographic zones included in CL28 are distributed across equatorial and/or warm temperature climate. All geographic zones of this cluster except Thailand have experience of colonization, which is also reflected by the pattern of the accessibility of edible species.

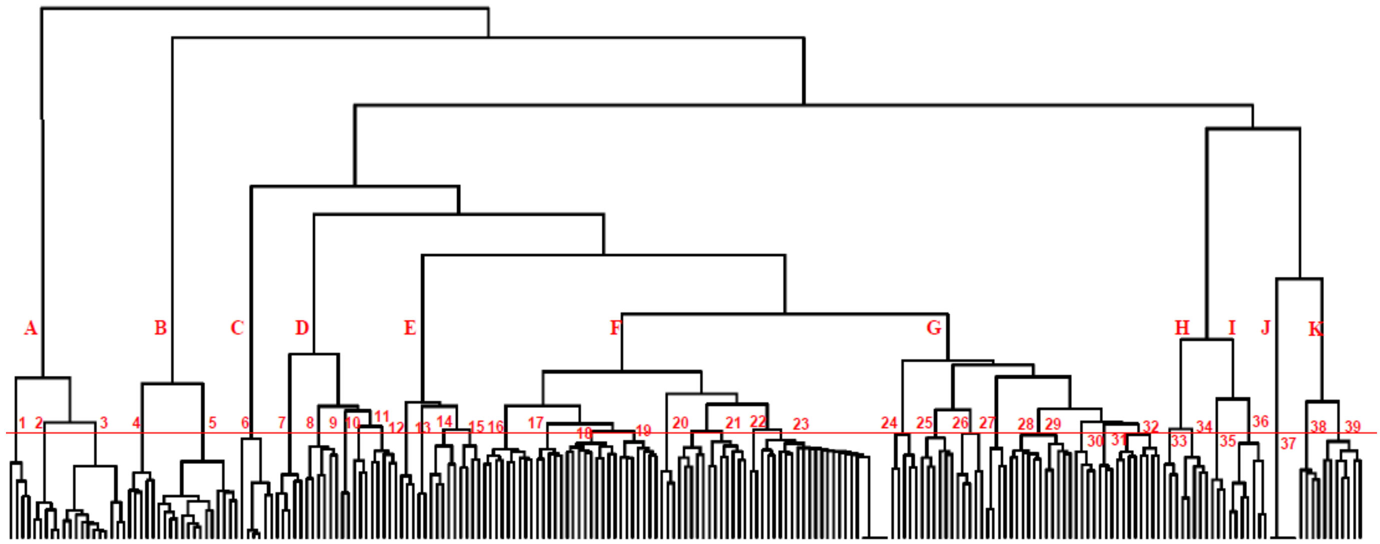

Figure 1.a. Dendrogram of 228 geographic zones. The 228 geographic zones are classified into 39 clusters (CL1-39) and 11 comprehensive groups (clade A-K). Members of individual clusters are listed in Table 2.

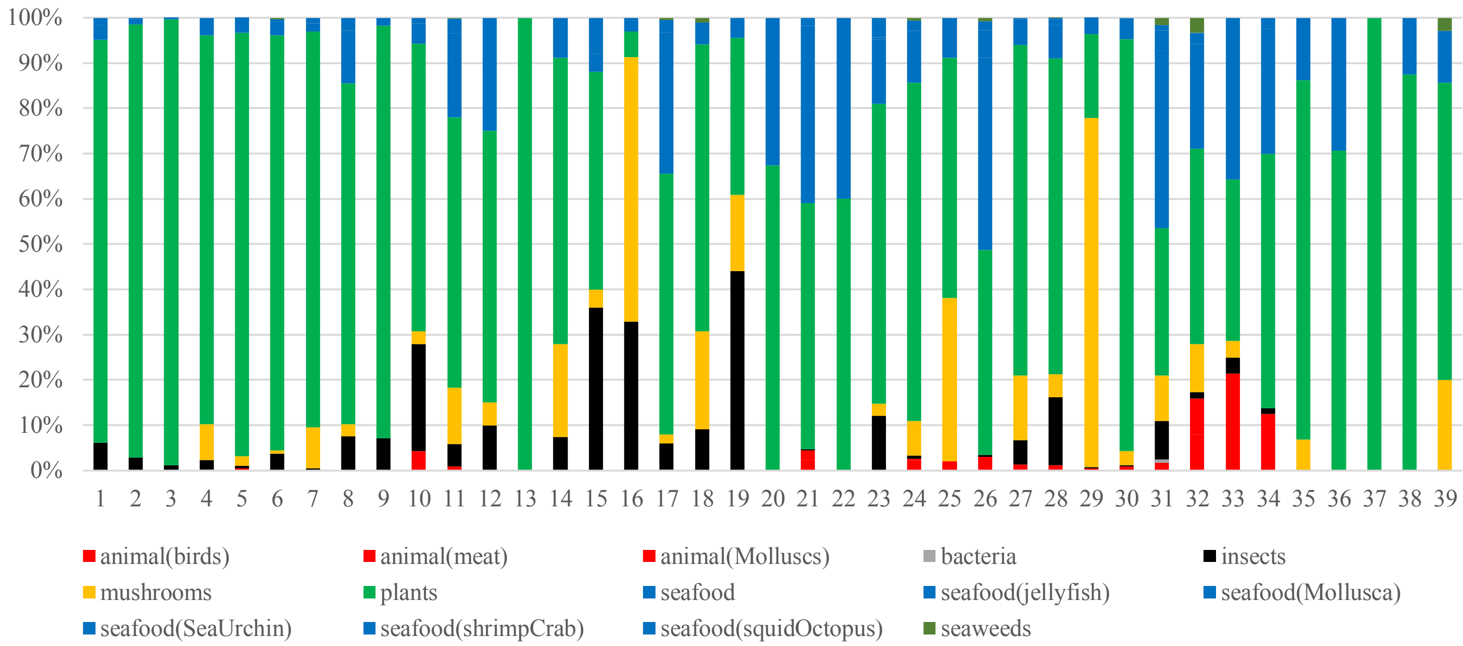

Figure 1.b. Proportion of edible species in each cluster

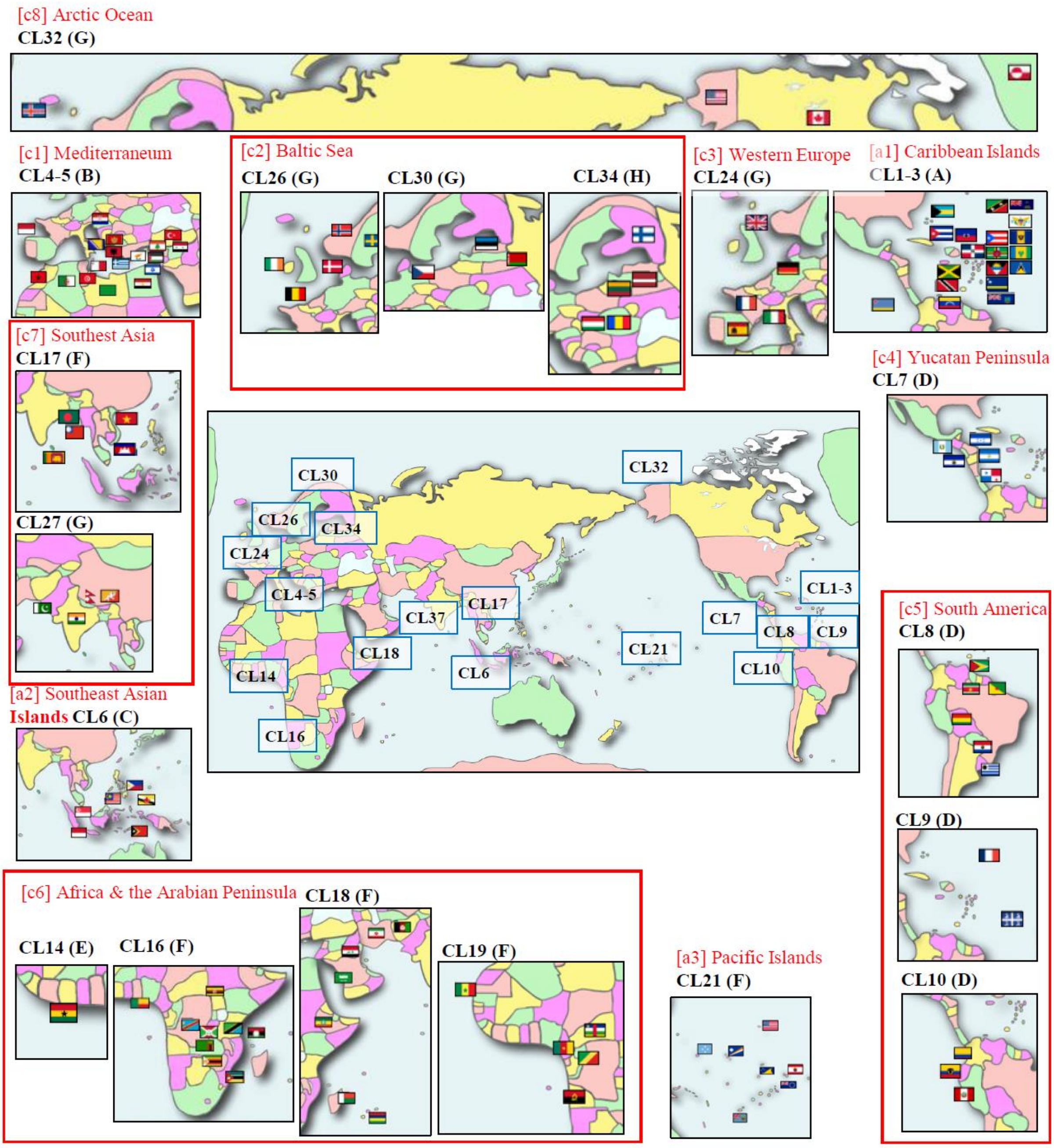

Figure 2. Geographic relationship among 18 clusters which could be explained in 11 geographic zones

Table 2. Classification of geographic zones based on clustering. Geographic groups are assigned by CL1-39. NZ,NS represent the number of geographic zones and that of edible species included in individual CLs. Parentheses represent the geographic zones with the number of edible species less than 20.

CL	NZ	NS	Geographic Zone
1	4	176	Dominican Republic, Jamaica, Republic of Trinidad and Tobago, Bolivarian Republic of Venezuela
2	5	93	Aruba, Republic of Cuba, Puerto Rico, Curacao, United States Virgin Islands
3	11	118	Antigua and Barbuda, Barbados, Cayman Islands, Commonwealth of Dominica, Saint Christopher and Nevis, Saint Lucia, Montserrat, Saint Barthelemy, Commonwealth of The Bahamas, Republic of Haiti, Saint Vincent and the Grenadines
4	5	169	Arab Republic of Egypt, Hellenic Republic, Kingdom of Morocco, Republic of Turkey, State of Israel
5	14	104	Republic of Albania, Bosnia and Herzegovina, Republic of Cyprus, People's Democratic Republic of Algeria, Republic of Croatia, Republic of Lebanon, Principality of Monaco, Republic of Malta, Republic of Montenegro, Republic of Tunisia, Libyan Arab Jamahiriya, The west Bank and Gaza Strip, Syrian Arab Republic, Republic of Slovenia
6	6	369	Republic of Indonesia, Brunei Darussalam, Malaysia, Republic of the Philippines, Republic of Singapore, The Democratic Republic of Timor-Leste
7	5	80	Republic of Guatemala, Republic of Honduras, Republic of Nicaragua, Republic of Panama, Republic of El Salvador
8	6	51	Republic of Bolivia, French Guiana, Republic of Paraguay, Republic of Suriname, Oriental Republic of Uruguay, Co-operative Republic of Guyana
9	2	28	Guadeloupe, Martinique
10	3	185	Republic of Colombia, Republic of Ecuador, Republic of Peru
11	5	86	Republic of Korea, Bermuda, Kingdom of the Netherlands, Taiwan, Republic of Costa Rica
12	3	7	(Republic of Niger), (Burkina Faso), (Republic of Mali)
13	2	2	(Western Sahara), (Republic of Guinea-Bissau)
14	5	14	(Republic of Liberia), (Republic of Cote d'Ivoire), Republic of Ghana, (Republic of Sierra Leone), (Republic of Togo)
15	4	6	(Republic of The Gambia), (Republic of Equatorial Guinea), (Gabonese Republic), (Republic of Guinea)
16	9	72	Republic of Burundi, Democratic Republic of Congo, Republic of Mozambique, Republic of Uganda, Republic of Benin, Republic of Malawi, United Republic of Tanzania, Republic of Zambia, Republic of Zimbabwe
17	5	81	(Kingdom of Cambodia), People's Republic of Bangladesh, Democratic Socialist Republic of Sri Lanka, Union of Myanmar, Socialist Republic of Viet Nam
18	12	30	Islamic Republic of Iran, Kingdom of Saudi Arabia, Islamic Republic of Afghanistan, Federal Democratic Republic of Ethiopia, (Republic of Iraq), Republic of Mauritius, (Faeroe Islands), (New Caledonia), Republic of Madagascar, (Republic of Seychelles), (Antarctica), (British Indian Ocean Territory)
19	7	29	Republic of Angola, (The Republic of the Sudan), (Belize), Central African Republic, Republic of Cameroon, Republic of Senegal, Republic of Congo
20	5	10	(American Samoa), (Guam), (Kingdom of Tonga), (Republic of Vanuatu), (Independent State of Samoa)
21	7	64	Cook Islands, Republic of the Marshall Islands, French Polynesia, Tokelau, Republic of the Fiji Islands, Federated States of Micronesia, The Island of Hawaii
22	2	3	(Republic of Kiribati), (Republic of Nauru)
23	22	11	Republic of Botswana, (Republic of Djibouti), (Falkland Islands), (Principality of Liechtenstein), (Republic of Maldives), (Northern Mariana Islands), (Republic of Namibia), (Niue), (Pitcairn), Republic of Palau, (Rodrigues Island), (South Georgia and the South Sandwich Islands), (St. Helena ex dep.), (Solomon Islands), (Republic of Somaliland), (Republic of San Marino), (Somali Democratic Republic), (Tuvalu), (Wallis and Futuna), (Grenada), Mongol Uls, (Democratic Republic of Sao Tome and Principe)
24	5	435	Spain, Republic of Italy, Federal Republic of Germany, French Republic, United Kingdom of Great Britain and Northern Ireland
25	6	32	Portuguese Republic, Republic of Armenia, Swiss Confederation, Hashemite Kingdom of Jordan, Kyrgyz Republic, Republic of Poland
26	5	53	Ireland, Kingdom of Denmark, Kingdom of Norway, Kingdom of Sweden, Kingdom of Belgium
27	4	319	Kingdom of Bhutan, State of Nepal, Islamic Republic of Pakistan, Republic of India
28	11	287	Federal Republic of Nigeria, Federative Republic of Brazil, Republic of Kenya, Lao People's Democratic Republic, Papua New Guinea, The Kingdom of Thailand, Republic of South Africa, Argentine Republic, Commonwealth of Australia, Republic of Chile, New Zealand
29	4	214	Republic of Bulgaria, Hong Kong Special Administrative Region, Russian Federation, Ukraine
30	3	149	Republic of Belarus, Czech Republic, Republic of Estonia
31	4	1924	People's Republic of China, Japan, The United Mexican States, United States of America
32	4	145	Republic of Iceland, Greenland, State of Alaska, Canada
33	3	9	(Republic of Austria), (Slovak Republic), (Grand Duchy of Luxembourg)
34	5	16	(Republic of Finland), Republic of Hungary, (Republic of Lithuania), (Republic of Latviaa), (Romania)
35	3	10	(Former Yugoslav Republic of Macedonia), (Republic of Kosovo), (Republic of Serbia)
36	8	8	(Republic of Azerbaijan), (Georgia), (Republic of Kazakhstan), (Republic of Moldova), (Republic of Tajikistan), (Turkmenistan), (Republic of Uzbekistan)
37	5	1	(Union of Comoros), (Republic of Cape Verde), (Kingdom of Lesotho), (State of Qatar), (Republic of Rwanda)
38	4	2	(State of Eritrea), (Islamic Republic of Mauritania), (Kingdom of Swaziland), (Republic of Chad)
39	7	5	(United Arab Emirates), (Kingdom of Bahrain), (State of Kuwait), (Sultanate of Oman), (Democratic People's Republic of Korea), (Reunion), (Republic of Yemen)

Table 3. Climate of geographic groups in geographic zones with edible species larger than 20. Number of countries is in each cluster and geographic zone.

	Equatorial				Arid				Warm temperature							Snow									Polar		Majority of climate classfication	Location in Earth
CL	**Af**	**Am**	**As**	**Aw**	**BSk**	**BSh**	**BWk**	**BWh**	**Csa**	**Csb**	**Cwa**	**Cwb**	**Cfa**	**Cfb**	**Cfc**	**Dsa**	**Dsb**	**Dwa**	**Dwb**	**Dwc**	**Dfa**	**Dfb**	**Dfc**	**Dfd**	**ET**	**EF**		
1	1	3		3																								Caribbean islands
2	1	1		3																								Caribbean islands
3	2	7		3																								Caribbean islands
4				1		1		2	4	2												1						Mediterranean
5						2	1	4	8	1			4															Mediterranean
6	5	1		1																								Southest Asian island
7	1	4		4																								Yucatan Penisula
8	3	1		4								2	2															South America
9	2																											South America
10	3	2		3									2												1			South America
11	1	1									1		3	1				1										
14				1																								West Africa
16	1	3		5							5																	Middle & East Africa
17		4	1	4							1																	Southest Asia
18	1		3		2	3	1	2	2		2			2														East Africa, the Arabian Peninsula
19			4	2		2		2			2																	Middle Africa
21	6		1																									Pacific Islands
23					1		2	1																				
24									2	2			1	5	1													Western Europe
25				1			1	1	1	1			1			1	1				1	1	1	1	2			
26														4									2		1			Scandinavian countriies
27		1		1				2			1	3																The Indian sub-continent
28	3	5	2	7	2	3	3	2			2	1	5	2														
29											1		2						1	1	1	2	1	1				
30													1									2						Baltic Sea
31		1		1	1	1	2	1	1	1	1		3					1	1	1								
32														1							1	1	1	1	3	1		Arctic Ocean
34										2							1											Baltic Sea & Scandinavian

: Equatorial climate **: Arid climate** **: Warm temperature climate**

: Snow climate **: Polar climate**

Chapter 4

Discussion

4.0 The relationship between food and latitude

When paying attention to the grain with the largest harvesting area in the world, the distribution is related to latitude (**Figure 3**). Wheat can be cultivated primarily in countries of high latitude area, but it cannot be cultivated in low latitude area because of temperature in the cultivation. Instead, in view of major staple foods, rice and maize are cultivated in Asian and the American regions, respectively. Latitude-dependent culture features of cereals as major staple foods like sorghum, millets, wheat, maize and rice can be seen in the north, the central and the south Africa. (Macauley, 2015). Sorghum (*Sorghum bicolor*), has absolute minimum temperatures ranging from 7 to 10 °C, optimum minimums from 15 to 27 °C, optimum maximums from 33 to 40°C. Millets, for example Pearl millet (*Pennisetum glaucum*), has optimum temperature range of 31 ± 5 °C (Squire et al., 1983). Wheat (*Triticum aestivum*), has absolute minimum temperatures ranging from 2 to 5 °C, optimum minimums from 15 to 20 °C, optimum maximums from 23 to 33 °C (Hollinger et al., 2009). Maize (*Zee mays*) has optimum temperature range for germination is between 18 and 32 ºC (Belfield et al., 2008), and rice (*Oriza Sativa*) requires a fairly high temperature, ranging from 20 to 40°C. Rice has the optimum temperature ranging from 30 to 35°C (Nagai and Makino, 2009).

The main grains are wheat and barley in the north Africa, and sorghum in the central Africa. Grilled field agriculture is also traditionally carried out in the in the central Africa, that is, the main cereals are roots and tubers. Maize is the main grain in the south Africa. However, because wheat of North America is for export and barley of North Africa and Europe is for food, it does not necessarily represent the staple food of that country (FOASTAT, 2004). In the present work, therefore, we collected and analyzed accessibility data of edible species actually consumed as food based on information in scientific literature. As a result, our observation in accessibility of edible species cannot be explained by only latitude in globe.

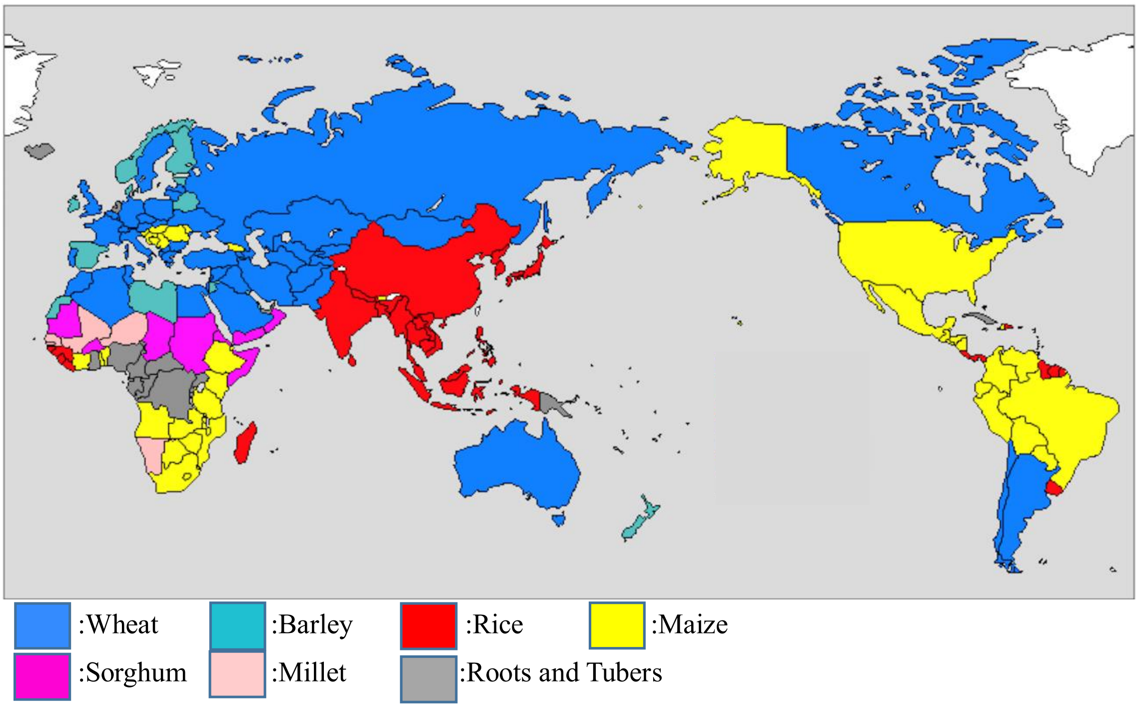

Figure 3. The world map indicated the main crops in the country. (FOASTAT, 2004)

4.1 Clusters explained by food cultures in geographic properties

Based on accessibility of edible species it has been possible to separate eight geographic regions, on continental land masses, these are Mediterraneum, Baltic Sea, Western Europe, Yucatan Peninsula, South America, Africa and Arabian Peninsula, Southeast Asia, Arctic Ocean; and three archipelagos which are Caribbean Islands, Southeast Asian Islands, and Pacific islands. Thus, total 11 geographic regions have been extracted from specificity of edible species.

There are several proposals of healthy diets, for example low-carbohydrate diet which restricts intake of total carbohydrate below some particular threshold and an operational definition is derived from Dietary Reference Intakes of the Institute of Medicine, which recommend to set total mean daily carbohydrate intake as below 45% of total calories (Food Nutr. Board, Inst. Med, 2005). The carbohydrate-restricted diets are utilized in diabetes management including insulin therapy and weight control (Accurso et al, 2008; Feinman, 2001). Low-carbohydrate eating is associated with quite limited population group and cultural experience, for example, Inuit diet (Jeppesen et al. 2013). Taking intake of meat and dairy into consideration, the Atkins Diet was proposed as newer versions of low-carbohydrate which increases saturated fat intake (Atkins, 2013). A low-carbohydrate dietary pattern based on high-protein plant rather than animal food called eco-Atkins diet was also proposed based on the Atkins Diet (Jenkins et al., 2009).

Low fat diets include vegetarian and traditional Asian diets. Vegetarian diets are mostly plant-based system, including dairy and eggs typically and other animal products such as fish and other seafood selectively (Richter et al., 2016). Because we need to take diets in two major viewpoints, that is, ecology and healthcare into consideration, we examine relationships between human health and individual local diets developed in different geographic regions.

4.2 Clusters related with biogeography on the continent

4.2.1 Africa and Arabian Peninsula

The earliest evidence for the possible use of aquatic resources by hominids come from East African Rift Valley localities where the remains of a variety of aquatic or amphibious fauna have been found with stone tools of about 2.5 to 17 million years ago (reviewed in Erlandson, 2001).

Geographic zones of east Africa and the Arabian Peninsula (Figure 2), mostly belong to super group

F (CL16, 18, 19). Those zones are associated with the area where the genus *Homo* evolved. The fossil evidence indicates that *Homo* arose in the vicinity of the East African Rift Valley lakes (Broadhurst et al. 1998). The diverse alkaline-fresh-water fish species in the lakes provided a source of both protein and polyunsaturated fatty acid (PUFA). Lipids of the freshwater fish have rich contents of DHA and AA in comparison of the other foods (Broadhurst et al. 1998).

Remains of 55 food plant taxa were excavated in Gesher Benet Ya'aqov (GBY) located in the northern Jordan Valley on the shoreline of ancient lake Hula which are estimated to be of the Lower-Middle Pleistocene period, some 780,000 years ago. GBY was Mediterranean climate 780,000 years ago because most tree species found at GBY were also found in Mediterranean (Melamed et al., 2016). The food plant remains were part of a much more diverse diet including food plant species, fish (Zohar and Biton, 2011), amphibians, reptiles, birds, mammals such as fallow deer (Rabinovich et al., 2008) elephants (Rabinovich and Biton, 2011), and various aquatic and terrestrial invertablates (Melamed et al, 2016).

Eaton and Konner (1985) indicated the possibility that the range of optimal nutrient combinations to support good health are present in the foods in Paleolithic period (2.5 million to 10,000 years ago) In addition, seaweeds containing iodine was a significant component of the Paleolitic diet because iodine deficiency results in impaired neurologic development (Cunnane, 2005). Furthermore, potential benefits of seaweeds on obesity has been reviewed in Lange et al. (2015).

Modern analogues for pre-agricultural diets based on tropical marine and lacustrine resource evolved in those geographic regions. Cat fish comprised over 90% of the fish fauna recovered from over forty Late Plestocene Nile River and East African Rift Valley lakes which had a relatively high AA and DHA (Broadhurst et al. 1998).

Together with Plaleolitic diet, procurement of animal resources was also included in the diet in Ethiopia before 2 million years ago (de Heinzelin et al., 1999) and in Kenya before 1.95 million years ago (Braun et al., 2010).

Traditionally, the various cuisines of Africa use a combination of locally available fruits, cereal grains and vegetables, as well as milk and meat products, and do not usually get food imported. In some parts of the continent, the traditional diet features a lot of milk, curd and whey products.

Lactose intolerance is due to the lack of enzyme lactase which generally breaks lactose into glucose and galactose. Several symptoms by milk including abdominal pain, bloating, diarrhea, gas, and nausea are caused by accumulation of lactose in human body. Lactose tolerance is advantageous in environments and cultures where humans have access to domesticated dairy animals. Multiple lines of evidence from human genetics, cattle genetics, and archaeological records suggest that populations in Middle East and North Africa domesticated cattle between 7500 and 9000 years ago, and that these animals were later brought into Europe. In that cow-friendly environment, if people can obtain nutrient by drinking milk directly (instead of having to process it into lower-lactose cheese) that is advantageous for nutrition and for a source of water during droughts. The lactose persistence mutation arose randomly, and once it arose, it had a distinct advantage in these populations and led to the lactose tolerance mutation. Recent evidence suggests that cattle may have been domesticated independently in several places including Africa, Europe and so on. In the case of Africa, lactose persistence became an advantageous trait after populations began herding cattle (estimated as 3,000-7,000 years ago; Check 2007) and the stage was set for the spread of a lactose tolerance mutation so called “the genetic roots of Africans' lactose tolerance” which has also occurred in Europe around the same age (Tishkoff et al. 2007). Thus, the convergent evolution of African and European populations in relation to cattle domestication reveals that shared aspects of human culture across different ethnic groups affects our evolution in similar ways.

The frequency of lactate persistence trait is high in milk-dependent nomads of the Afro-Arabian desert zones as well as in Northwestern European, for example, Swedish, Danes, Irish, British, Finland, Germans, Czechs, Swiss, Spanish Estonia. In Afro-Arabian desert zone, the pastoralists tend to have higher frequencies of lactase persistence than the neighboring non-pastoralists in the same countries (Swallow, 2003; Deng et al., 2015).

Depending on the region, there are also sometimes quite significant differences in the eating and drinking habits and proclivities throughout the continent's vast populations: Central Africa, East Africa, the Horn of Africa, North Africa, Southern Africa and West Africa each have their own distinctive dishes, preparation techniques, and consumption mores. Based on accessibility of edible species, we have four clusters (CL14, CL16, CL18, CL19) and three of them (CL16, CL18, CL19) belong to super group F, and the other CL14 belongs to super group E. There is a trend that the former corresponds to the area related with pastoralists, and the latter to the non-pastoralists. Ghana consists of Yoruba peoples belongs to CL14. Nowadays, the Yoruba don’t herd cattle, and don’t have any mutations for lactose persistence (Check, 2007).

The Maasai are seminomadic pastoralists distributed in East Africa, northern Tanzania and southern Kenya that they migrate within semi-arid lowlands and more humid uplands to obtain water and pasture and a large majority of the population has obtained their livelihood through husbandry of cattle, goat and sheep.

It is well known that in traditional culture, Maasai people exclusively consume meat, milk, and blood, that is, cholesterol rich diet, and the occurrences of heart disease and atherosclerosis are very low. Their adaptation for a high cholesterol and high-fat diet is associated with that in genome level involving lactose and lipid metabolism (Wagh et al., 2012).

Meat, milk, blood, and soups were the basic traditional foods of the Maasai, while herbs were either added to them or consumed directly. By the survey of 120 households, total 35 species are listed, 11 species for grains, legumes and nuts, 6 species for roots and leafy vegetables, 11 species for wild fruits, 15 species for herbs, 17 species for animal products, 2 species for fish and 2 species for sugar and cooking oil. Several herbs play nutritional roles to provide a variety of important micronutrients involving vitamin C, non-heme iron, selenium, zinc, calcium (Oiye et al, 2006).

The low levels of coronary risk factors and low mortality from cardiovascular causes can also be interpreted by the very high levels of energy expenditure of the Maasai, that is, the Maasai people generally walk at least 19 km more per day. Habitual physical activity and cardio-respiratory fitness contribute regulation of metabolism and major determinants of modern lifestyle diseases such as Type 2 diabetes and cardiovascular disease (Gill et al., 2006) which can be supported by the evidence that the physical activity levels of rural East Africa including Maasai are 15-20% higher than recent estimates from rural West Africa (Christensen, et al., 2012). Therefore, physical activity as well as diet patterns should be taken into consideration for healthcare of individual geographic areas (Mbalilaki et al., 2010).

Preservation and maintenance of the Maasai traditional indigenous food-based knowledge can be carried out through integration between the existing health and nutrition interventions with traditional food promotion as well as continuous education of young members of the community about their traditional food systems and their cultural contexts (Oiye et al, 2006).

Indigenous Arabs are direct descendants of humans who migrated out of Africa, before others continued on to colonize Europe and Asia (Rodriguez-Flores, 2017), This is consistent with our results where gulf and east African regions are clusterized in the same super group F (Figure 2).

The Arab cuisine encompasses a wide variety of local cuisines covering the Arab world from Mesopotamia to North-Africa. Originally, the people of the Arabian Peninsula relied heavily on a diet of dates, wheat, barley, rice, meat and yoghurt without butter fat called ‘leben’. Flat bread ‘couscous’ and rice are staples and olives, as well as dates, figs, and pomegranates are widely used (Garduno, 2015). In gulf region, a radical change in dietary patterns from a traditional diet to a less healthy industrialized diet lead to a worsening prevalence of non-communicable chronic diseases (Fahed et al., 2012). Therefore, the selection of a healthy diet based on the food dome, dietary guidelines for Arab countries and the undertaking of physical activity are essential in the prevention of these diseases (Musaiger, 2012).

Wheat (*Triticum dicoccoides*; Özkan et al, 2010) and barley (*Hordeum vulgare*; Badr et al., 2000) were the first crops to be domesticated in Fertile Crescent between 12,000 and 10,000 years ago. Wheat was used for making bread in Egypt by 5000 BC as main staple in the *diet* and its cultivation had spread to Europe by 4000 BC. As farming started in the Middle East around 11,000 years ago, cattle herders learned how to reduce lactose in dairy products to tolerable levels by fermenting milk to make cheese or yogurt (Curry, 2013).

Grains such as wheat and corn except wheat germ, generally tend to be low in lysine which is classified as an essential amino acid, that is, human body cannot biosynthesize lysine and must rely on adequate dietary intake (Morey, 1983) of animal proteins, such as meats, poultry and, milk and its fermented products are rich source of lysine (Hejtmánková et al., 2012; Kwak et al, 2011). Development of both agriculture and animal husbandry led to provide important role for sustaining human health in view of nutrition including fermented foods as well as foods originated in plants and animals.

4.2.2 Western Europe

After the development of agriculture and animal husbandry, human dietary choices would have been extended. In addition, milk was also utilized for nutrition and the lactose persistence mutation spread through ancient European populations as well as Africa (Tishkoff et al, 2007). Many thousands of years later, we see the indirect (but delicious) effects of this mutation's success in European cuisines: oozing French cheeses, Swiss milk chocolate, and creamy Italian gelatos. Food found in Western diets generally unavailable to pre-agricultural period are milk, cheese butter, grains, high-fructose corn syrup, salad with cooking oil, shortening, margarine and so on (Cordain et al., 2005). This transition occurred too recently on an evolutionary time scale for human genome to adjust and lead to so-called diseases of civilization in Western population (Cordain et al., 2005).

Populations of European origin have lower rates of glucose intolerance and diabetes than do other populations (Amerindians, Polynesians, Chinese, Australian Aboriginals, Africans and South Asians) and might reflects, at least partly, a regional divergence in population genetics due to the different timings and types of agrarian transitions during much of the past 11,000 years (McMichael, 2005).

The Western dietary pattern is characterized by a high consumption of red meat, refined grains, processed meat, high-fat dairy products, desserts, high-sugar drinks, and eggs. In the 14^{th} century, average per capita meat intakes in traditional agricultural societies were 5-10 kg a year. In most subsistence peasant societies, meat was eaten no more frequently than once a week and relatively larger amounts were consumed, as roasts and stews, only during festive occasions. Growing populations needed conversion of pastures into arable land, which lead to reduce average per capita meat supply in many countries of early modern Europe (Smil, 2002). By gradual intensification of farming, animal foods provided generally less than 15 percent of all dietary protein, and saturated animal fats supplied around 10 percent of all food energy for preindustrial populations at the 18 century. Currently, Meat consumptions for French and Britain reached around 120 kg/capita and 80 kg/capita, respectively (Smil, 2002). Based on accessibility of edible species, 5 geographic zones corresponding to Western and Southern Europe are clustered in CL24 (Super group G, Figure 2). A high intake of red meat including meat products increases the risk of nutrition-related diseases such as cardiovascular diseases, type 2 diabetes and several cancers, whereas high levels of dietary fiber-rich cereal products, vegetables and fruit can decrease the risk of those disease (Bouvard et al., 2015; Boeing et al., 2012).

Compared to omnivores, vegetarians generally have lower blood pressure and body weight closer to desired levels (Dwyer, 1988). There are five type of plant-based vegetarian diets which permitted fish, eggs, milk and dairy products for pesco vegetarians; eggs, milk and dairy products for ovo-lacto vegetarians, milk and dairy products for Lacto vegetarians, eggs for ovo vegetarians, and non-permitted other than plants for vegans (Richter et al., 2016). A meta-analysis indicated trend that persons with a vegetarian diet exhibited a lower risk of metabolic and cardiovascular diseases than persons not on a vegetarian diet and the risk of ischemic heart disease and cancer were lower (Dinu et al, 2016) though the lower risk of disease is presumably not only due to nutritional differences (Kwok et al., 2014). There were no differences with respect to mortality of pesco, ovo-lacto vegetarians and vegans with people who took a high vegetable mixed diet, containing low levels of meat and meat product (Appleby et al., 2016). Therefore, it can be assumed that a plant-based diet with or without low levels of meat is associated to reduced risk of nutrition-related diseases in comparison with the currently conventional German diet (Richter et al., 2016).

The animal-based foods contribute to the supply of the nutrients including proteins, essential amino acids, eicosapentaenoic acid (EPA), DHA, vitamin D, riboflavin, vitamin B12, calcium, iron, iodine, zinc, and selenium. As vegetarian diets including only plants contribute to the supply of those nutrients insufficiently, especially, a vegan diet increases the risk of vitamin B12 deficiency. Therefore, the German Nutrition society (DGE) recommended that vegetarians and vegan should replace meat, fish, milk and eggs with legumes, such as peas, beans, chick peas and lentils, or with soya products and other protein sources (Richter et al., 2016).

Consequently, the risk is determined by food composition, particularly the balance between animal and plant-based foods. Common fermented foods in Western diet such as yogurt, cheese, sauerkraut, sourdough bread, beer, and wine have health-modulating potential. Lactate biosynthesized by Lactobacillus, and Streptococcus was reduced pro-inflammatory cytokine secretion of TLR-activated, bone-marrow-derived macrophage, dendritic cells in a dose-dependent manner (Iraporda et al, 2015) and alters redox status by reducing the reactive oxygen species burden in intestinal enterocytes (Kahert et al, 2016). B vitamins including folate, riboflavin, and B12 are biosynthesized form various non-vitamin precursors by dairy food (Chamlagain et al., 2015; Russo et al., 2014). So fermented foods may contribute to brain health via direct and indirect pathways because fermentation may amplify the specific nutrient or phytonutrient content of foods, the ultimate value of which is associated with mental health (Selhub et al., 2014).

4.2.3 Mediterraneum

Mediterranean diet is originated from a collection of eating habits traditionally followed by people in the different countries bordering the Mediterranean Sea (Sofi et al, 2010), which has fertile soils and abundant sunshine, both of which are key factors in agriculture and is the best known and best researched example (Bere and Brug, 2008). Based on accessibility of edible species, 18 geographic zones corresponding to Mediterranean are clustered in CL4 and 5. Both clusters are closely related with each other because they belong to the same Super group B (Figure 2).

Archaeologist have found evidence for the production of wine in Iraq and Egypt at 8,000 and 3,000 years ago, respectively (McGovern et al., 1997) and in that time, these fermentation technologies expanded from Mesopotamia through the world, for example, the cultivation of grape vine and the production of wine has spread all over the Mediterranean Sea towards Greece (4,000 years ago) and Italy (3,000 years ago) (Petorius, 2000). The particular focus was on mimicking the traditional diet emphasized on olive oil, vegetable, fruits, nuts and seeds, beans and legumes, selective dairy intake, wine and whole grains, often seafood including fish, quite limited consumption of meat and moderate wine intake (Schinkel, 2013; Trichopoulou et al, 2003). Meta-analysis of the Mediterranean diet on health confirmed a significant protection against major chronic diseases such as neoplastic diseases, cardiovascular diseases, neurodegenerative diseases including Parkinson's disease and Alzheimer's disease (Sofi et al, 2008, Sofi et al, 2010).

4.2.4 Baltic Sea

Locally oriented and culturally appropriate dietary patterns in areas other than around the Mediterranean should be explored because several of the ingredients of the Mediterranean diet do not grow well in many areas, therefore require greenhouse or long-distance transportation. Thus New Nordic Diet or Baltic Sea Diet has been proposed by geographic zones surrounded by Baltic Sea (Kolehmainen, 2017; Bere and Brug, 2008). The four criteria for choose ingredients are constructed for a more health-enhancing and environmentally friendly ways. (1) Ability to produce locally over large areas within the Nordic countries without usage of external energy; (2) A traditional as a food source within the Nordic countries, (3) Possessing a better potential for health-enhancing effects in similar Mediterraneum foods (4) Ability to be eaten as foods not as dietary supplements. Then, the following ingredients are selected; native berries, cabbage, native fish and other seafood, wild and pasture-fed land-based animals, and rapeseed oil, and grains (oat, barley, rye). Healthy Nordic Food Index (HNFI) was also developed for evaluation of the health effects of adhering to a Nordic Diet (Olsen et al., 2011) and the negative relation between HNFI score and the incidence of colorectal cancer was demonstrated (Kyro et al., 2012). Based on the accessibility of edible species, 8 geographic zones surrounding the Baltic Sea are clustered in Super group G (CL26 and CL30), whereas 5 geographic zones are clustered in Super group H (CL34). Depending on accessibility of edible species, healthcare diets should be separately designed for Super groups G and H. Healthy new Nordic Diet

(Ministry of food, agriculture and Fisheries of Denmark, 2017) includes fruits (e.g. apples and pears), berries (e.g., lingonberries and blue-berry jam), vegetables, legumes, low-fat dairy products, fatty fish (e. g. salmon, herring and mackerel), and oats, barley, soy protein, almonds and phyllium seeds (Adamsson et al., 2011)

However, in recent years, with the industrialization of neighboring countries the Baltic Sea, fishery is obsolete and hardly fish can be caught. Once the Baltic Sea was filled with fish enough to be said that the net was filled with the fish if you push the net in the sea, and the harpoon stood if you inserted a harpoon into the sea. Although an environment of Baltic Sea has been distracted by pollutant accumulation due to development and accelerated overfishing. Early 19th century, annual phosphorous inflow into the Baltic Sea area was 10 thousand tons, and nitrogen was 200 thousand tons. However, in the 1987 survey, phosphorous inflow into there was 50 thousand tons, and nitrogen was 940 thousand tons. As a result, it was observed eutrophication of seawater, abnormality of seaweeds, devastation of the seafloor, mercury contamination of fish, deposition of DDT and PCB on the coast, and increasing trend of cadmium and lead. Therefore, ecosystem and food chain of marine organisms came to be in crisis rapidly. (Finnish Environment Institute, 2014).

4.2.5 Southeast Asia

According to the accessibility of edible species, Southeast Asian countries (CL17) are assigned to Super group F whereas the countries of the Indian sub-continent (CL27) are assigned to Super group G. Though these countries are geographically nearer, they are different in terms of pattern of edible foods and this difference can be attributed to geographical separation by Ganges Valley. Thus, food culture is significantly different between the west and east sides of the Ganges Valley. In these both geographic regions and other parts of Asia, people eat rice as common staple. The archaeological evidence suggested that more than 10,000 years ago, ancient people began to gather and consume *Oryza rufipogon*, a wild grass species grew in the swamps and marshes throughout tropical and subtropical Asia. A process of continuous selection for desirable feature made it possible to transform wild rice into *Oryza sativa* (Kovach et al., 2007; Gross et al., 2014), whereas genetic support that two genomes of 110 LTR retrotransposons in the genomes of two rice varieties, Japonica rice (*O. japonica*) and Indica rice (*O. indica*) diverged from one another at least 200,000 years ago and Indica rice and Japonica rice arose from two independent domestication events in Asia (Vitte et al., 2004) and *O. indica* and *O japonica* genomes diverged at 440,000 years ago based on the analysis of 9,383 substitutions in 972 kb of common sites (Ma and Bennetzen, 2004). The rice domestications occurred in different parts of the southeast world such as on the west side of the Ganges Valley (*O. aus*), southern Asia on the east side of the Ganges Valley (*O. indica*), and east Asia (*O. japonica*) (Civan et al., 2015). Thus, the history of domestication of rice species is reflected in the classification obtained in the present work based on accessibility to edible species.

The primary staple foods of India are fermented foods based on butter and several spice and grains produced by several crops, for example, pulses urad, mung, masoor, rice, back gram, Bengal gram, finger millet, horse gram and so on. During fermentation, microorganisms can produce important nutrients such as Vitamin B12, beta-galactosidase enzyme, and lysine from leucine. People cook tropical fruits (banana, jackfruit, monkey jack, Bael fruit, mango, Jamun fruit, Papaya, bitter gourd, and so on) and green leafy vegetable (spinach, radish, tomato, ginger, and so on). Milk by cow, buffalo, and goat, and fermented milk including clarified butter (called ghee in India), curd, paneer (india cheese), cheese and buttermilk indian yoghurt (dahi) were consumed at 2800 years ago. (Sarkar et al, 2015). Turmeric is known as the "golden spice" as well as the "spice of life", and has strong associates with the sociocultural life of the people of the Indian subcontinent documented by at least 6,000 years ago. It is native to South Asia, India and Indonesia, and is predominantly grown in South India and widely used in traditional Indian medicine as well as a dietary spice (Ravindram et al., 2007). Thus, plant foods are popular rather than animal foods and probiotic processed foods are also traditionally invented in India. Yoga breathing is an important part of health and spiritual practices in Indo-Tibetan traditions (Brown and Gerbarg, 2009).

Cuisines of East Asia, the east sides of the Ganges Valley, fundamentally consists of rice, fish and vegetables. Animal proteins obtained from aquatic organisms including fish, shells, prawns and shrimp, squids and so on. Fermented foods using aquatic organisms are consumed daily. Rice is a source of vegetable protein, amino acids and energy. Various kinds of fish sauces, traditional food supplements in the diet, are used as a staple ingredient in various cuisines in Indo-Chinese peninsula including Myanmar, Cambodia, Philippines, Thailand, Lao and Vietnam. Ruddle and Ishige (2010) have indicated that the-Thai-Lao adopted initially the use of fermented fish from the earlier inhabitants after entering the Indo-Chinese peninsula. Shelfish, Fish, edible algae and fermented fish are sources of vitamin B12 (Watanabe, 2007).

4.2.6 Arctic Ocean

Geographic regions surrounding Arctic Ocean are clusterized into CL32 (Super group G) which is closely related with CL30 (Baltic Sea). Humans first moved to the North American Arctic (northern Alaska, Canada, and Greenland) from the Bering Strait region beginning around 6,000 years ago (Harritt, 1998). Though only a period of 6,000 years, individual inuits adapted cold environment and a limited accessibility of edible species.

The traditional Inuit diet has little in the way of plant food, no agricultural or dairy products, and was unusually low in carbohydrates. Most part of nutrition is obtained from fish and animals. Vitamins A and D is consumed by cold-water fishes and sea mammals as well as from the animals' livers. Vitamin C is consumed by freezing meat and fish, for example, raw caribou liver, seal brain, raw kelp, whale skin and muktuk (Gadsby, 2004).

Inuits in Greenland and Alaska have adapted cold environment by fatty acid metabolism, and low-carbohydrate diet. Greenlandic Inuit and lower incidence and morbidity associated with coronary heart disease (He et al., 2004). Inuits have probably adapted to the cold Arctic climate and invented their traditional diet, which has a high content of omega-3 PUFAs derived from seafood (Deuch et al., 2007) and a content of omega-6 PUFAs that is lower than in Danish (Bang et al., 1980). The strongest signal of selection is located within a region on chromosome 11 encompassed five genes (TMEM258, MYRF, FADS1, FADS2, and FADS3) examined in 191 individuals of the indigenous Greenlandic Inuit (Voruganti et al., 2012). FADS1, FADS2, and FADS3 have fatty acid desaturases, that is, delta-5 desaturase (FADS1), delta-6 desaturases (FADS2), and unknown function gene (FADS3). FADS1 and FADS2 corresponds to the rate-limiting steps in the conversion of omega-6 and omega-3 unsaturated fatty acids to the longer, respectively. EPA and DHA classified into omega-3 unsaturated fatty acids, whereas arachidonic acid classified into omega 6 unsaturated fatty acids. Polymorphisms in or near TBX15 on chromosome 1 are detected in Greenlandic Inuit. TBX15 plays a role in the differentiation of brown subcutaneous adipocyte and brite inguinal adipocyte (Gburcik et al., 2012). On stimulation by exposure to cold, brite adipocyte can differentiate into cells capable of expressing UCP1 (uncoupling protein 1), which produces heat by lipid oxidation. Thus, TBX15 is a candidate of adaptation to cold.

Analysis of skeletal muscle biopsies in the genotyped 2,733 participants in the Inuit Health in Transition cohort Lower of Greenland revealed mRNA and protein levels on the long isoform of

TBC1D4, and lower muscle protein levels of the glucose transporter GLUT4 with increasing number of alleles with mutation at the 684th amino acid from arginine to termination codon. Here TBC1D4 affects glucose uptake and occurs at high frequency only among the Inuit (Moltke et al, 2014). TBC1D4 is associated with nonsense variation with type 2 diabetes, and mutation of GLUT4 elevates circulating glucose and insulin levels after an oral glucose load (Moltke et al., 2014).

Polymorphisms in FADS1 and FADS2 are associated with increased level of plasma and erythrocyte delta-5 desaturases in Alaskan Inuit (Voruganti et al., 2012) as well as with levels of PUFA in blood and breast milk (Xie and Innis, 2008; Rzehak et al., 2009). In addition, fermented seal fat is the most commonly consumed traditional foods and offers the nutrients produced by fermented process (Sheehy et al., 2013). Thus, in the case of Inuit, balanced nutrients are obtained from animal raw and fermented foods and the metabolic pathways are strengthened in fatty acids in genome levels for adaptation of limited plant foods.

4.2.7 Yucatan Peninsula

Geographic zones in South America are clusterized in CLs7-10 in the same Super group D. Thus, the accessibility of edible species tends to be conserved in South America. Of them, CL7 is separated from other clusters CL8-10 in Figure 1. Modern native Americans are descendant from Siberian ancestors who moved into eastern Beringia between 26,000 and 18,000 years ago, spreading southward into the Americas after 17,000 years ago, then inhabited the Yucatan Peninsula at 12,000-13,000 years ago (Chatters et al., 2014). Yucatan Peninsula belongs to the physical landscape of the Maya area. Maize was an important crop along with squash and beans and domesticated in the Central Balsas Valley by 8,700 years ago (Piperno et al., 2009; Ranene et al., 2009).

The first developments in agriculture and the earliest villages were established in Maya Lowlands by the Archaic period (~5,000 years ago). Their diets consisted of ramon nuts (*Brosimum alicastrum*), root crops (*Manihot esquelenta*), maize, fish, seafood, a wide variety of terrestrial animals including deer, peccary, and tapir. Of them, maize was a major food source at all time in Maya civilization from pre-Classic to Historic times (White et al., 1989) and include a variety of nutrients, that is, starch, proteins and oils, a number of important B vitamins, folic acid, vitamin C, and provitamin A (i.e., precursor to vitamin A), phosphorus, magnesium, manganese, zinc, copper, iron and selenium, and has small amounts of potassium and calcium, dietary fiber. However, maize contents low level in lysine and tryptophan which are among 8 essential amino acids (Ufaz and Galili, 2008). Cacao (*Theobroma cacao*) also play a significant role in Classic period Maya civilization (Hurst et al., 2002) and it contains all amino acids including tryptophan which is contained in non-protein forms. Here tryptophan is the second most deficient amino acid after lysine (Bertazzo et al., 2011). In fermented process of cocca, tryptophan is transformed into tryptamine and 5-hydroxytryptamin (serotonin) (Bertazzo et al., 2011; Kang et al., 2007), which can affect central nervous system (Shalaby, 1996). Modern Mayan diet have those traditional foods. Based on traditional Maya diet, new Mayan cuisine has been established in today's modern food practices and developed a great diversity of foods such as chocolate, avocado/guacamole, tortillas, and tamales and so on.

4.2.8 South America

Human populations first occupied high elevations in the Andes Mountains at least 7,000 years ago. A richness in flora and fauna of the Andes derived from the vast geographical extension and specific soil and climate conditions made it possible to produce a broad variety of traditional crops including tubers, roots, cereals, vegetables, fruits and the raising of animals such as guinea pigs and camelids (Antonelli and Sanmartin, 2016; Piperno, 2011).

Positive selection in the region of 82.0-82.3 Mb in chromosome 10 is observed for Andean natives and, Aymara and Quechua who live in the high altitude (> 2500 meter above sea level) and FAM213A in the region is associated with accelerated growth in lung volume and chest dimensions (Meer et al., 1995). It might be a developmental compensatory response to high-altitude hypoxia (Fnsancho, 2013). This indicates that adaptation to high altitude has been carried out in genetic level, though the region would not relate with the Andes diet.

Potatoes are an important staple for the Peruvians who consume 253 g/adult equivalent/day on average and provide ideal sources of energy, proteins, fats, vitamins except B12, minerals, and fiber (Rose et al., 2009). Vitamin B12 can be complemented by Cheese which is a key ingredient in Andean dishes (Mikuy and Mikuy, 2013), and other animal source foods (meat, eggs, milk; Beri et al., 2014).

4.3 Clusters related with biogeography of the islands

In the accessibility patterns of edible plants, three groups of geographic zones are dominated by archipelagoes as follows: CL1-3 (Super group A) associated with Caribbean Islands, CL6 (Super group F) with Southeast Asian Islands, and CL21 (Super group F) with Pacific Islands. Asian Islands and Pacific Islands are more similar in terms of edible patterns compared to Caribbean Islands. In general, islands have a less diverse range of species than the mainland because of the difficulties that animals often faced in getting to the islands (MacArthur and Wilson, 1967) which leads to a limited types of animals for food. Otherwise people can easily access to fish and seafood and their diets tend to incline towards seafood and plants including crops.

4.3.1 Caribbean Islands

CL1-3 corresponds Caribbean islands, and those are isolated from the other clusters as well as two clusters associated with Southeast Asian Islands and Pacific Islands. This means that accessibility patterns of edible species of the Caribbean Islands are very different from other geographic regions.

The first wave of human colonization in the Caribbean islands was started around 6,000 years ago (Wilson, 2007). The food remains from Banwari Trace in southwestern Trinidad suggests the change of economic shift from hunting/fishing/collecting to fishing/hunting/collecting (Harris, 1973). This change of the order of economic shift depended on the cultural patterns for people who had lived along the river systems of South America utilizing marine resources (Newsom and Wing, 2004).

Caribbean diet tends to be rich in meat and high carbohydrate foods such as yams, sweet potatoes, plantain, cassava, beans etc. One of the main problems is the amount of meats in diet, that is the amount is traditionally generous. The use of fatty meat and products build up cholesterol leading to heart problems (Lottery Funded 2015).

The main fisheries resources in Jamaica are coral reef fishes, (i. e. snappers, groupers, jacks, goatfishes, parrotfishes, grunts, triggerfishes, doctor fishes, squirrelfishes, angelfishes), spiny lobsters, conch, small coastal pelagic finfish and large offshore pelagic finfish (Akin and Kong, 2000). Cuisine called Cou-cou is part of the national dish in Barbados made from ground corn (cornmeal) and boiled okras, cooked into a firm paste which is usually served with steamed fish and frizzled salt fish (Sharma et al., 2007).

Caribbean people can easily access to seafood but the problem is the cost of food. Henny et al (2015) examined the relationship between cost and healthy rank for commonly consumed foods in Jamaica. They classified foods into 6 categories, staples, vegetables, food from animals, legumes and nuts, fats and oils, and fruits. This study reveals that healthy options for ' food from animals ' are substantially more expensive in Jamaica.

In Mesoamerican diet including Caribbean diets, fermented, mildly alcoholic, and nutritious beverages were part of the daily, for example, pozol, made out of maize, pulque, produced from the agave cactus plant and so on. Pozol is traditional fermented maize dough prepared by Indians and mestizos in southeastern Mexico. It includes microbial assemblage in a spontaneous lactic acid fermented food. Lactic acid bacteria accounted for 90 to 97% of the total active microflora (Ampe, F., et al., 1999). Thus, Caribbean diet consists animal, plant and their fermented foods.

4.3.2 Southeast Asian Islands

According to accessibility of edible species Southeast Asian Islands are clusterized in CL6 (Super group C), which are different from those of continental Southeast Asia (CL6 in Super group C;CL17 in Super group F; CL27 in Super group G). Homo genus was present on the East Indonesia island of Flores by at least 880,000 years ago which is a possible evidence for Homo erectus crossing of initial water gap from Sunda to Flores (Morwood et al., 1998).

People in the Philippines, Malaysia, and Indonesia used coconut oil or butter as their source of fat and rice as staple, Other carbohydrate-rich foods included cassava, corn, sago or noodles, although they were sometimes considered as snacks. The protein source consumed daily was fish.

Nutrients are sufficiently obtained from plants based on tropical fruits and vegetables because Indonesia and the Philippines are amongst the world's mega-biodiversity countries (Persoon, 2006).

Fermented soybean food, Tempeh is very popular and a staple food in Indonesia and Malaysia and originated hundreds of years ago in central and east Java Island (Shurtleff & Aoyagi 1979). The earliest version of tempeh is 'Sambal Lethok', a dish made of overripe tempeh, recorded in a 17th century Centhini (old Javanese) inscription. The first occurrence of the word for soybean in ancient Javanese documented in the Sri Tanjung from the 12th -13th century (Astuti, 2001). Tempeh is a highly nutritious, easily digestible and tasty product. Soybeans, and thus soybean tempeh, contain all essential amino acids, low in saturated fats and free of cholesterol (Fatmah 2013).

4.3.3 Pacific islands

The earliest periods for shell middens, fishing and seafaring at several sites in Melanesia islands were determined by 35,000 years ago (Erlandson, 2001; Allen et al., 1988). The Pacific Islander's original diet consisted of taro, breadfruit, yams, coconut, arrowroot, bananas, and seafood. Especially, seafood is main food in these geographic zones, 90% of island people respond that fish is an important ingredient on survey on the degree of importance of fish for various uses (Kikarski et al., 2006) (**Table 4**). Maize, cassava, sweet potatoes, chicken and pork were introduced by Spanish and rice by Japanese. In the 1940's after World War II, there are virtually no obesity, hypertension or diabetes among population. The Pacific Island's diet transitioned to predominantly rice and imported food when the United States occupied Micronesia beginning in the 1960's and 1970's. Current Micronesia's diet mainly consisting of rice, wheat flour, sugar, refined foods, and fatty meats lead to high obesity and diabetes rates (Ichino et al., 2013). Thus many factors involved in history, landscape, climate change urbanization, and population growth have led to current food situation and health status in the pacific islands.

Promoting traditional food and the cultivation of these foods are expected to cause the change in their diet and physical activity patterns because a study of the Aborigines people, an indigenous group in Australia indicate that a group of Aborigines people who had changed to a modern diet and lifestyle were convinced to switch back to their traditional diet, leading to significant improvement in health (Bollan Michael 2016, Documentary: Judth Helfand).

The traditional diet is based around whole fruits, vegetables and seafood, which provide a well-balanced diet. A wide variety of seafood and fish are a source of protein. The most traditional cooking style is "umu", an underground cooking style where wrapped food was cooked on heated rocks (Haden, 2009). Breadfruit has been a staple food and traditional crop in the Pacific for more than 3,000 years (Turi et al., 2015). Fruit part of breadfruit are generally cooked by roasting whole in hot coals, boiling or baking. Since breadfruit is a seasonal crop Pacific islanders have developed techniques to preserve breadfruit based on fermentation process, called ma (Marquesas), mahi (Cook & Society Islands) masi (Samoa & Tonga), madrai (Fiji), namandi (Vanuatu), mahr (Pohnpei), furo (Kosrae), and bwiru (Marshall Islands) (Ragoni, 2002). Some evidence indicate a potential that a traditional diet based on breadfruit and other pacific staples of prevent onset of type II diabetes (Turi et al., 2015; Lans, 2006; Ramdath et al., 2004).

Table 4. Survey responses (percent) on the degree of importance of fish various uses (collected from Kilarski et al., Decision Support for Coral Reef Fisheries Management, 2006)

Degree of Importance	Uses of Fish						
	For Food	To Buy	To Sell	For Recreation	For Cultural Use	For Aquarium Trade	To Maintain Healthy Ecosystem
Important	90	32	46	45	73	25	91
Somewhat Important	5	36	19	16	13	20	4
Neutral	2	2	5	4	3	6	1
Somewhat Unimportant	1	5	3	3	1	4	1
Unimportant	2	24	26	32	8	44	3
No Response	0	0	1	1	1	1	0

4.4 Clusters based cross-cultural communication

Exchanging process of people and materials such as colonization and transportation are also reflected in accessibility of edible species. CL28 consists of colonized territories where Chile, and Argentina were colonized by Spain. Kenya; Australia, South Africa, New Zealand and Nigeria were colonized by Great Britain; and Lao, New Guinea and Brazil were colonized by French, Netherlands and Portuguesa, respectively. Those colonization process led to similar accessibility of diversity of edible species linked to Europe. Thailand has a potential to incorporate cuisines from surrounded geographic regions and thus got included in this cluster. Thai traditional medicine is derived from Ayurvedic and Chinese sources (Van Esterik, 2008). Thai also imported from India some ideas about the cooling and heating properties of food and how food affects individuals at certain stages of their life cycle in seasons (Van Esterik, 2008). The cooling and warming food system was also developed as body balance based on culinary art in Chinese traditional medicines, for example, the concept of "Yin and Yang", that is, the idea that there are two opposing forces in every aspect of life and condition of health is considered to be maintained by the balance of those forces. Here there are different types of the opposing forces, food to cool and warm body, male and female, dark and light, soft and hard and so on (Teng et al, 2006).

CL31 consists of People's Republic of China, Japan, The United Mexican States, United States of America. Major climate classification of China corresponds to warm temperature climate, fully humid & hot summer (Cfa) but China has an incredibly vast mix of geography and climate. These geographic zones have a geographic common feature, that is "westward intensification". Various ocean currents are flowing throughout the world, and they have a great influence on the ecosystem. Kuroshio Current is flowing in the waters around Japan. It is a north-flowing ocean current on the west side of the Pacific Ocean. Typically, in the west side of the ocean, the ocean current becomes stronger because it is pressed against the continent in a lagging rotation of the earth. This phenomenon is called westward intensification, Kuroshio current in the Pacific Ocean, and Gulf stream in the Atlantic Ocean (**Figure 4**). It is known that biodiversity in the sea is enhanced by westward intensification (Costello et al.,2010) (**Figure 5.a, Figure 5.b**), therefore a wide variety of marine products can be obtained in these geographic zones. CL31 is a group that can obtain a variety of seafood by benefiting of current.

In the southeast, there are lush tropical rainforests, in the southwest the snow-capped Himalayas, the north is near-frozen tundra, and dry deserts spread central and western China. Those led to very diverged edible species and very diversity of cuisine. There are actually eight different cooking styles corresponding to provinces, Anhui, Guangdong (Cantonese), Fujian, Hunan, Jiangsu, Shandong, Szechuan (or Sichuan) and Zheijang. Those are reflected by a rich tradition drawn from history and culture in their cuisines (Schinkel, 2013). Modern Japanese cuisine is the outcome of a tripod of Chinese, Western, and Japanese cuisine constructed in the early 20th century (Ceccarini, 2010).

After World War II, Japanese began absorbing some Western ways of life and continue to consume some of the high-calorie, high-fat foods featured in the American diet, including bread, ice cream, doughnuts, hamburgers, French fries and pizza. The difference between Japan and the US is size of cuisines, that is, "Japanese-sized, not American-sized," For instance, a regular size pizza in Japan has a diameter of about nine inches whereas, in the States, a twelve-inch pizza is a medium pizza. That means that a regular pizza in Japan is about 56% of the size of an American medium pizza. This situation can be interpreted by a Japanese proverb, "Hara hachibu", which means "stop eating when they are 80% full." Mexico, about a third of the size of the US, but it has highly diverged geographies, and deep history of food. Thus geographic zones having access to highly diverged species are clusterized in CL31. In Chinese medicine, disease has historically been associated with body constitution which is thought to be the result of both inherent and acquired factors and Constitution in Chinese Medicine Questionnarie (CCMQ) has been developed be Qi et al (2006) which has been utilized in Japan (Yanbo et al., 2008).

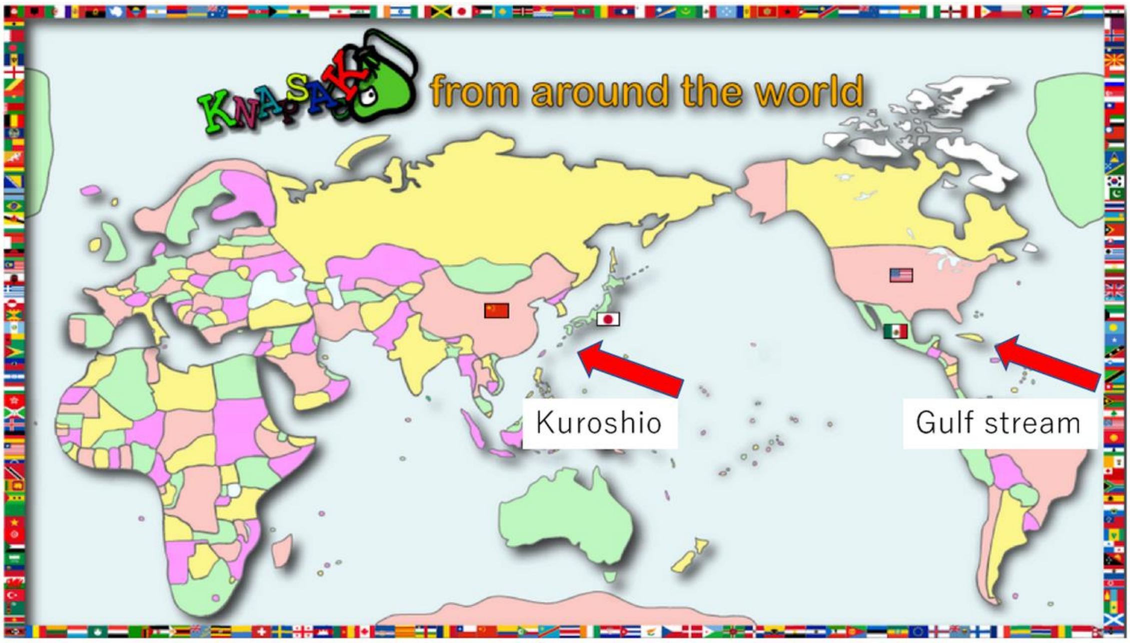

Figure 4. World map indicated westward intensification of big two currents in the world. Kuroshio current is in the Pacific Ocean, and Gulf stream is in the Atlantic Ocean.

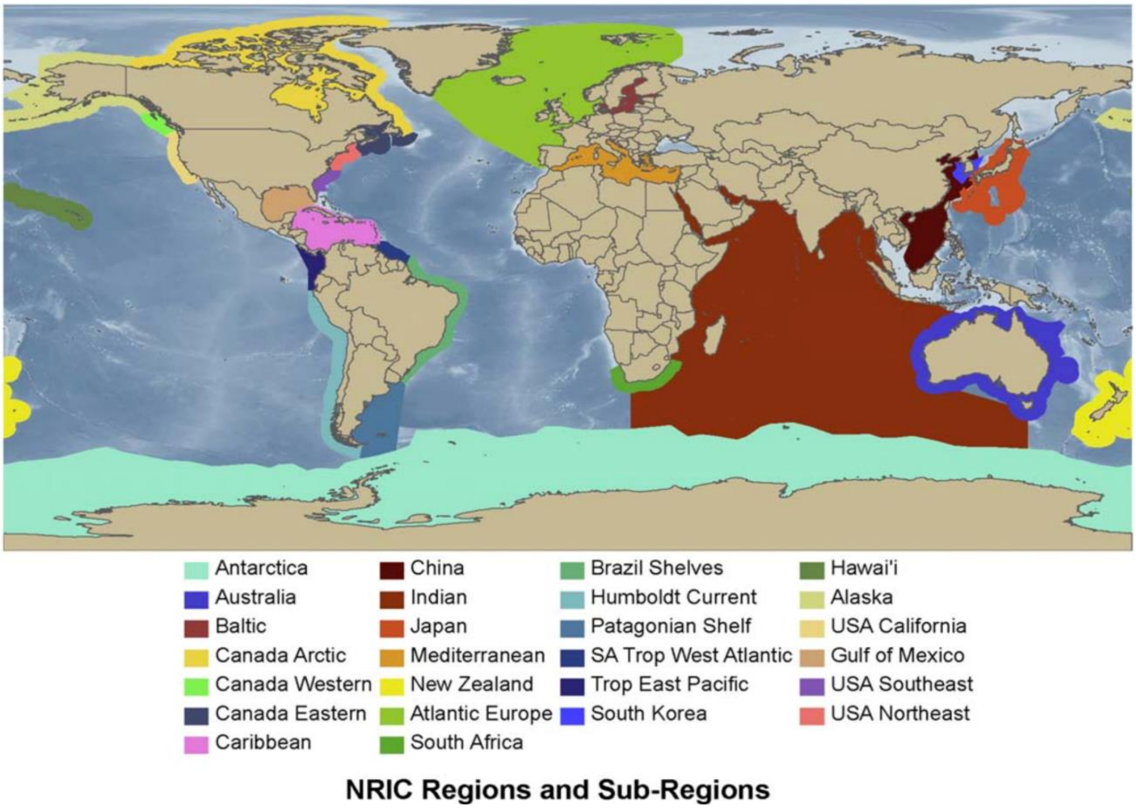

Figure 5.a The location of the geographic regions reviewed by the Census of Marine Life (collected from Costello et al., Census of Marine Biodiversity, 2010)

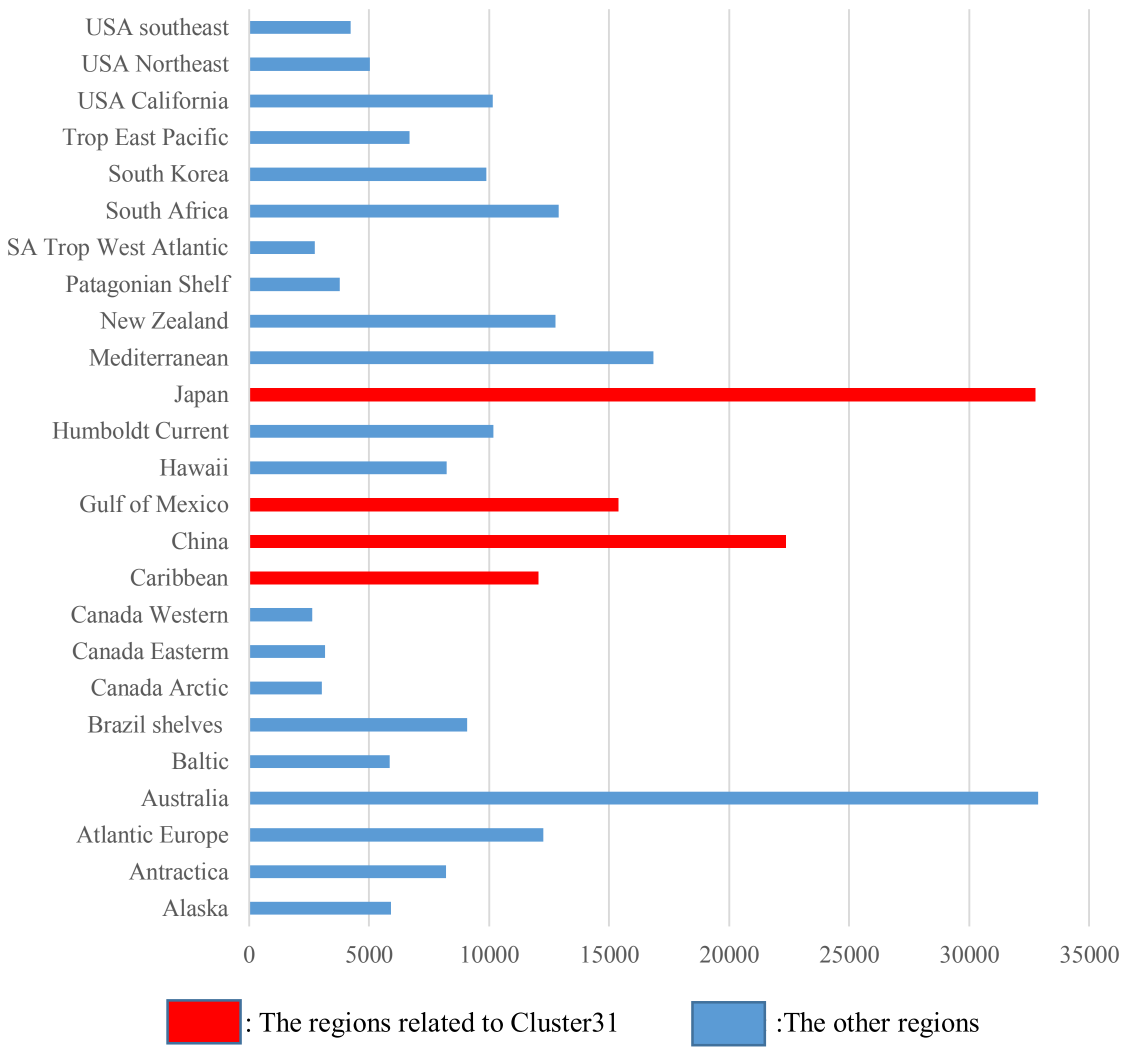

Figure 5.b Species number in each NRIC Region and Sub-Region (collected from Costello et al., Census of Marine Biodiversity, 2010)

Chapter 5
Conclusion Remarks and Perspectives

Diet and physical activities are the most important factors for sustainable society throughout human history. Human beings have adapted and disseminated to the environment on the earth after many years. Of course the food is also included in that environment, the local culture is formed by human beings' adaptation to the environment. That is, the environment included foods causes genetic diversity, as a result, it can be said that the region specificity on the present earth has occurred. And traditional foods also have been produced since long time ago based on accessibility of foods in individual area that is by taking ecology of individual area into consideration. As seen in examples of diet systems, we initially need to consider food accessibilities on the basis of climate and geographic properties to construct healthy food systems. Generally, traditional foods originated from animals and plants and fermented foods are associated with makeup of balanced diets in harmony with the original background of individual areas. In addition, for maintaining good health we also need to consider cardio respiratory exercise in slow pace such as, long time walking or Yoga exercise.

Prof. Klaus W. Lange launched International Movement and Nutrition Society (IMNS) at 2015. The purpose is to exchange researches in interdisciplinary fields for physical activities (Movement) and Diet (nutrition) to construct well-being society, which plays a central role in long-term health and illness. The IMNS website quotes that the International Movement and Nutrition Society is an association of scientists, clinicians, healthcare professionals and laypersons interested in the importance of nutrition and physical activity for health and disease.

IMNS should play an important role for accumulation of information through researches in cross-cultural communication and provide scientific information on promoting health by diets and physical exercise.

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Appendix

Appendix Figure A.1-A.28, Distribution of geographic regions in each CLs

Appendix Figure A.1, Distribution of geographic regions corresponding to Clusters 1-3.These clusters consist of Dominican Republic, Jamaica, Republic of Trinidad and Tobago, Bolivarian Republic of Venezuela, Aruba, Republic of Cuba, Puerto Rico, Curacao, United States Virgin Islands, Antigua and Barbuda, Barbados, Cayman Islands, Commonwealth of Dominica, Saint Christopher and Nevis, Saint Lucia, Montserrat, Saint Barthelemy, Commonwealth of The Bahamas, Republic of Haiti, and Saint Vincent and the Grenadines.

Appendix Figure A.2, Distribution of geographic regions corresponding to Clusters 4-5.These clusters consist of Arab Republic of Egypt, Hellenic Republic, Kingdom of Morocco, Republic of Turkey, State of Israel, Republic of Albania, Bosnia and Herzegovina, Republic of Cyprus, People's Democratic Republic of Algeria, Republic of Croatia, Republic of Lebanon, Principality of Monaco, Republic of Malta, Republic of Montenegro, Republic of Tunisia, Libyan Arab Jamahiriya, The west Bank and Gaza Strip, Syrian Arab Republic, and Republic of Slovenia.

Appendix Figure A.3, Distribution of geographic regions corresponding to Cluster 6. This cluster consists of Republic of Indonesia, Brunei Darussalam, Malaysia, Republic of the Philippines, Republic of Singapore, and The Democratic Republic of Timor-Leste.

Appendix Figure A.4, Distribution of geographic regions corresponding to Cluster 7. This cluster consists of Republic of Guatemala, Republic of Honduras, Republic of Nicaragua, Republic of Panama, and Republic of El Salvador.

Appendix Figure A.5, Distribution of geographic regions corresponding to Clusters 8. This cluster consists of Republic of Bolivia, French Guiana, Republic of Paraguay, Republic of Suriname, Oriental Republic of Uruguay, and Co-operative Republic of Guyana.

Appendix Figure A.6, Distribution of geographic regions corresponding to Cluster 9. This cluster consists of Guadeloupe and Martinique.

Appendix Figure A.7, Distribution of geographic regions corresponding to Cluster 10. This cluster consists of Republic of Colombia, Republic of Ecuador, and Republic of Peru.

Appendix Figure A.8, Distribution of geographic regions corresponding to Cluster 11. This cluster consists of Republic of Korea, Bermuda, Kingdom of the Netherlands, Taiwan, and Republic of Costa Rica.

Appendix Figure A.9, Distribution of geographic regions corresponding to Clusters 12-15. These clusters consist of Republic of Niger, Burkina Faso, Republic of Mali, Western Sahara, Republic of Guinea-Bissau, Republic of Liberia, Republic of Cote d'Ivoire, Republic of Ghana, Republic of Sierra Leone, Republic of Togo, Republic of The Gambia, Republic of Equatorial Guinea, Gabonese Republic, and Republic of Guinea.

Appendix Figure A.10, Distribution of geographic regions corresponding to Cluster 16. This cluster consists of Republic of Burundi, Democratic Republic of Congo, Republic of Mozambique, Republic of Uganda, Republic of Benin, Republic of Malawi, United Republic of Tanzania, Republic of Zambia, and Republic of Zimbabwe.

Appendix Figure A.11, Distribution of geographic regions corresponding to Cluster 17. This cluster consists of Kingdom of Cambodia, People's Republic of Bangladesh, Democratic Socialist Republic of Sri Lanka, Union of Myanmar, and Socialist Republic of Viet Nam.

Appendix Figure A.12, Distribution of geographic regions corresponding to Cluster 18. This cluster consists of Islamic Republic of Iran, Kingdom of Saudi Arabia, Islamic Republic of Afghanistan, Federal Democratic Republic of Ethiopia, Republic of Iraq, Republic of Mauritius, Faeroe Islands, New Caledonia, Republic of Madagascar, Republic of Seychelles, Antarctica, and British Indian Ocean Territory.

Appendix Figure A.13, Distribution of geographic regions corresponding to Cluster 19. This cluster consists of Republic of Angola, The Republic of the Sudan, Belize, Central African Republic, Republic of Cameroon, Republic of Senegal, and Republic of Congo.

Appendix Figure A.14, Distribution of geographic regions corresponding to Clusters 20-21. These clusters consist of American Samoa, Guam, Kingdom of Tonga, Republic of Vanuatu, Independent State of Samoa Cook Islands, Republic of the Marshall Islands, French Polynesia, Tokelau, Republic of the Fiji Islands, Federated States of Micronesia, and The Island of Hawaii.

Appendix Figure A.15, Distribution of geographic regions corresponding to Cluster 22-23. These clusters consist of Republic of Kiribati, Republic of Nauru, Republic of Botswana, Republic of Djibouti, Falkland Islands, Principality of Liechtenstein, Republic of Maldives, Northern Mariana Islands, Republic of Namibia, Niue, Pitcairn, Republic of Palau, Rodrigues Island, South Georgia and the South Sandwich Islands, St. Helena ex dep., Solomon Islands, Republic of Somaliland, Republic of San Marino, Somali Democratic Republic, Tuvalu, Wallis and Futuna, Grenada, Mongol Uls, and Democratic Republic of Sao Tome and Principe.

Appendix Figure A.16, Distribution of geographic regions corresponding to Cluster 24. This cluster consists of Spain, Republic of Italy, Federal Republic of Germany, French Republic, and United Kingdom of Great Britain and Northern Ireland.

Appendix Figure A.17, Distribution of geographic regions corresponding to Cluster 25. This cluster consists of Portuguese Republic, Republic of Armenia, Swiss Confederation, Hashemite Kingdom of Jordan, Kyrgyz Republic, and Republic of Poland.

Appendix Figure A.18, Distribution of geographic regions corresponding to Cluster 26. This cluster consists of Ireland, Kingdom of Denmark, Kingdom of Norway, Kingdom of Sweden, and Kingdom of Belgium.

Appendix Figure A.19, Distribution of geographic regions corresponding to Cluster 27. This cluster consist of Kingdom of Bhutan, State of Nepal, Islamic Republic of Pakistan, and Republic of India.

Appendix Figure A.20, Distribution of geographic regions corresponding to Cluster 28. This cluster consists of Federal Republic of Nigeria, Federative Republic of Brazil, Republic of Kenya, Lao People's Democratic Republic, Papua New Guinea, The Kingdom of Thailand, Republic of South Africa, Argentine Republic, Commonwealth of Australia, Republic of Chile, and New Zealand.

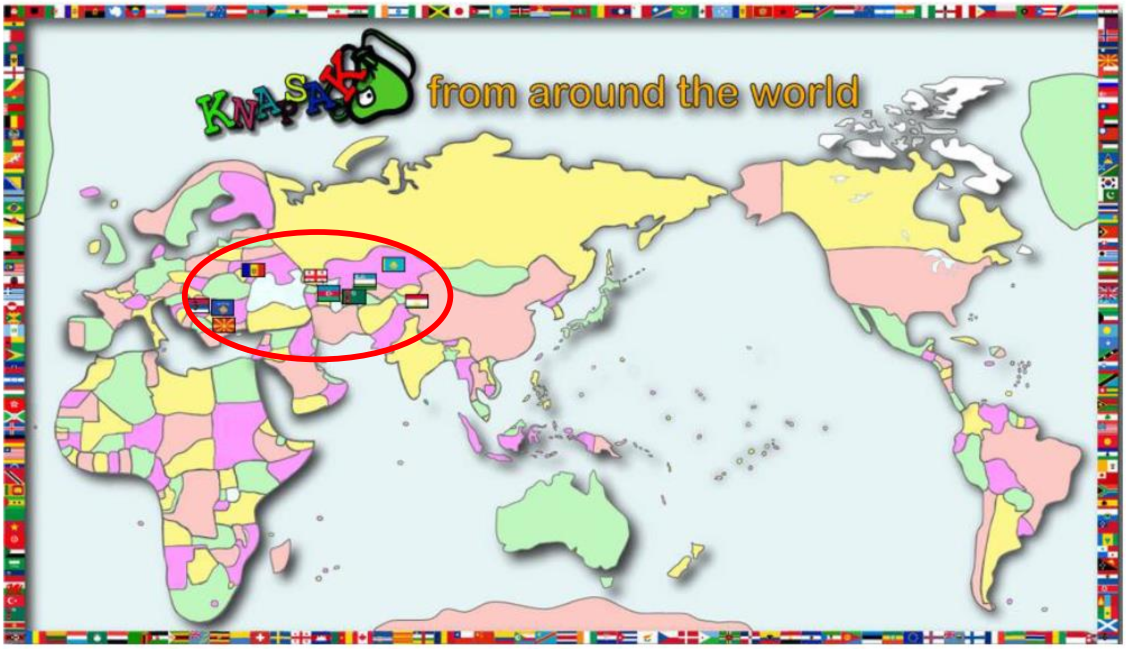
Appendix Figure A.21, Distribution of geographic regions corresponding to Cluster 29. This cluster consists of Republic of Bulgaria, Hong Kong Special Administrative Region, Russian Federation, and Ukraine.

Appendix Figure A.22, Distribution of geographic regions corresponding to Cluster 30. This cluster consists of Republic of Belarus, Czech Republic, and Republic of Estonia.

Appendix Figure A.23, Distribution of geographic regions corresponding to Cluster 31. This cluster consists of People's Republic of China, Japan, The United Mexican States, and United States of America.

Appendix Figure A.24, Distribution of geographic regions corresponding to Cluster 32. This cluster consists of Republic of Iceland, Greenland, State of Alaska, and Canada.

Appendix Figure A.25, Distribution of geographic regions corresponding to Clusters 33-34. These clusters consist of Republic of Austria, Slovak Republic, Grand Duchy of Luxembourg, Republic of Finland, Republic of Hungary, Republic of Lithuania, Republic of Latvia, and Romania.



Appendix Figure A.26, Distribution of geographic regions corresponding to Clusters 35-36. These clusters consist of Former Yugoslav Republic of Macedonia, Republic of Kosovo, Republic of Serbia, Republic of Azerbaijan, Georgia, Republic of Kazakhstan, Republic of Moldova, Republic of Tajikistan, Turkmenistan, and Republic of Uzbekistan.

Appendix Figure A.27, Distribution of geographic regions corresponding to Cluster 37. This cluster consists of Union of Comoros, Republic of Cape Verde, Kingdom of Lesotho, State of Qatar, and Republic of Rwanda.

Appendix Figure A.28, Distribution of geographic regions corresponding to Clusters 38-39. These clusters consist of State of Eritrea, Islamic Republic of Mauritania, Kingdom of Swaziland, Republic of Chad, United Arab Emirates, Kingdom of Bahrain, State of Kuwait, Sultanate of Oman, Democratic People's Republic of Korea, Reunion, and Republic of Yemen.