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Knowledge mapping of GMO/GMF research in social sphere

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Abstract: The document examined the intellectual development, evolution, and progress in the field of “Genetically Modified Food” (GMF) and “Genetically Modified Organisms” (GMO) by adopting the approach of bibliometric analysis. The total of 1,045 academic articles, 288 researchers, 204 journals and 15,744 references are covered during the current study. In term of identifying, defining, and bringing insight about the intellectual bases, research fronts, and the knowledge domain of GMO/GMF, the theoretical grounds are reviewed and future patterns are predicted. The current document studied articles, authors, keywords, institutions, countries, and journals who are actively participating in the knowledge area of GMO/GMF related studies under the sphere of WoS’s Social Science Citation Index. Moreover, the current study identified cluster-level evolution of the knowledge domain of GMO/GMF. The study concluded by arguing about the urge to address hotspots, which support the emerging trends as the future directional work in the research area.

Subjects: Agriculture and Food; Agriculture; Food Biotechnology

Keywords: genetically modified food; genetically modified organisms; bibliometric; biotechnology

1. Introduction
The revolutionary transformation of the world through technological innovations accentuate the need to analyze the acceptance and the perceived attitude of the consumers toward it. In the recent decades, the interdisciplinary researches is enormously observed to define and
answer the emerging complex problems, the interdisciplinary research encourages to view and elaborate the situation through the prism of multiple school of thoughts simultaneously. The brief synopsis of the diffusion of technological development as a process, highlights the decisional outcome which comprises of the factors like uncertainty avoidance, psychological beliefs, observability and testability of the innovation, and perceived cost associated with it.

The term Genetically Modified Organism (GMO) can be classified as the genetic engineering technique in the discipline of biotechnology, which manipulates the organism's genome to improve the organism(s) (Rabaey, 2016b). Specifically, in context of GMO/Genetically Modified Food (GMF), It can be further branded into transgenic and cisgenic modification (Blancke, Van Breusegem, De Jaeger, Braeckman, & Marc, 2015). In the commercial perspective, the GMO/GMF was introduced to improve the shelf life of edible products, improve yield and to maximize the benefits to the customers (Dizon et al., 2016). In the scientific terms, the GMO/GMF in terms of bio-engineering, can be alienated into three generations. First generation: to provide tolerance to deal with weed-killer chemicals and ability to survive in different climate conditions. Second generation: provides the enrichment of nutrition by improving the quality of the agricultural products.

The importance of effective communication strategy and policies reforms have already been discussed by to improve the acceptance of GMO/GMF by the different researches in the past (Frewer, Howard, & Shepherd, 1998; Hansen, Holm, Frewer, Robinson, & Peter, 2003; Lusk, 2003). On the other hand, different behavioral, socio-psychological dimensions are also been discussed to increase and improve the Willingness to Pay (WTP) and Willingness to Accept (WTA) (Huffman, Rousu, Shogren, & Tegene, 2007; Lusk, Roosen, & Bieberstein, 2014; Spence & Townsend, 2006; Steur et al., 2010).

In terms of the initiatives to study about the GMO/GMF knowledge structure, different scientists have studied the literature, that is, Costa-Font, Gil, and Bruce Traill (2008) studied the overview of 90 previously conducted studies in context of behavioral framework and suggested policies for GMO/GMF acceptance. Frewer et al. (2004) studied the social aspect by revisiting the controversies related to GMO/GMF. Frewer, Gupta, Giles, and Coles (2014) also studied the public perception about the nanotechnology in food industry. Nicolia, Manzo, Veronesi, and Rosellini (2013) studied the recent 10 years literature analysis about the safety aspect of GM foods. Zhang et al. (2016), studied the bibliometric study about GMF only, while covering the Social Science Citation Index (SSCI) and Science Citation Index - Expanded (SCI-E), and highlighted the importance of social concerns in the brief manner.

During the current course of study and through an overview of the existing literature reviews, it can be confidently concluded that the holistic view of the GMO/GMF literature under the hood of SSCI has not yet been studied to examine the evolution of social and behavioral aspect. The prime goal of the current document is only to study the GMO/GMF related publications under the umbrella of SSCI, as it will help to understand the intellectual structure of GMO/GMF studies in the explanatory style.

2. Methodology and data collection

In the academic discipline of library science and information management, the Bibliometric approach of data analysis includes the quantitative approach and statistical techniques to map and visualize the trends and information construction in the existing intellectual structure of knowledge domains (Budd, 1988; Fairthorne, 1969). The sole purpose is to extract the dominating literature in the form of methods, models, concepts, terms, and technology. In quantitative approach, the concepts of nodes and links usually used to define and understand the associations
and nature of the activity within the research field (Nerur, Rasheed, & Natarajan, 2008; White & Griffith, 1981). The resultant value from bibliometric quantitative study generates the list of dominating articles, authors, keywords, journals, and clusters of research areas within the intellectual structure (Narin, Olivastro, & Stevens, 1994). The findings from the bibliometric analysis helps reader to understand the pace and direction of evolution of the knowledge area within the specific time zone, creation and decaying of knowledge, themes, and research fronts (Hood & Wilson, 2001).

The cocitation in bibliometric analysis identifies the semantic resemblance to explain the relationships. It highlights the clusters of cocited references, by identifying the linking in the form of co-occurrence of two or more references in citing articles as a part of their reference list (Chen, Liu, Luo, Webber, & Chen, 2016; Chen, Song, Yuan, & Zhang, 2008). The higher frequency of citation explains the worthiness and importance of the article in the intellectual structure (Mustafee, Bessis, Taylor, & Sotiriadis, 2013; Shiau, 2015). The function of burst detection adopted the algorithm of Kleinberg, which was genuinely designed to detect single word’s burst (Chen, 2016, 2006). However, multi-word terms used in the time-series to detect bursts in the article cocitation analysis (Chen, 2006). The term “turning point” coined to address the issues of heterogeneity, nodes as visually salient, and to enhance the clarity of the network. It highlights the nodes with the sudden growth of citation, in the early timespan of publications and act like a bridge between the intellectual bases in the knowledge domains (Chen, 2004; Seyedghorban, Matanda, and LaPlaca 2016). Moreover, the codoc occurrence will be examined to analyses about keywords as it helps to understand the evolution of keywords within the intellectual structure of the knowledge domain. (Gu, Jingjing, Xingguo, & Liang, 2017; Lin, Wu, and Hong 2015)

The current bibliometric research of GMO/GMF was targeted to explore and examine the intellectual structure, dominating authors, key participants in the form of countries and institutions influence the academic literature and emerging research fronts. To achieve the prime goal, GMO/GMF-related literature were examined to list down the initial keywords. After the careful consideration, two keywords were selected for the current study. Namely, they were “genetically modified food” and “genetically modified organism.” The search query over the ISI’s Web of Science was executed. Specifically, the SSCI-based master list was focused as it provides the interdisciplinary view. The WoS provides indexing for citation, support pattern recognition, and helps to make graphical representations (Web of Science, 2016). The WoS is mostly preferred to conduct bibliometric studies has been observed in the previous studies (Feng, Zhang, Yuneng, & Wang, 2015; Lin, Wu, and Hong 2015; Merigó & Yang, 2016). Being to improve the collected data quality, all the authors of the current document individually analyze the information for each of the returned article from WoS’s SSCI search query. Specifically, the title, keywords, and abstract were examined for the relevancy of each result. From the initial search query result of 1,196 documents, the content in the form of reviews (84), proceedings (58), book reviews (30), editorial (22), book chapters (8), and other formats (8) were removed with the intentions to focus on scholarly articles only.

Bibliometric study of emergy (Chen et al., 2016), pharmaceutical R&D (Rafols et al., 2014), biotechnology (Dalpé, 2002), the environmental health in European perspective (Tarkowski, 2007), GMF-related study over SSCI, and SCI-expanded observed (Zhang et al., 2016). However, no bursts, turning points and cluster analysis of knowledge domain of GMO/GMF have never been extracted in the comprehensive manner.

CiteSpace-V as the data visualization tool will be adopted, where the following algorithms and principles to be followed while study any knowledge domain. (1) Decomposition of the large scale problem to the solvable smaller sections, which are easy to be conquered. (2) The high citation increases the probability of the article to be read and observed to be cited in the future studies. (3) To elaborate Social Network Analysis, Pathfinder network scaling will be used where the attributes will be considered as nodes. (4) Furthermore, the minimum spanning trees and clustering methods
are usually adopted where prim algorithm and EM clustering algorithm are commonly observed, respectively (Feng et al., 2015). The Java-based software package (CiteSpace) provides comprehensive tool to examine cocitation, coauthor, and coupling (Chen, 2016; Lin, Wu, and Hong 2015; Mustafee et al., 2013). Similarly, the coword analysis for the keywords, over the timescale provides better understanding of the growth and dynamics of intellectual structure of research domains (Chen, 2006; Chen et al., 2008). The unique features like centrality (between-ness) and burst analysis provides the comprehensive details about intellectual bases and research fronts, respectively (Chen, 2016; De-Marcos et al., 2016; Lin, Wu, and Hong 2015).

3. Results
The total 10 document types were observed in the initial outcome of the search query as discussed in the previous section. However only 1,045 academic articles were considered for the bibliometric analysis. Specifically, 15,744 references, 288 researchers, 204 journals observed to be participated in the academic literature of GMO and GMF under the umbrella of WoS’s Social Science Citation index for the last couple of decades. All academic articles published in seven different languages, however more than 96% (1014) literature published in English. The rest of the 4% included Spanish (8), German (6), French (5), Lithuanian (5), Portuguese (5), and polish (2). The language preference of researchers can be observed as individual’s preferences and the most of the SSCI-listed journals are comprised of the English journals. The publication trend can be observed to be fluctuated during the timeframe of world’s economic recession around the year 2008 as shown in Figure 1(a). Interestingly, almost 50% of the publications are accounted in the last 5 years. The citation count is holding steady growth which highlights the emerging trend in the research area of GMO/GMF in the social science studies as shown in Figure 1(b). In the further section of the analysis, the cocitation analysis of cited articles, journals, institutions, and the country will be observed. The cluster analysis of the GMO/GMF-related studies will also be studied to redefine the intellectual base of the academic literature. Moreover, the coword analysis of keywords will be highlighted to identify the research fronts and future directions.

Amongst the most actively participating journals in the literature of GMO/GMF in the recent couple of year, the Journal of Agricultural Environmental Ethics, Food Policy, and Public Understanding of Science are recorded top three journals with the count of 54, 39, and 31, respectively. Moreover, the list of top 10 most actively participated journals is listed in Table 1.

3.1. Cocited reference analysis in GMO/GMF intellectual structure
The publications cocitation exploration helps to understand the network and associations of cocited references (Yu and Xu 2016). It also helps to illustrate the intellectual edifice of the research area (Chen, 2006). In other words, the uniformity in the research trends and references can be examined.
through publication’s cocitation analysis (Chen, 2016). The high value of cocitation frequencies of any academic article indicates its prominent role in the development of the intellectual structure of the knowledge area (Chen, 2006; Chen et al., 2008). In the current study, to understand the GMO/GMF intellectual structure, 240 cited articles as nodes and 317 links are being examined to academic publication between the years 2000 and 2017. In the cocitation analysis by using CiteSpace for data visualization, each node can be considered as an article, journal and author etc. In the graphical output through the CiteSpace, size of the node represents the cumulative frequency, the density of the circle explains the count of cocitation observed over the decomposed timeframes. The different colors of the nodes, links, and edges explain the divisions and dispersion of intellectual bases in the intellectual structure (Chen, 2016). Moreover, the links explains the cocitation between nodes and the higher cocitation count represents by the thinness of the links in Figure 2.

Table 2 represents top 10 highly cocited articles in the intellectual structure of GMO/GMF studies. The article by Montserrat Costa-Font et al., (2008) with the title “Consumer acceptance, valuation of and attitudes towards genetically modified food: Review and implications for food policy” (51 citations) overviewed the 80 publications and collected the consumers based evidences about risk, trust, impact of individual attributes and factors affecting the objective and subjective knowledge, and concluded the explanatory process for GMF acceptance. Second most highly cocited
Table 2. Top 10 cocited articles in the knowledge domain of “GMO/GMF” between the years 2000 and 2017

| #  | Freq. | Author and Year | Title of the Article                                                                 | Source (Journal)                  |
|----|-------|-----------------|--------------------------------------------------------------------------------------|-----------------------------------|
| 1  | 51    | (Costa-Font et al., 2008) | Consumer acceptance, valuation of and attitudes toward genetically modified food: Review and implications for food policy | Food Policy                       |
| 2  | 42    | (Lusk et al., 2004) | Effect of information about benefits of biotechnology on consumer acceptance of genetically modified food: evidence from experimental auctions in the United | European Review of Agricultural Economics |
| 3  | 39    | (Lusk, Jamal, Kurlander, Roucan, & Taulman, 2005) | A Meta-Analysis of Genetically Modified Food Valuation Studies | Journal of Agricultural and Resource Economics |
| 4  | 34    | (Noussair & Ruffieux, 2004) | Do Consumers Really Refuse To Buy Genetically Modified Food?* | Economic Journal                   |
| 5  | 31    | (Noussair, Robin, & Ruffieux, 2002) | Do consumers not care about biotech foods or do they just not read the labels? | Economics Letters                  |
| 6  | 29    | (Gaskell et al., 2004) | GM Foods and the Misperception of Risk Perception | Risk Analysis                     |
| 7  | 28    | (Gaskell, Bauer, Durant, & Allum, 2000) | Worlds Apart? The Reception of Genetically Modified Foods in Europe and the U.S. | Science                           |
| 8  | 26    | (Chen and Li 2007) | The consumer’s attitude toward genetically modified foods in Taiwan | Food Quality and Preference        |
| 9  | 26    | (Bredahl, 2001) | Determinants of Consumer Attitudes and Purchase Intentions With Regard to Genetically Modified Foods— Results of a Cross-National Survey | Journal of Consumer Policy          |
| 10 | 25    | (Huffman et al., 2007) | The effects of prior beliefs and learning on consumers’ acceptance of genetically modified foods | Journal of Economic Behavior & Organization |

Table 3. Intellectual turning points in the knowledge domain of “GMO/GMF” between the years 2000 and 2017

| Centrality (Between-ness) | Frequency | Author and Year |
|---------------------------|-----------|-----------------|
| 0.65                      | 21        | (Scholderer & Frewer, 2003) |
| 0.55                      | 06        | (Frewer et al., 1998) |
| 0.36                      | 18        | (Christoph, Bruhn, & Roosen, 2008) |
| 0.36                      | 15        | (Hansen et al., 2003) |
| 0.31                      | 07        | (Levidow, Carr, & Wield, 2000) |
article is by Lusk et al. (2004) with the title “Effect of information about benefits of biotechnology on consumer acceptance of genetically modified food: evidence from experimental auctions in the United States, United Kingdom, and France” (42 Citations) studied the impact of information about benefits of biotechnology to increase customer acceptance, and observed that the location and type of information affects the response toward information. Another paper by Lusk et al. (2005) with the title “A Meta-Analysis of Genetically Modified Food Valuation Studies” (39 Citations) studied 25 studies to define and understand the willingness to pay (WTP) and willingness to Accept (WTA). The Noussair and Ruffieux’s (2004) with title “Do Consumers Really Refuse To Buy Genetically Modified Food?” ranked fourth with 34 Citations, studied the behavior toward WTP in France only and concluded the characteristics’ search, experience, and evidences affect WTP. On fifth place in highest cocited references is Noussair et al. (2002) with the title “Do consumers not care about biotech foods or do they just not read the labels?” (31 citation) examined EU population by performing experiment and concluded to have low awareness of GMO among consumers and mostly consumers not even notice about the labelling.

The sixth highly cocited reference in the intellectual structure is by George Gaskell et al., (2004) with the title “GM Foods and the Misperception of Risk Perception” (29 Citations) studied the risks and benefits analysis by using Eurobarometer and concluded that the most of the assumed risks are the misconception and strong risk communication strategies are needed. Seventh in the rank is Gaskell et al. (2000) with the title “Worlds Apart? The Reception of Genetically Modified Foods in Europe and the U.S.” (28 citations): observed while comparing perception of EU and US consumers through studying the media releases in the last decade (1984–96) and highlighted the challenges for industry and government to deal with. On the eighth place, Chen and Hsiao-Lan (2007) with title “The consumer’s attitude toward genetically modified foods in Taiwan” (26 Citations) mentions the positive influence of institutes to increase trust and acceptance of GMO/GMF. On the ninth place, Lone Bredahl’s (2001) with the title “Determinants of Consumer Attitudes and Purchase Intentions With Regard to Genetically Modified Foods—Results of a Cross-National Survey” (26 Citation) analyzed consumers from Denmark, Germany, Italy and United Kingdom and observed strong behavior toward GMO despite of lack of basic and actual experience. Interestingly, Italy observed with least negative behavior toward GMO. On the tenth place, Huffman et al. (2007) with the title “The effects of prior beliefs and learning on consumers’ acceptance of genetically modified foods’ (25 Citation) analyzed the factors affecting WTP for GMO/GMF and concluded that the positive influence of verifiably information affects to improve perceived value and to create favorable behavior of consumers.

3.1.1. Evolutionary articles in GMO/GMF intellectual structure
In the current subsection, the reference cocitation results examined to uncover the turning points which can be labelled as evolutionary articles in the intellectual structure of GMO/GMF research (Chen, 2004). The nodes can be classified as evolutionary articles they are observed to be have several links (Mustafee et al., 2013). In the (data visualization tool) CiteSpace, the purple circles as shown in Figure 2. The dominating nodes (references) indicates the high centrality and can be labelled as evolutional research articles. Moreover, evolutionary articles also act like the bridging connection between different intellectual bases (Chen, 2004).

In terms of centrality and high between-ness, the first document with 0.65 centrality observed by Scholderer and Frewer (2003) with the title “The Biotechnology Communication Paradox: Experimental Evidence and the Need for a New Strategy” highlighting the need of new risk communication model after conducting attitude change experiment in Denmark, Germany, Italy, and the United Kingdom. The second document with the centrality of 0.65 by Frewer et al. (1998) with the title “The influence of initial attitudes on responses to communication about genetic engineering in food production” also discussed the need and attention required by the governing authorities for improved communicate model to explain benefits and reduced risks in transgenic crops. The third document with high centrality (between-ness) is by Christoph et al. (2008) with the title “Knowledge, attitudes towards and acceptability of genetic modification in Germany” discussing
about GMF acceptability in Germany, the quantitative, factor analysis approach to create opinion clusters was observed and concluded that the GM for nonfood items is comparatively acceptable and appreciated. The fourth highly cocited reference with centrality of 0.36 is observed by Hansen et al. (2003) with the title “Beyond the knowledge deficit: recent research into lay and expert attitudes to food risks” discussing the importance to deal with consumer’s risks perception and communication. Moreover, highlighting the need of institutional level support to gain public trust and handling risks in the case of GMO/GMF. The fifth highest centrality (0.31) observed for Levidow, Wield, and Carr (2000) with the title “Genetically modified crops in the European Union: regulatory conflicts as precautionary opportunities” explaining the GMO/GMF’s adverse effect and attention to be required to precautionary level communication as it can reduce the future risks and misconceptions about GMO/GMF in European Union.

3.1.2. Article cocitation burst analysis in GMO/GMF intellectual structure
Through CiteSpace, the “Burst detection” mechanism helps to underline the trending nodes (keyword, article, author, and journal etc.), which can be labelled as “research fronts” (Chen, 2016, 2006). In terms of intellectual structure visualization, bursts define the notable nodes which can predict the future directions and emerging trends as shown in the Table 3 below. Moreover, the future oriented interdisciplinary vision can be proposed with the help of “Burst analysis.” Table 4 presents the top five highly cocited references bursts observed in the knowledge area of GMO/GMF between the years 2000 and 2017.

The highest burst of 14.47 is observed by Vilella-Vila and Costa-Font (2008) between the years 2010 and 2017 where they studied the possible effect of media issues and publications over the attitude of individual’s toward GMO/GMF adoption in Spain and United Kingdom over the time span of 6 years (1999–2004). The second highest burst value of 9.55 is recorded by Gaskell et al. (2000) between the years 2002 and 2007, discussing the public perception over the basis of press publication during the years 1984–1996 and the survey about public perception in 1996–97. As the primary findings, Gaskell emphasized the government and industry to participate in reducing perceived risks in GMO/GMF usage. The similar findings from the Huffman et al. (2007) scored 8.55 burst between the years 2010 and 2015, where they emphasize the need to involve third party to increase the trust and WTP among consumers, as the verifiable information increases the perceived value and change behavior of the consumers. Siegrist (2000) with burst value of 7.78 between the years 2004 and 2008 also discussed the supportive GMO/GMF adoption behavior in the presence of institutional trust as it reduces the perceived risks and increases the perceived benefits among Swiss consumers. The last article in Table 4 is with the burst value of 7.20 by Frewer et al. (1997) between the years 2002 and 2005. They discussed the public concerns, ethical aspect of risk and benefit analysis of GMO/GMF adoption in the context of United Kingdom. Interestingly, many of the intellectual bases and research fronts of GMO/GMF are extensively evolved only on basis of western research and experiments.

| Sr# | Author and Year                          | Strength | Begin | End   |
|-----|----------------------------------------|----------|-------|-------|
| 1   | (Vilella-Vila & Costa-Font, 2008)       | 14.7744  | 2010  | 2017  |
| 2   | (Gaskell et al., 2000)                  | 9.5523   | 2002  | 2007  |
| 3   | (Rousu, Shogren, Tegene, & Huffman, 2007) | 8.5789   | 2010  | 2015  |
| 4   | (Siegrist, 2000)                        | 7.7835   | 2004  | 2008  |
| 5   | (Frewer, Howard, & Shepherd, 1997)     | 7.2004   | 2002  | 2005  |
Out of 17 ongoing bursts in article cocitation analysis, a few of the recently observed are discussed in the current section. The article by Rodríguez-Entrena, Salazar-Ordóñez, and Sayadi (2013) with the burst of 3.41 started from the year 2015 is observed while adopting quantitative manner and explaining the moderating role of knowledge on GMF buying intentions. They highlight the need for an accurate consumer behavior profile for making effective and successful political strategy. Second ongoing burst value 2.94 is recorded by Nicolia et al. (2013) starting from the year 2015 analyzing the GM crops safety related research over the span of last 10 years and mentioning no significant hazard been recorded in the defined time period because of GM Crops. Furthermore, the research emphasizes toward the need of scientific information to increase favorable opinion of consumers toward GMO/GMF.

### 3.2. Keyword coword analysis

The co-occurrence of keywords analysis works to identify the changing trends in research under the knowledge domain (Li, Emily, & Hailin, 2017; Seyeghorban et al., 2016). Similarly, the growing dimensions can also be identified through keyword co-occurrence analysis, as it helps to identify developing concepts under the research domain (Chen, 2016; Wei, Grubesic, & Bishop, 2015). Table 5 is representing the most notifiable research concepts in terms of frequent, centrality, and by burst by examining 263 links and 1403 nodes. Specifically, the word “Biotechnology” is observed to be most occurring keyword with the frequency of 259 in the GMO/GMF knowledge domain. It is also being observed that the attitude, risk, information, and perception are also highly observed keywords. In terms of the centrality, benefits and labelling are observed to be the triggering keywords to direct new research dimensions as GMO/GMF intellectual structure. In terms of Burst, the risk is observed to be the most intensively used keyword during the time span of the years 2000–2003. On the other hand, Ethics is observed to be the most length burst from the years 2000–2008 with the strength of 5.6.

The timeline for the keywords co-occurrence analysis explains the timespan when the keyword appears for the first time, and trend to discuss the keyword become the fashion in the literature, it also explains when the attention toward the keywords start following the decreasing trend, and whether the keyword succeed to produce turning points in the literature (Chen, 2016). In Figure 3, it is clearly observable that keyword in the last 10 years haven’t succeed to make a dominating effect on the knowledge sphere of GMO/GMF studies.

The keywords, been discussed and initiated to be in used during the years 2000–2007 are still under the limelight and having the dominating effect on the literature. In other words, the keywords related to the article cocitation clusters evolved in the years 2010 and afterward with the cluster, that is, Gateway Belief Model, Knowledge Construction, Social movement haven’t succeeded to create dominating trend in the keywords co-occurrence.

### 3.3. Cluster analysis in GMO/GMF intellectual structure

CiteSpace group together cocited references on the basis of strong association among them as a cluster and differentiate them from other cocited references on the basis of weak association, and as the member of other clusters (Chen et al., 2008; Madani & Weber, 2016). The association used to highlight the actively researched areas in the knowledge domain and to predict the future trends and evolution of the intellectual structure (Chen, 2006; Madani & Weber, 2016). Figure 4 is

| Keyword          | Freq. | Keyword | Cent. | Keyword          | Burst |
|------------------|-------|---------|-------|------------------|-------|
| Biotechnology    | 259   | Food    | 0.12  | Risk             | 6.44  |
| Attitude         | 150   | Science | 0.11  | Health           | 6.17  |
| Risk             | 139   | Biotechnology | 0.10 | Genetically Modified Crops | 5.93 |
| Information      | 116   | Benefits | 0.09 | Biotechnology    | 5.91  |
| Perception       | 115   | Labeling | 0.09 | Uncertainty      | 5.71  |
representing the cluster analysis on the basis of cocitation analysis of the references in the intellectual structure of GMO/GMF during the years 2000–2017. Conceptually, the cluster analysis divides the cocited references into four groups of clusters as represented by using colors as marked in Figure 4. Namely, Group 1 comprised of the essence of social rights, risks, profitability, commercialization, and socio-scientific issues ( #3 Folic Acid Supplementation, #4 Food Production, #5 Social Representation). Group 2 holds consumer choices and attributes classifying the difference between GM and non-GM products ( #0 Public Opinion, #1 GM Food, #6 Consumer Acceptance, #7 Food Safety, #8 Food label). Group 3 contains more scientific perspectives of GMO/GMF debate in the social sciences ( #2 Transgenic Plant, #9 Bacillus Thuringiensis), and Group 4 is examining in terms of decision making and knowledge development ( #10 Gateway Belief Model, #12 Knowledge Construction, #13 Social movement). The overlapping parts of the groups represents the interdisciplinary trends in the research. For the further cluster analysis, the threshold for cluster size = < 15 will be marked and only top eight clusters will be discussed as mentioned in Table 6.

 #0 Public Opinion (cluster size 26) mostly holds European studies discussing about socio-economic factors to understand the WTA and WTP, arguing about high acceptance level of GM with medical nature, need to increase social trust, improve health and environment related expectations, and importance of objective knowledge to create better opinion (Connor & Siegrist, 2010; H De Steur et al., 2010). #1 GM Food (cluster size = 25) discussed the reasons of GMF/GMO controversies, and the factors which can differentiate GMF with non-GMF. Most of the researchers suggest to involve public value as a core part of GMF. Risk analysis is vital for its commercial success (Frewer et al., 2004; Spence & Townsend, 2006). #2 Transgenic Plants (cluster size = 21) highlighting the high rate of controversies observed with the increase of GM commercialization, and urging to focus toward the ethical context by dealing with socio-economic and socio-cultural factors. Moreover emphasizing the need to involve precautionary principles and to include GMO/GMF issues as a part of public policies (Myhr & Traavik, 2002; Pouteau, 2000). #3 Folic Acid Supplementation (cluster size = 20) includes most of the studies covering the consumer acceptance of folate, by studying about the risk, trust, WTP/WTA, and the economic perspective by measuring the productivity (Hans De Steur et al., 2013).
#4 Food production (cluster size 19), mentioning the customer as the critical stakeholder, and perceived perception of end-users toward recent development in food technologies. For holistic view, the cultural, environmental, animal welfare, public engagement, and the need of government strategies, policies, and regulations are being discussed and examined (Freewer et al., 2014; Lusk et al., 2014). #Social representation (cluster size 18) covers the perceived behavior and opinion of other stakeholders in the supply-chain network of GMO/GMF production and consumption, that is, by examining the people in production units of GMO/GMF, in the markets and in academic sphere (Bett et al., 2010; Sorgo & Dolinske, 2010). #Consumer acceptance (cluster size 16) explains the commercial success and factors affecting WTP/WTA and magnifying the behavior of demographic features of the society. Moreover, the regional level strategies to improve WTP/WTA are observed while examining the cluster (Grimsrud et al., 2004; Mucci et al., 2004). #Food safety (cluster size 15), also observed targeting demographics to understand the parameters to define value, individual’s preferences, concerns about GMO, and practices of labelling. Interesting trend of WTP to avoid GMO is also been observed in the food-safety cluster which directs toward new commercial value and potential research front (Burton et al., 2001; Subrahmanyan & Cheng, 2000).

3.4. Institutions cocitation network analysis n GMO/GMF intellectual structure
In order to understand the evolution of the academic literature, the mate-analysis provides differentiated view to understand the contributors and the key players in the evolution of the literature (Lin et al., 2015). In the institutional level analysis, 102 formal bodies in the form of nodes and 59 interinstitutional links in the academic world were studied through the CiteSpace. The list of highest contributors is presented in Table 7.

Wageningen University (Netherlands) with the count of 33 ranked 1st. National Institute for Agricultural Research (France) scored 2nd position with the publication count of 13, followed by Ghent University (Belgium) with 12, Iowa State University (United States) with 11, and University of Nottingham (United Kingdom) with 9 publications scored 3rd, 4th, and 5th position in the top five chart, respectively.
| Cluster ID | Label                  | Size | Silhouette | Mean (Mean) | Author (Year) Cited Reference | Author (Year) Title Citing Reference |
|------------|------------------------|------|------------|-------------|-------------------------------|-------------------------------------|
| 0          | Public Opinion         | 26   | 0.877      | 2004        | (Viella-Vila & Costa-Font, 2008) | (Connor & Siegrist, 2010)          |
|            |                        |      |            |             | (Frewer, Scholderer, & Bredahl, 2003) | (H De Steur et al., 2010)          |
| 1          | GM Food                | 25   | 0.933      | 2001        | (Gaskell et al., 2004)         | (Frewer et al., 2004)              |
|            |                        |      |            |             | (Siegrist, 2000)               | (Spence & Townsend, 2006)          |
| 2          | Transgenic Plant       | 21   | 0.884      | 1997        | (Gaskell, Bauer, et al., 2000)  | (Myhr & Traavik, 2002)             |
|            |                        |      |            |             | (Gaskell, Allum, et al., 2000)  | (Pouteau, 2000)                    |
| 3          | Folic Acid Supplementation | 20   | 0.929      | 2006        | (Lusk et al., 2004)            | (Steur, Feng, Xiaoping, & Gellynck, 2013) |
|            |                        |      |            |             | (Noussair & Ruffieux, 2004)     | (Kaye-Blake & Saunders, 2008)       |
| 4          | Food Production        | 19   | 0.931      | 2008        | (Siegist, Cousin, Kastenholz, & Wiek, 2007) | (Lusk et al., 2014)               |
|            |                        |      |            |             | (Frewer, Van Der, & Reinders, 2013) | (Frewer et al., 2014)              |
| 5          | Social Representation  | 18   | 0.912      | 2007        | (Christoph et al., 2008)       | (Luk et al., 2014)                 |
|            |                        |      |            |             | (Qaim, 2009)                   | (Frewer & Hug, 2010)               |
|            |                        |      |            |             |                                | (Sorgo & Dolinsek, 2010)           |
| 6          | Consumer Acceptance    | 16   | 0.923      | 2001        | (Bredahl, 2001)                | (Grimsrud, Mccluskey, Loureio, & Wahl, 2004) |
|            |                        |      |            |             | (Burton, Rigby, Young, & James, 2001) | (Mucci, Hough, & Ziliani, 2004)    |
| 7          | Food Safety            | 15   | 0.875      | 1998        | (Lusk et al., 2005)            | (Subrahmanyan & Cheng, 2000)       |
|            |                        |      |            |             | (Lusk, 2003)                   | (Burton et al., 2001)              |
As the result of low density, very rare trend of interinstitutional research is being observed and
the less centrality between-ness recorded. In other words, less-dominating role of institutions are
recorded while the intellectual research fields are concerned as shown in Figure 5. As a far as the
burst value are concerned, the Ghent University (4.25), National Institute for Agricultural Research
(4.24), University Illinois (3.97), and Iowa State University (3.07) which represents the institutional
strong growth in their citation for the certain timeframe during the last couple of decades as a part
of GMO/GMF intellectual structure. Moreover, these bursts are visible in the form of red-circles in
Figure 5.

Table 7. Top 5 most productive institutions in the knowledge area of GMO/GMF

| #  | Institute Name               | Location       | Specialized Area                                      | Since | Frequency |
|----|------------------------------|----------------|-------------------------------------------------------|-------|-----------|
| 1  | Wageningen University        | Netherland     | Healthy food and living environment                    | 2007  | 33        |
| 2  | National Institute for Agricultural Research | France | Agriculture, food, and the environment | 2000  | 13        |
| 3  | Ghent University             | Belgium        | Medicine, plant science, and microbiology             | 2011  | 12        |
| 4  | Iowa State University        | United States  | Bio-economy, agribusiness, and innovation             | 2003  | 11        |
| 5  | University of Nottingham    | United Kingdom | Sustainable societies, health and wellbeing, and transformative technologies | 2004  | 9         |

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Figure 5.

Figure 5. Institutions cocitation analysis of GMO/GMF.

![Figure 5. Institutions cocitation analysis of GMO/GMF.](image-url)
3.5. Countries citation analysis

During the last 17 years, the institutes from the United States have successfully published 331 academic papers. In the country’s ranking to have highest number of publications, United Kingdom and Canada can be noted as 2nd and 3rd by publishing 117 and 80 publications, respectively, as shown in Table 8. Interestingly, from the Asian region, its only P. R. China scored 8th position in the highest publication’s board by holding the count of 35. Apart from the United States, Canada and P. R. China, all the European countries marked their position in the top 10 publishing countries while studying the intellectual edifice of GMO/GMF-related studies.

In the current section, the most dominating academic articles from top three contributing countries will be highlighted. From the United States, the article by Daniel Sarewitz (2004) with the title “How science makes environmental controversies worse” noted with the cocitation count of 416. Specifically he discussed that how controversial topics like GMO are been used in the political context, how the perception about the values and risks can drive through political controversies. The second highest cocited article with the count of 241 from the country’s origin of United states observed by Doh and Guay (2006) with the title of “Corporate Social Responsibility, Public Policy, and NGO Activism in Europe and the United States: An Institutional-Stakeholder Perspective” studied the case of GMO while making the cross country overview about “Corporate social responsibility” practices on the basis of neo-institutional and stakeholder theories. The third most cocited article from the United States with the count of 146 by Lusk (2003) with the title “Effects Of Cheap Talk On Consumer Willingness-To-Pay For Golden Rice” concluded the negative impact of unfavorable discussion and talk about GMF produces less willingness of consumers to accept it. Among the publication from English origin, Alan Irwin’s (2013) with the cocitation count 276 and the publication title “The Politics of Talk: Coming to Terms with the ‘New’ Scientific Governance,” studied about the influence of “scientific studies” like GMO/GMF has the influence on the “public talk.” The second highly cocited paper from Britain is recorded as Gaskell et al.’s (2004) “GM Foods and the Misperception of Risk Perception” with the cocitation count of 139 which emphasized on importance of trust-worthy source for communication can improve the GMO/GMF adoption. Among the Canadians’ publications, the prominent study with the cocitation count of 45 is recorded by Satter, Gregory, Klain, Roberts, and Chan (2013) with the title of “Culture, intangibles and metrics in environmental management” discussing the importance and the significance of cultural knowledge while planning and making and decision regarding environmental management.

Table 8. Top 10 most-observed country in terms of frequency, centrality, and burst

| Country       | Freq. | Country     | Centrality | Country     | Burst  |
|---------------|-------|-------------|------------|-------------|--------|
| USA           | 331   | USA         | 0.44       | UNITED KINGDOM | 5.72   |
| UNITED KINGDOM | 117   | UNITED KINGDOM | 0.15      | BELGIUM    | 4.67   |
| CANADA        | 80    | CANADA      | 0.1        | PEOPLE'S R CHINA | 4.38   |
| NETHERLANDS  | 75    | SPAIN       | 0.1        | NEW ZEALAND | 4.27   |
| GERMANY       | 58    | NETHERLANDS | 0.09       | MALAYSIA   | 4.2    |
| FRANCE        | 49    | GERMANY     | 0.09       | FRANCE     | 4.12   |
| AUSTRALIA     | 49    | DENMARK     | 0.09       | JAPAN      | 3.56   |
| PEOPLE'S R CHINA | 35    | TURKEY      | 0.07       | SOUTH KOREA | 2.96   |
| ITALY         | 32    | FRANCE      | 0.05       | NORWAY     | 2.95   |
| SPAIN         | 31    | ITALY       | 0.04       |            |        |
The findings also suggest that the higher centrality of United States (0.44), United Kingdom (0.15), Canada (0.10), and Spain (0.10) proves their significant role in the development of intellectual bases in the literature of GMO/GMF. Interestingly, the countries with the highest cited burst represents the dominating role of the countries in research fronts in the intellectual edifice of GMO/GMF-related studies. Namely they are United Kingdom (5.27), Belgium (4.67), and P. R. China (4.38) as shown in Table 8.

3.6. Category
Based on the generated results from the search query from WoS’s SSCI database, and with the support of data visualization tool the 66 nodes and 111 links studied with the pathfinder pruning method and excluding “anonymous” title as the research category. In terms of frequency, the Business and Economics ranked 1st, with the citation count of 288. Its followed by Agriculture and Economics with the citation count of 252 and 245, respectively as shown in the Table 9 below. The pink rounded circle over the research category defines its importance in the intellectual structure of the academic literature as shown in Figure 7.

In the case of GMO/GMF the “History and Philosophy” and “Social Sciences” recorded as two prime intellectual bases in the literature of GMO/GMF with the observed centrality of 1.16 and 0.61, respectively. The highest positive change rate in the citation which represents with the red circles in Figure 7, is noted for “Science and Technology” and “Social Sciences” with the burst count of “7.20” and “6.64,” respectively.

| Category                        | Frequency | Starting Year | Burst | Centrality |
|---------------------------------|-----------|---------------|-------|------------|
| Business and economics          | 288       | 2000          | -     | 0.06       |
| Agriculture                     | 252       | 2000          | -     | 0.22       |
| Economics                       | 245       | 2000          | -     | -          |
| Agricultural economics          | 166       | 2001          | -     | 0.17       |
| Environmental science           | 150       | 2000          | -     | -          |

Figure 6. World’s dispersion of GMO/GMF literature.

Table 9. Dominating subject categories
3.7. Journal cocitation analysis in GMO/GMF intellectual structure

The social network analysis of journal's cocitation helps to reveal the discursive formation of the GMO/GMF's knowledge domain and to highlight the dominating journals and their contribution in the intellectual foundation of the research area (Chen et al., 2016; Seyedghorban et al., 2016). Through the analysis of 630 nodes and 3330 links, the highly cocited journals in terms of frequency are Science, Risk Analysis, AGBIFORUM, Food policy and American journal of Agricultural economy. Interestingly, among top 10 in terms of cocited journals only 2 journals were multidisciplinary, 2 were with the objectives to deal with economics, and 5 were specifically dealing with behavioral, social, and consumer orientation. The centrality in the (data visualization tool) Cite-Space, defines the turning points in the intellectual structure of the knowledge (Chen, 2004). While studying the centrality in the GMO/GMF studies, it can be concluded that the journals like American Behavioural Scientists and Risk Analysis are accounted as more influential in terms of generating transitional turns in the literature of GMO/GMF as discussed in Table 10.

It is vigorous to mention that the consumer's acceptance and perception are the dominating factors while defining intellectual fields in the literature of GMO/GMF. The high burst values of specific journal mention the role of journal in developing research fronts. The academic journals addressing the economic value of GMO/GMF are more prominent as research fronts. Almost all journals with high burst value are dealing with economic and technical aspect of GMO/GMF in the intellectual structure as shown in Table 10. Namely, the top three burst value holder journals are Plos ONE, The economic journal, and Biotechnology, respectively.

3.8. Author's cocitation analysis in GMO/GMF intellectual structure

The author's cocitation analysis helps to understand author's distance, relevancy of the studies, identification of research relationships among authors by observing the trend of citing together-ness (White & Griffith, 1981). To achieve one of the prime objective of the current study, the author's cocitation analyzed based on 288 network nodes and 415 links studied through the data visualization software as shown in Figure 8. The authors, with the high citation, and high centrality usually appears with the purple-rounded circles as shown in Figure 8. Specifically, the dominating authors in the findings can be concluded as the leading and valued authors in the GMO/GMF research space. Moreover, the red-rounded circles in the author's contribution highlights the high
rate of attention gained within the specific timespan during last couple of decades as shown in Figure 8. In terms of frequency, the George Gaskell, Lynn Frewer, and Jayson Lusk are having the highest frequency count of 234, 225, and 174, respectively.

Table 10. Analysis of cocited journals on the basis of frequency, burst and centrality

| #   | Journal Title                                      | Year | Research Area                                                                 | Freq. | IF   |
|-----|----------------------------------------------------|------|--------------------------------------------------------------------------------|-------|------|
|     | By Citation                                        |      |                                                                                 |       |      |
| 1   | Science (AAAS)                                     | 2000 | Multidisciplinary                                                               | 316   | 34.66|
| 2   | Risk Analysis                                      | 2000 | Society for Risk analysis                                                      | 306   | 2.22 |
| 3   | Food Policy                                        | 2004 | Policies for food sector in different economies                                 | 242   | 2.04 |
| 4   | American Journal of Agricultural Economy          | 2000 | Global economics of food, agriculture, rural and community development         | 240   | 1.44 |
| 5   | Nature                                             | 2000 | Multidisciplinary                                                               | 207   | 38.13|
|     | By Centrality                                      |      |                                                                                 |       |      |
| 1   | American Behavioral Scientist                      | 2000 | Contemporary issues in social and behavioral science                            | .56   | 1.90 |
| 2   | Risk Analysis                                      | 2000 | Society for Risk analysis                                                      | .51   | 2.22 |
| 4   | Food and Chemical Toxicology                       | 2002 | Study toxic effect of food, drugs and chemicals in live-bodies.                 | .39   | 3.58 |
| 4   | American Economic Review                           | 2000 | Applied economics, and empirical microeconomic issues                          | .38   | 3.83 |
| 5   | Agriculture and Human Values                       | 2000 | Addressing human value, food and agricultural issues in society                | .38   | 2.22 |
|     | By Bursts                                           |      |                                                                                 |       |      |
| 1   | Plos ONE (Public Library of Science)               | 2014 | Applications and research about science and medicine                            | 14.42 | 3.08 |
| 2   | The Economic Journal                               | 2001 | Mathematical economic theories and microeconomic factors                       | 12.68 | 2.37 |
| 3   | Biotechnology                                      | 1996 | Covering all aspects of biotechnology                                          | 11.53 |      |
| 4   | Land economics                                     | 2001 | In the relevance of public policies, focuses natural and environmental resources| 10.88 | 1.44 |
| 5   | New Biotechnology                                  | 2014 | Science and biotechnology over the spectrum of politics, business and economics | 10.16 | 3.20 |

Abbreviations: Freq. = Frequency, Cent. = Centrality, IF = Impact factor (Note: all recorded Impact factors are for the year 2015)
Further analysis of authors to produce transactional change in evolving literature by measuring centrality between-ness through CiteSpace, the authors Jayson Lusk (0.65), John A. List (0.36), and Matthew Rousu (0.34) are recorded as key authors as shown with the pink circles in Figure 8. Moreover, the highest burst value for Montserrat Costa-Font in the year 2010 (14.74) and Charles Noussair in the year 2002 (11.4) highlights their intensive citing trend in the intellectual structure of GMO/GMF studies.

4. Discussion and implications

Through the journal’s publication and cocitation analysis, the valuable and massive contribution of Journal of Agricultural Environmental Ethics, Food Policy, and Risk Analysis can be observed as shown in Table 1. However, the journals addressing economic value of GMO/GMF in terms of Land and Agriculture are currently observable at research fronts. It can be observed through the journal’s cocitation analysis that the technological aspect of GMO/GMF in the intellectual structure is one of the push factor to create new research fronts and turning points as shown in Table 10.

During the articles cocitation analysis, it is observed that the GMO/GMF intellectual structure is evolving as researchers are addressing consumer’s needs and perceived value in the strategic manner. The articles as turning point in the GMO/GMF knowledge sphere started from the public understanding and their concerns (Frewer et al., 1997; Miles & Frewer, 2001) and trust in information and institutions (Frewer, Howard, Hedderley, & Shepherd, 1996; Siegrist, 2000; Frewer et al., 1998) and currently heading toward the communication intentions to increase favorable opinion and acceptance in the form of WTP and WTA (Huffman et al., 2007; Lusk, Roosen, & Fox, 2003; Huffman, Shogren, Rousu, & Tegene, 2003). Similarly, the GMO/GMF studies as a knowledge sphere initially observed to be more focused toward scientific perspectives, experimental results (Bergelson & Purrington, 1998; Regal, 1994), which shifted toward political and regulatory aspects (Grove-White, Macnaghten, Mayer, & Wynne, 1997; Levidow et al., 2000), and currently the intellectual articles are directing toward more knowledge development and construct development of attitude of consumers in quantitative manner (Christoph et al., 2008; Gaskell et al., 2006; Scholderer & Frewer, 2003).
In the current study, the keyword co-occurrence analysis predicts the extensive attention to the emerging research areas, that is, “intentions” to use and consumer GMO/GMF, “decision making” and knowledge development for decision making, the effect of GMO/GMF on the environment and climate, and the “food security” are future topics of debates as these keywords are the recent burst keywords, which are having the continuing research till present date as predicted by the current bibliometric analysis.

During the cluster analysis of the intellectual structure, the following observations are being observed in each group. **Group 1:** The case studies are under the limelight to understand consumer’s perception regarding GM food production. Similarly, the social representation is gaining attention as it is appreciating to involve all stakeholders in the economic and commercial success of GMO/GMF. **Group 2:** Food safety related controversies are observed to trigger the research about GM food and other technologies, customer’s acceptance influencing factors for WTP and WTA. Currently, the GMO/GMF is recorded to be the global strategic issue and under the research as important factor of national security, public policy and governance. **Group 3:** The scientific examination of GMO/GMF advancements are observed to examine risks and uncertainties. However, almost all these scientific studies are observed to be triggered in the GMO/GMF intellectual structure for 20 years. **Group 4:** In the recent most development in the intellectual structure of GMO/GMF, the behavioral modelling and knowledge constructs are under review in the quantitative and qualitative manner which will lead to the emerging trend like the growing stems of GMO/GMF knowledge domain.

The less-dominating role of Brazil, Russia, India, China, and South Africa (BRICS) is the thought provoking element to be observed in the current study, only 2 publications with 6 citations from South Africa, 4 publications with 7 citations from India, 12 publications with 12 citations from Brazil, and 35 publications with 199 citations are recorded from P. R. China specifically observed, which comprises almost 70% of the future’s population of the world. Moreover, the international cooperation among countries are mostly visible between the America and the European countries. Similarly, the networking trend is also notable between America and Japan. The equal trend of Oceana’s cooperation with American and European countries can be observed as shown in Figure 6. However, comparatively less coordination of P. R. China and African region is observed while defining international cooperation for GMO/GMF related studies.

Interestingly, only 50 institutes recorded when the threshold of 3 was marked in the intellectual structure of GMO/GMF related studies. In terms of the institutional count based on continents, 26 among the top 50 are observed to be from North American region. European countries ranked 2nd by scoring 19. Alarmingly Oceanica countries, and Asia scored 4th and 1st, respectively. Moreover, the institutional level saturation still needs more time in the intellectual structure of GMO/GMF studies as almost 37 institutes out of 102 started to participate in the academic literature after the year 2011, which predicts more chances to observe interinstitutional diversification.

The interesting trends of English domination in the highly cocited authors can be concluded as almost 50% of the highly cocited authors are from the United Kingdom as shown in Table 11. The authors talking about the economic value in terms of agricultural and technological aspect are major driving researches in the intellectual structure of GMO/GMF (i.e., John A. List, Jayson Lusk, Les Bredahl, Wallace e. Huffman and Brian Wynne). The current study conclude that the Lynn Frewer ranked first in terms of producing relevant publication, as till the March, 2017. She has successful published 225 research documents which vastly discussing food safety, the social and consumer behavior toward factors formulating individual’s behavior toward willingness to buy, to eat and try edible products. On the second place, Jayson Lusk with the 167 count of publication is intensively discussing different aspects of agricultural economy. Although the publication count of Michael Siegrist is 187 but the notable documents relevant to the studies about GMO/GMF are around 60, which is the same as the publication count of George Gaskell. The author’s cocitation analysis conclude that the quantitative literature evolution is comparatively low. However, in recent couple
of years, the literature related to knowledge construction, intentions and models to WTP/WTA are started to be examined which can lead to more specified knowledge domain evolution.

The findings indicate the broadly defined disciplines like Social science are evolving in the specialized manner. For example, The Green and sustainable Science and Technology is emerged as a recent research front in the literature of GMO/GMF. Similarly, the psychological aspect in the bio-technological development is defined as a strong intellectual base in the recent years. It’s vital to be mentioned that the ethics related studies are frequently being studied. However, no ethical aspect is being observed in its top 10 charts in terms of centrality and burst in research categories’ analysis.

### 5. Conclusion and limitations

The current document, mapped the GMO/GMF research in the comprehensive manner over the basis of WoS’s SSCI publications between the years 2000 and 2017. The growth of the literature was seen in terms of publication and citation. The highly trending, influential and observable nodes in the form of authors, articles, keywords, categories, institutions, and regions were examined. By the support of this study, the intellectual structure of GMO/GMF reviewed in clear and depicted fashion. By the help of data visualization tool (CiteSpace), the analysis of the literature evolution of in the form of cluster analysis helped to understand the evolution of intellectual domain in multi-disciplinary view.

It can be easily concluded that the evolution of the intellectual domain of GMO/GMF is getting the critical input from the scientific, socio-political, economic, and humanitarian spheres of knowledge (Caplan, 2001; Krimsky, 2015). In the critical perspective, the economic drivers are dominating the ethical and social factors in the research evolution (Glasner, 2015; Robaey, 2016b). Although the institutions exist which are purposefully working to create sustainable and healthier environment for living, but they are still struggling to create collaborative work to create the shared value for the critical stakeholders. Authors are writing about the factors affecting GMO/GMF acceptance and awareness, even most of the authors are highlighting the need to create strategic communication model to increase trust and reduce perceived risk. However, very few number of authors took initiative to quantitatively measure the

| Sr# | Frequency | Author     | Research Content                                                                 | Relevant Publications | Associated Institute and Country          |
|-----|-----------|------------|----------------------------------------------------------------------------------|-----------------------|-------------------------------------------|
| 1   | 234       | George Gaskell | Beliefs and attitude, Society and science, social implications of bio-technology | 58                    | London School of Economics, United Kingdom |
| 2   | 225       | Lynn Frewer   | Food and society, Food safety and consumer behavior.                             | 225                   | Newcastle University, United kingdom      |
| 3   | 174       | Jayson Lusk   | Agricultural economics                                                           | 167                   | Oklahoma State University, United States   |
| 4   | 139       | Michael Siegrist | Consumer behavior                                                                | 59 (187)              | ETH Zürich, Switzerland                    |
| 5   | 137       | Paul Slovic   | Risk perception, Decision making, Behavioral and communication studies           | 39 (204)              | University of Oregon, United States        |

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intensions, decision making procedure, knowledge constructs, and the belief models of individuals toward GMO/GMF. The author's level alliances are obvious, as most of them are preferring to work in the cross-country comparisons. In the geographic perspective, the literature of GMO/GMF is entirely dominated by the studies from the west where only few countries are being studied to generalize the trends for the rest of the world. However, very limited number of researches addressed the issues of GMO/GMF in the developing nations. It is important to be mentioned that the world’s most of the population future is predicted to be in the developing countries. However, the authors, institutions and country level trends all are consistently focusing the WTA/WTP and intentions in the west region of the globe. Unfortunately, the limited count of publications recorded while proposing any comprehensive plan or action set to increase GMO/GMF acceptance in the quantified and measureable manner. As discussed in the beginning of the current section, the economic factors are creating the major push in the evolution of the GMO/GMF literature. However, the ethical, environmental, and safety related perspective is lesser in discussion while discussing as humanitarian and social responsibility (Yang & Chen, 2015; Frewer et al., 2006; Dizon et al., 2016; Grove-White et al., 1997; Robey, 2016a). To prove the domination of the economics forces in the GMO/GMF literature, it can also have been observed that most of the journals participating in the literature evolution are more of related to economics and commerce as shown in Table 10. In the future, GMO/GMF literature will be overlapping with the other disciplines, that is, National security (Aerni & Bernauer, 2006; Yang & Chen, 2015), Politics (Carroll, 2015; Clancy & Clancy, 2016; Sorgo & Dolinek, 2010), and Climate change if social scientist failed to pay more attention to the strategic problem of GMO/GMF rejection and avoidance in the more constructive and productive way.

5.1. Limitation
The current document can’t be labelled as flawless or limitations free. Firstly, the researchers selected the keywords like “Genetically Modified Food” and “Genetically Modified Organism.” From the current document, the new evolving terms are suggested, that is, nanotechnology and biotechnology, which can be considered to analyze in the future. Secondly, the document just cited high points (nodes) while studying authors, keywords, institutions, research papers, and country level analysis. Thirdly, the time span for SSCI studies included last 17 years. However, the GMO/GMF studies in the form of examining transgenic crops, benefits, and potential risks are also being observed to be published in the last decade of the last century.

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