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Work Sample

Nanobiotechnology Trends in Agriculture

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INTRODUCTION

Nanobiotechnology is an interdisciplinary mesh which involves several core scientific principles and applications in major areas of science and technology and it is prophesied to have tremendous potential to enhance the rapid developments in the biotechnological fields. Any particular invention of nanotechnology can have applications in as varied and as diverse fields of plasma physics and advanced medical surgery at the same time. The multifaceted nature of this technology and applications is providing new challenges in technology transfer and commercialization. In this paper we attempt to understand this multifaceted approach of nanotechnology in terms of technology as related to agriculture and analyze the overlaps in the patented technologies. The study analyses the Nanobiotechnology based patents as indicators of current trends in research and technology development. Finally a cross impact analysis was undertaken and a technology network established to study the interrelations of the technologies and their applications. The study also focuses on multidisciplinary nature of Nanobiotechnology and how the same may be used as a potent tool for patent commercialization in general and agriculture in particular. This study is aimed at presenting what more can be done with an existing or new patent portfolio using techno-legal patent data as indicators.

BACKGROUND

Nanobiotechnology center of Cornell University describes nanobiotechnology as “creating nanofabricated materials, structure and devices to examine and engage with biological systems on sub cellular and molecular levels”. The field of nanobiotechnology has not left any field unexplored and its applications have been speculated in almost all technology fields. Agriculture field is no exception to this and it is a strong belief that this sector will contribute significantly to agri- food sector and there by enhance food security. (Kalpana et al, 2009).

When looked at from an Indian prospective it is being speculated that nanobiotechnology can create same history as green revolution did back in 1960’s. Although this area is more of a science and less of a technology as of now, but the use of modern intellectual property management approaches like use of patents as trend indicators, technology mapping, technology trend

extrapolation can go a long way in contributing to the growth of agriculture using nanobiotechnology.

METHODOLOGY

The detailed process followed for the fulfillment of the objectives was divided into 5 main stages which are explained as follows:

1. Patent Collection
2. Patent Parsing
3. Text Mining
4. Technology Analysis
5. Clustering

These are explained below

PATENT COLLECTION AND PATENT PARSING

- The patents were searched in the areas of nanobiotechnology using a combination of keywords and patent classifications.
    - The patent classifications used for the purpose were USPC, ECLA, and IPC include USPC 977, IPC AO1N, IPC C12N
    - The key strings were based on 2 main concepts, they are:
        - Biotechnology
        - Nanotechnology
    - The concept of agriculture was not used as the one of the objectives was to link these core Nanobiotechnology patents with agriculture applications.
- As an end result of the search a list of **470** patents were taken
- These 470 patents were taken as a starting point for analysis for the next step.
- The databases used for search are USPTO, EPO, Patent Lens, Delphion.

TEXT MINING

This refers to the model that was made before processing the patents obtained after the search. This was needed to for drive the paper towards the fulfillment of objectives which include studying current impact of nanotechnology and biotechnology in agriculture and identification of niche areas.

In this case various search fields were identified for formulation of database queries. Individual patents were analyzed for Inventors, Dates and technology Indicators Chosen for Assessment. These indicators are explained as follows:

1. Sector of agriculture supply chain affected
2. Agriculture thematic area
3. Nano-research area
4. Possible agriculture applications
5. Biotechnology core area

PRINCIPLE BEHIND THESE INDICATORS

The life cycle of new and emerging technologies like nanotechnology typically progresses through identifiable patterns of scientific, technological and economic developments. There is a time lag between the three different stages and usually, the scientific push will precede the technology pull and market pull. Accordingly, the Research and Development (R&D) outputs of nanobiotechnology can be assessed and quantified by publications (for scientific performance), patents (for technological performance), and products in the market (for commercial presence).

We only intend to focus on patents are indicators for technology assessment and driving R&D activities in this study

MULTIDISCIPLINARY NATURE OF NANOTECHNOLOGY

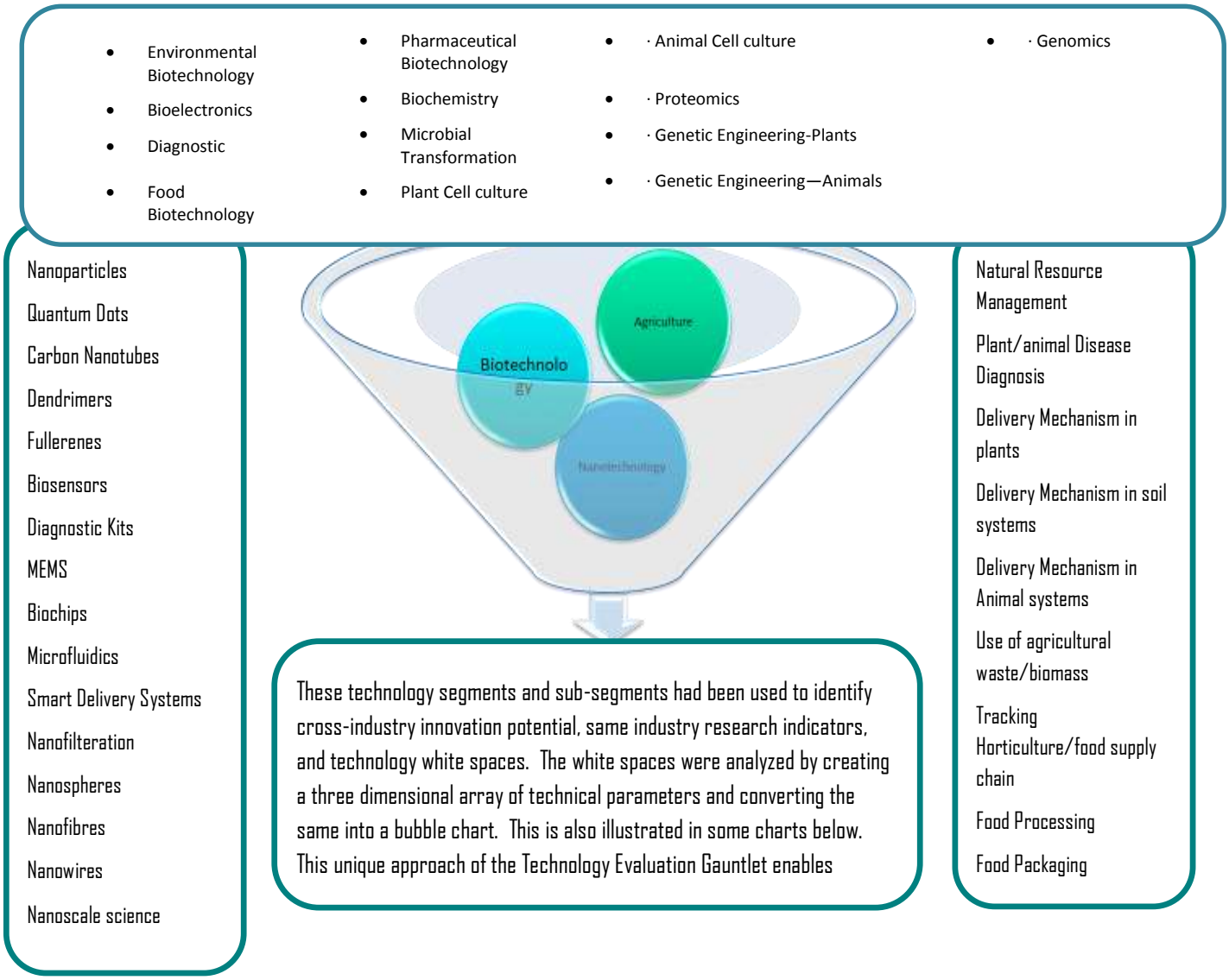
To study the multidisciplinary nature of nanotechnology as regarding agriculture it is important to understand the relationships among technologies. It is for this reason that we need to construct a taxonomy which could present a generalized and process based framework (Fig 1) to enable identification and characterization of the patents (which are

used as indicators), and map them to the different agricultural research theme areas through the filter of links in the agri-value chain is proposed. The framework also permits assessing the implications for technology transfer, and impacts on society and environment. The framework comprises:

(i) Identification of relevant nano research, biotechnology and agri research thematic areas (tables 2 -5),

(ii) Mapping the outputs of nano research areas to the agri-food research areas using the different links in the agricultural value chain as guides using database technologies.

Figure 1: The Model for mapping and mining patents



TECHNOLOGY ANALYSIS

Analysis was done based on text mining model and patents were classified based on IPC codes, and claims section of specification. The indicators for assessment described above were used as model to classify claimed applications and to understand the scope of the claims.

This technology Analysis also formed the basis for cluster development and trend analysis.

CLUSTERING

Technology Clusters were formed using key concepts across the 470 patents and 50 clusters were formed. Each of these 50 clusters were analyzed further for IPC similarities, claim coverage. Every technology cluster was subjected to detailed spider citation, and forward citation analysis for studying technology diffusion trends and finding cross industry innovation and commercialization aspects. For example, a technical cluster having 10 patents from different assignees but all center around preparing nanoparticles for making transgenic plants. Then, it helps us in looking for any technical spillovers, technology diffusions, patent licensing opportunities and the like. All technical clusters will be mentioned in results section below.

RESULTS AND DISCUSSION

The results present a multidimensional analysis involving the search fields of IPC, claims and Derwent manual codes, assignee and Publication dates. They also include the trends in Nanobiotechnology as pertaining to agriculture. All these are explained in different subsections as follows:

1. Trends in Nanobiotechnology R&D pertaining to agriculture based on patents as indicators
2. IPC analysis
3. Technology Cluster Analysis
4. Technology Diffusion

They are explained as follows:

TRENDS IN RESEARCH AND DEVELOPMENT USING PATENTS AS INDICATORS

Patents are generally referred to as indicators of research and development and patenting trends show the direction of research. Often for technologies it has been observed [citation needed] that patents are found as groups concentrating on a particular sector of that technology. Higher the number of patents in such a cluster higher will be the amount of research going on in that sector. This approach was the underlying principle of the trend analysis.

For studying trends in nanobiotechnology applications as pertaining to agriculture value chain can be studied easily by separately studying all indicators chosen for assessment. The trends shown by indicators chosen for assessment are as follows:

TRENDS IN AGRICULTURE THEMATIC AREAS:

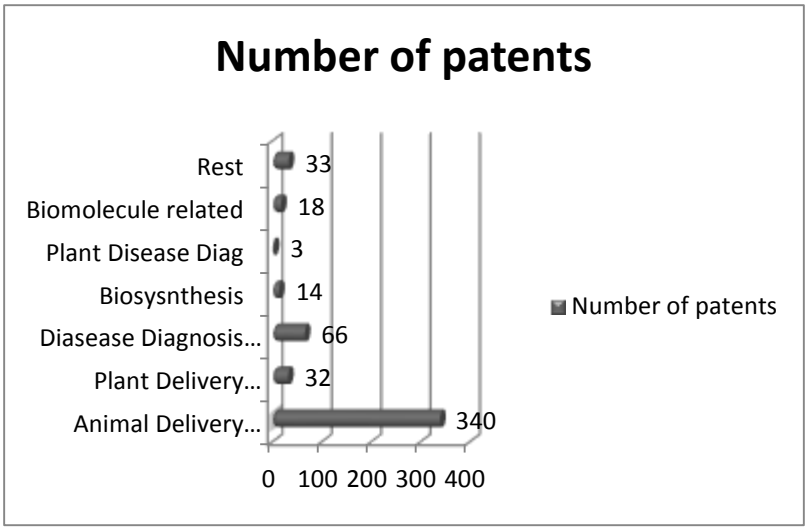


Figure 2: Trends observed in Agriculture Thematic Areas

TRENDS OBSERVED IN BIOTECHNOLOGY THEMATIC AREA

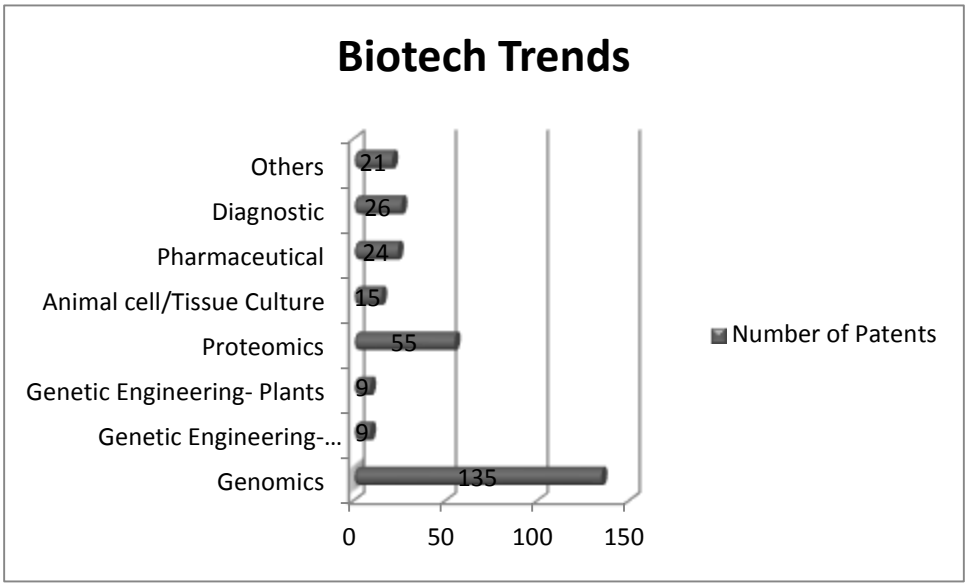


Figure 3: Trends observed in Biotechnology

NANOTECHNOLOGY TRENDS

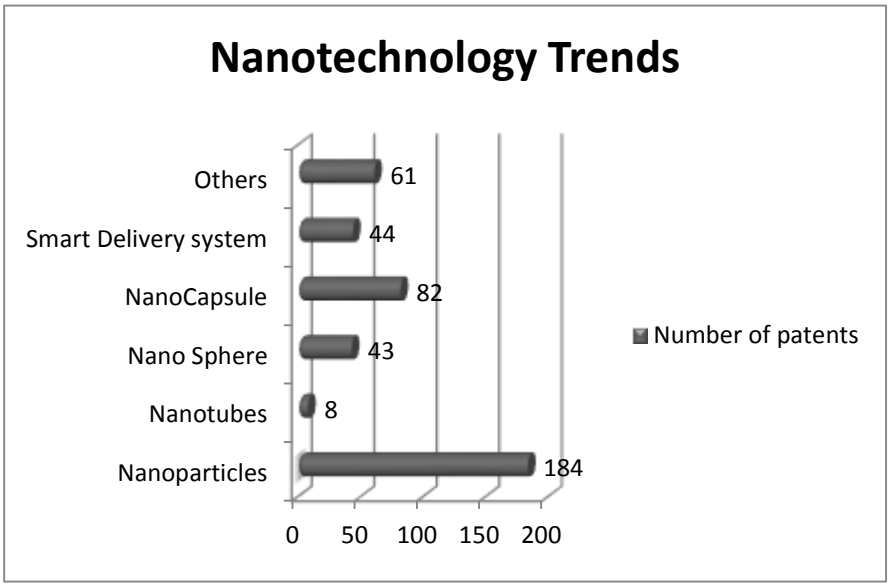


Figure 4: Nanotechnology Trends

TRENDS OBSERVED IN APPLICATION(S) INVOLVED

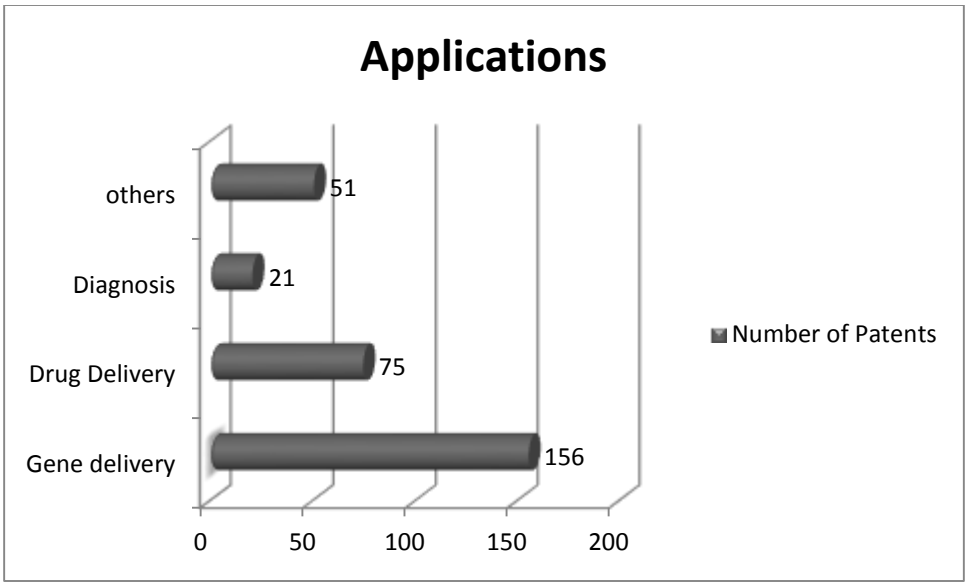


Figure 5: Application Trends

IPC ANALYSIS

International Patent Classification (IPC) consists of 8 classes each representing a different facet of technology. The classification of patent into a particular class depends on the type of technology involved. This approach had been useful for technologies that are not multifaceted like nanobiotechnology. An IPC analysis revealed that few patents pertaining to nanobiotechnology in agriculture were also classified elsewhere apart from normal class (A01N and C12N).

All patents that had been classified elsewhere (apart from normal class A01, were examined for cross industry potential and their citation charts were studied to provide conclusive evidence of cross industry commercialization potential) – THIS PART OF STUDY IS STILL UNDER CONFIDENTIALTY AGREEMENT AS CONCLUSIONS DRAWN COULD STILL BE USED AS INDICATORS FOR PATENT COMMERCIALIZATION BY A PERSON SKILLED IN ART

A representation of IPC analysis is shown as follows:

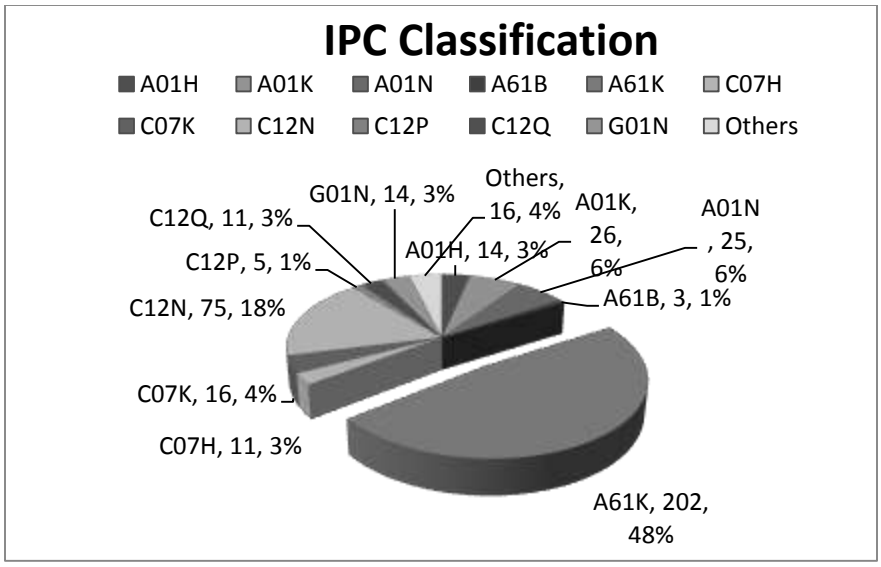


Figure 6: IPC Analysis: Most of the work is going on in therapeutics for animals.

TECHNOLOGY CLUSTER

Table 1: Technology Clusters

17 clusters out of 50 total are being presented in this work sample.

Cluster No.	Publications	Concepts of the cluster
1	31	Vaccines related to Nucleic Acids
2	27	Associated with expression, targeting, encoding, or modulation using antisense compounds for disease treatment
3	22	Polymer preparation for drug delivery
4	21	Polynucleotides use for diagnosis and treatment
5	20	Delivery system composition
6	18	Genetic intervention to improve cell culture
7	18	Nucleic Acid composition administration for therapeutic purpose
8	18	Gene delivery for disease treatment
9	17	Neutralizing antibodies
10	17	Pharmaceutical compositions comprising double-stranded ribonucleic acid
11	16	Nanoparticles for providing protein based treatment in cardiac disorders

12	13	Introducing transgenic organism with fatty acid, lipids.
13	13	Pre-trans-splicing molecule, trans-splicing, trans-splicing reaction for expression, mediation, invention, or vivo production of proteins
14	12	Polypeptides and polynucleotides for cancer treatment
15	12	Drug encapsulation using nanoparticles for cancer treatment
16	12	Adeno-associated vector composition for amelioration of symptoms, creation of transformed host cells
17	10	Preparing nanoparticles for making transgenic plants

Each of these clusters were further analyzed to provide technical spillover and patent license opportunities. THE SAME CAN'T BE INCLUDED IN THIS DOCUMENT DUE TO CONFIDENTIALITY AGREEMENT, AS THE INFORMATION HAS DIRECT COMMERCIAL POTENTIAL.

TECHNOLOGY DIFFUSION

As nanobiotechnology is a multifaceted field and so may not be very uncommon to find cross industry technology overlaps. These technology diffusion trends were studied using IPC codes, and patent citations in a 2 dimensional analysis. Patent citations are used as a source to trace the trajectory patterns of a technology. They provide an insight as to how different technologies evolve from established technologies and how all technologies are related to each other. Patent citation analysis can also be used to calculate quantitative evolution of a technology as it can be used to calculate the time lag between citations. Patent citations can also be a source for studying cross disciplinary nature of inventions. Normally 2 types of citation analysis are undertaken for studying patent citation patterns. They are:

1. Forward citation analysis
2. Spider search using lateral citations

Using both of these we were able to arrive at various conclusions that served dual purpose of pointing out research indicators for future research and identifying licensing opportunities. They cannot be presented here without breaking confidentiality agreement.

NANOPARTICLES – WHITE SPACE ANALYSIS BASED ON ABOVE FRAMEWORK

A remarkable array of new technologies, biotechnology, information technology, nanotechnology, etc, now exists that can be integrated into agricultural research and development to impact agricultural productivity, food and nutritional security and economic growth. Many of these emerging technologies are enabling technologies that can be extended across the agricultural and biotechnical value chain (from farm to plate and vice versa). The focus is on exploring the current technological innovations in nanotechnology, and understanding of their possible role in enhancing technology development using biotechnology in agriculture sector. The method is based on technology road mapping and database management concepts where it introduces the basic concepts of nanoscience through query based framework to map the potential of such technologies against the current gaps of knowledge in biotechnology and agriculture sectors for enhancing portfolio value, technical development and licensing opportunities. Using this framework, knowledge mapping of data from analysis of relevant set of literature and patents was done for used of NANOPARTICLES with possible applications in agriculture using biotechnology in this sector, either on stand-alone basis or in complementarily with the existing technologies.

Ariculture Theme Area	Genomics	Genetic Engineering-Animals	Genetic Engineering-Plants	Proteomics	Animal cell/Tissue Culture	Plant cell Culture	Transformation Using MO's	Biochemistry	Pharmaceutical	Diagnostic	Bioelectronics	Environmental	Food Biotech	Other
Natural Resource Management- Soil														
NRM- Water														
NRM- Energy														
Use of agri waste/biomass/biosynthesis														
Disease Diagnosis- plants											1			
Disease Diagnosis-Animals	11			5	1				1	19				
Delivery Mechanism in plant Systems	4	3	4	2				1						
Delivery Mechanism in Soil systems														
Delivery Mechanism in Animal systems	82	6	5	33	6			1	17	15				
Tracking Of Biomolecules	2				2	1				1				
Food Processing														
Food Packaging														
Bioindustrial Products				1										
Risk Assessment														
Ethical, legal, social implications														
Crop Improvement														
Livestock, Breeding and Improvement														
Policy														
Other														

The above chart directly indicates white spaces and occupied spaces with reference to use of nanoparticles along with various biotechnical processes in agriculture.

We have done similar analysis for in the same project.

NanoScale Phenomena and processes
Quantum Dots
Nanotubes/ Nanopipettes
Dendrimers
Fullerenes
Biosensors
Diagnostic Kits
MEMS/ Nanocantilevers
Biochips
Microfluidics
Smart delivery systems
Nanofilteration
Smart System integration
Environment, social, health, ethical implications
Education
Nanosphere
Nanofibres
Nanowires
Nanocapsules

Each of the above mentioned nanotechnology theme area was mapped with aforementioned agriculture theme areas, biotech theme areas and possible applications to give a holistic picture of technology diffusion trends and has helped in identifying many technology spillover and technology licensing opportunities.

DISCLAIMER

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