Potential Economic Impacts of Agri-Nanotechnology

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Plan of Presentation

- Introduction
- Potential for nanotechnology in agri-systems
- Agri-Food sector as business
  - Perspective of India
- Case discussion

Indian Agriculture – Recent Concerns

- Decline in growth of AGDP: 3.6% during 1985-95 to less than 2% in the decade 1995-05
- Particular areas of concern
  - Low productivity levels of food grains
  - Impact of climate change
  - Market risks
- Threatened food security, even with respect to its first component, food availability
- Steady decline in farm incomes and rural distress

Nanoscience to Nanotechnology

- Leads to creation of improved materials, devices and delivery systems at molecular level
- Set of technologies at nanometre scale and not a single technological field
- Application areas: Materials, Electronics, ptoelectronics, Medicine, Biotechnology, Measurements, anufacturing, Environment, Energy, **agriculture and food**.

NT- Potential for agri-food sector

- Projected applications for
  - pathogen and contaminant detection
  - identity preservation and tracking (e.g. providing information on the origin and movement of crops, livestock or agriculture products)
  - smart treatment delivery systems (e.g. miniature device implanted in livestock or crop variety, that can test for pathogen and or release treatment.
- But essential to examine if
  - Nanotechnology can potentially impact as an enabling technology

    complementing conventional technologies

Status of Indian Agriculture at Global Level

Largest Producer		2nd largest Producer	
• Fresh Fruit • Lemons /limes • Buffalo milk • Castor oil seed • Safflower seed • Sorghum • Millet • Spices • Okra • Jute • Bees-wax • Bananas • Mangoes • Guavas	• Pulses • Buffalo Meat • Fruit, tropical • Ginger • Chick peas • Areca nuts • Pigeon peas • Papayas • Chillies • Peppers • Fennel, coriander • Goat milk	• **Wheat** • **Rice** • **Vegetables** • **Sugar cane** • **Groundnuts with shell** • **Lentils** • **Garlic** • **Cauliflowers/ broccoli** • **Peas (green)** • **Sesame seed** • **Cashew nuts with shell** • **Silk-worm cocoons**	• Cow milk • Tea • Potatoes • Onions • Cotton lint • Cottonseed • Eggplants • Nutmeg, mace and cardamoms • Goat Meat • Cabbages and other brassicas • Pumpkins, squash & gourds

Source: FAO Stat, 2009

But

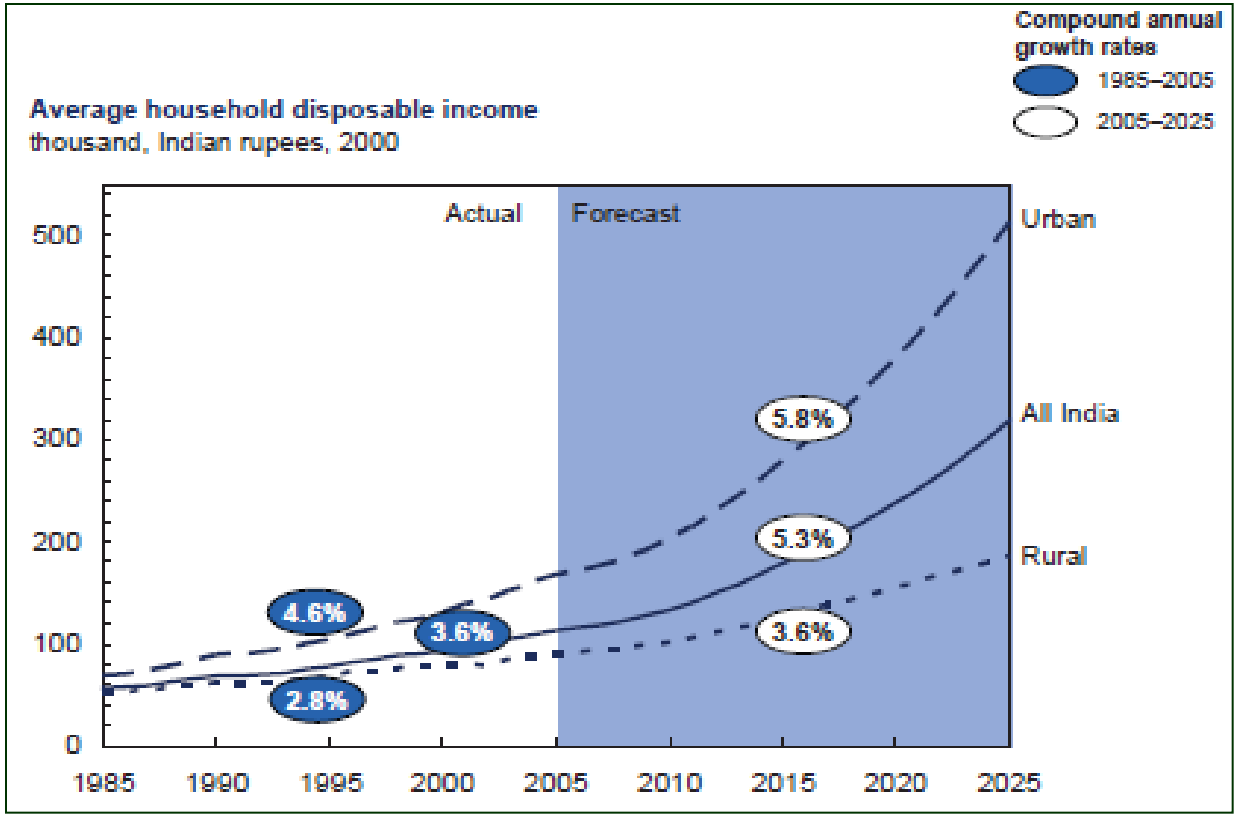
Indian food industry is of US $ 250 billion size, out of which **food processing industry size is US$ 110 billion.**

- ✓ Only 2.2% of total production processed, largely at small scale.
- ✓ Cold storage facility available for only 10% of produce
- ✓ The poor and weak linkage between farmers and markets, as well as, farmers and processing companies encouraged the involvement of middlemen leading price rise to the products.
- ✓ Milk processing in India is around 35%, of which the organized dairy industry account for 13% of the milk produced.
- ✓ Milk is processed and marketed by 170 Milk Producers' Cooperative Unions, which federate into 15 State Cooperative Milk Marketing Federations.

- Low processing
  - –2.20 % in fruits
  - –35 % in milk
  - –6 % in poultry
- Value addition – 20%
- Cost of wastage 6 times amount spent on food subsidy

Source: Ministry of Food Processing Industry, GoI; Task force Report on Development of cold chain in India – GOI/CII

Rising Household Incomes



Source: McKinsey Global Institute, 2007

Rising incomes will lift 291 million out of poverty and create 583 million strong middle class.

Share of household expenditure on food beverages would decline from 42% in 2005 to 34% in 2015 and 25% in 2025.

Food will remain the largest consumption category

Business Opportunities

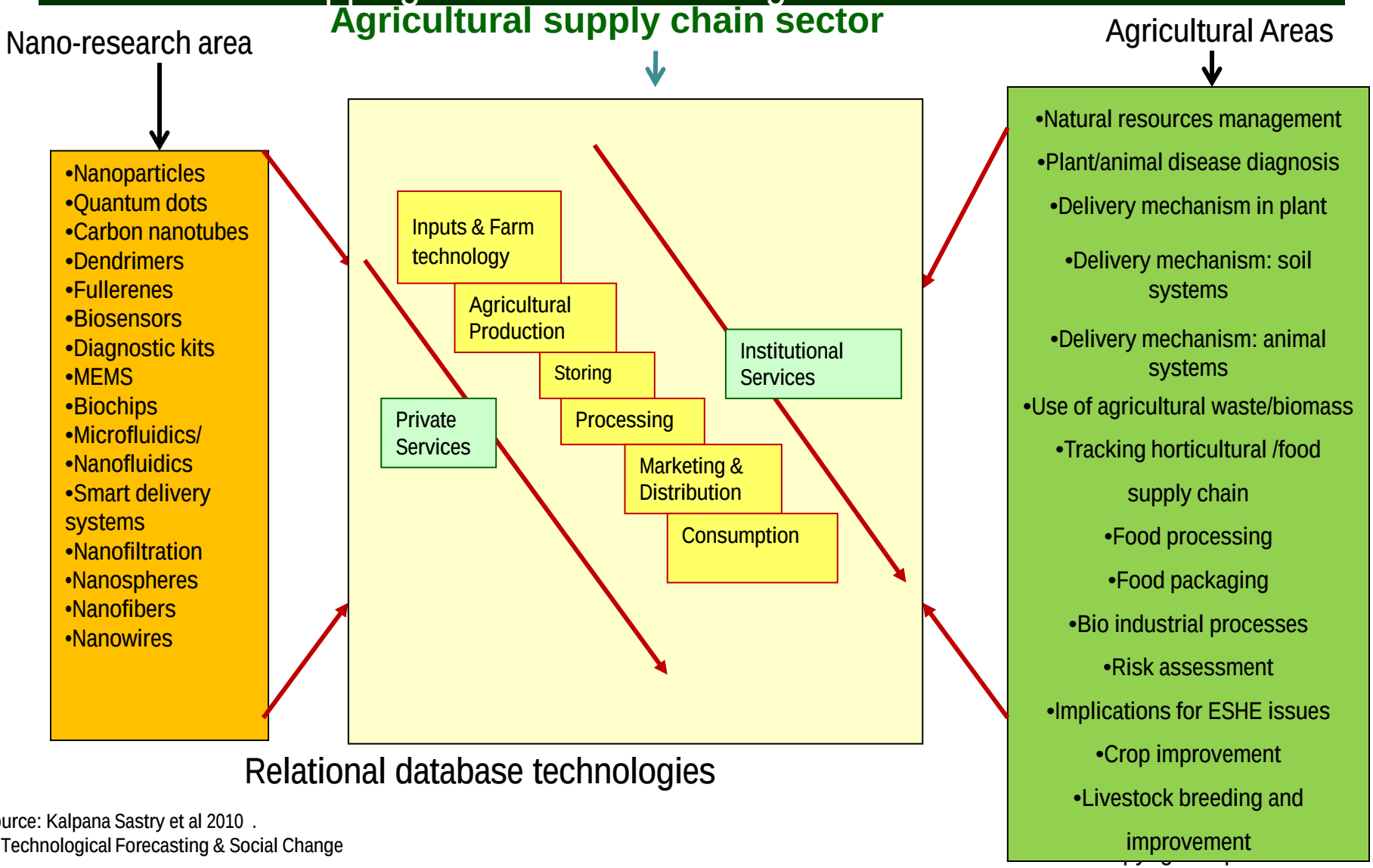
- Processed food (Specialty food, Energy foods, Nutri-based, etc.)
- Value chain innovation (Processing, packaging, retailing)
- Farmer-end (Productivity, quality - pre & post harvest, scale-neutral technologies)
- Quality certification and standardization
- Efficiency along the whole chain (Integration, coordination, infrastructure)

Players in Agribusiness India

- Reliance Retail
- ITC (Agribusiness Division)
- Bharti- Walmart
- Aditya Birla Retail
- Future group
- Tata Chemicals
- Mahindra ShubhLabh Services Ltd (MSSL)
- Parle agro Pvt ltd
- Nestle Dairy
- Britannia
- Godrej Agrovet
- Adani willmar (Fortune brand)
- Spencer (RPG)
- Metro- Cash & Carry
- SAB Miller

Framework Developed:

for mapping nanoresearch to agri-food thematic areas

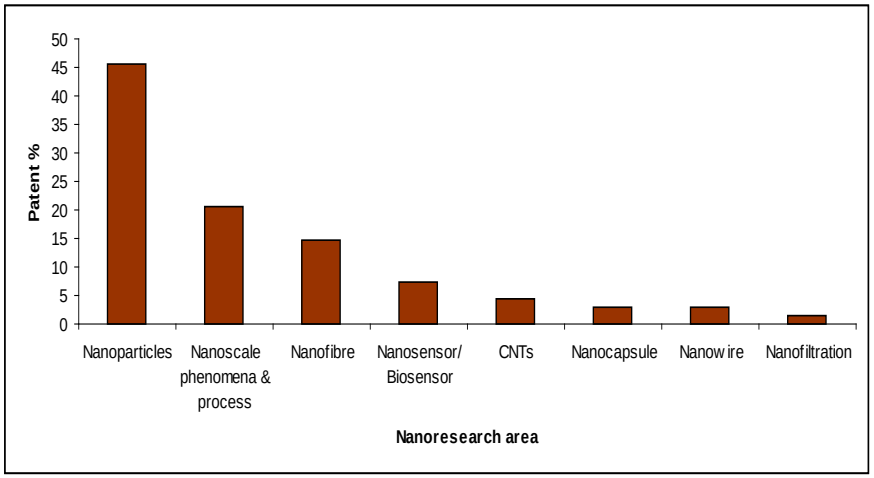


Source: Kalpana Sastry et al 2010 .
In:Technological Forecasting & Social Change

Basis

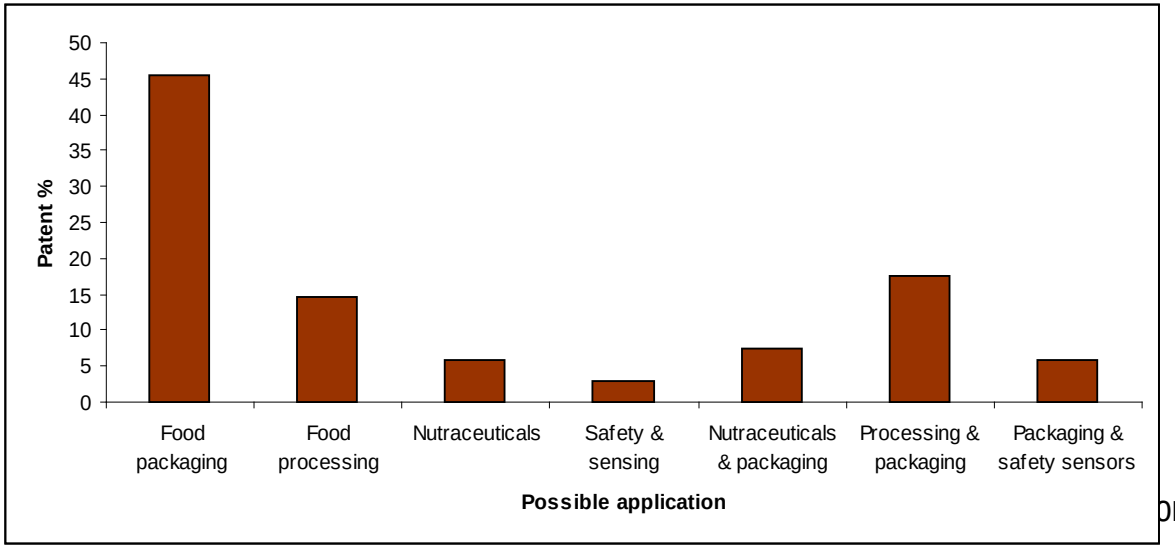
- New Technologies undergo typical patterns of scientific, technological and economic developments
- The scientific –push is prior to technology pull and market pull
- Essential to estimate output indicators
  - publications, (for scientific performance)
  - patents (as indicator for technological performance)
  - products in the market (as indicators for commercial presence)

Empirical Study-Patents



Nanoresearch area in food technology (n=69)

Possible application of nanotechnology in food sector (n=69)

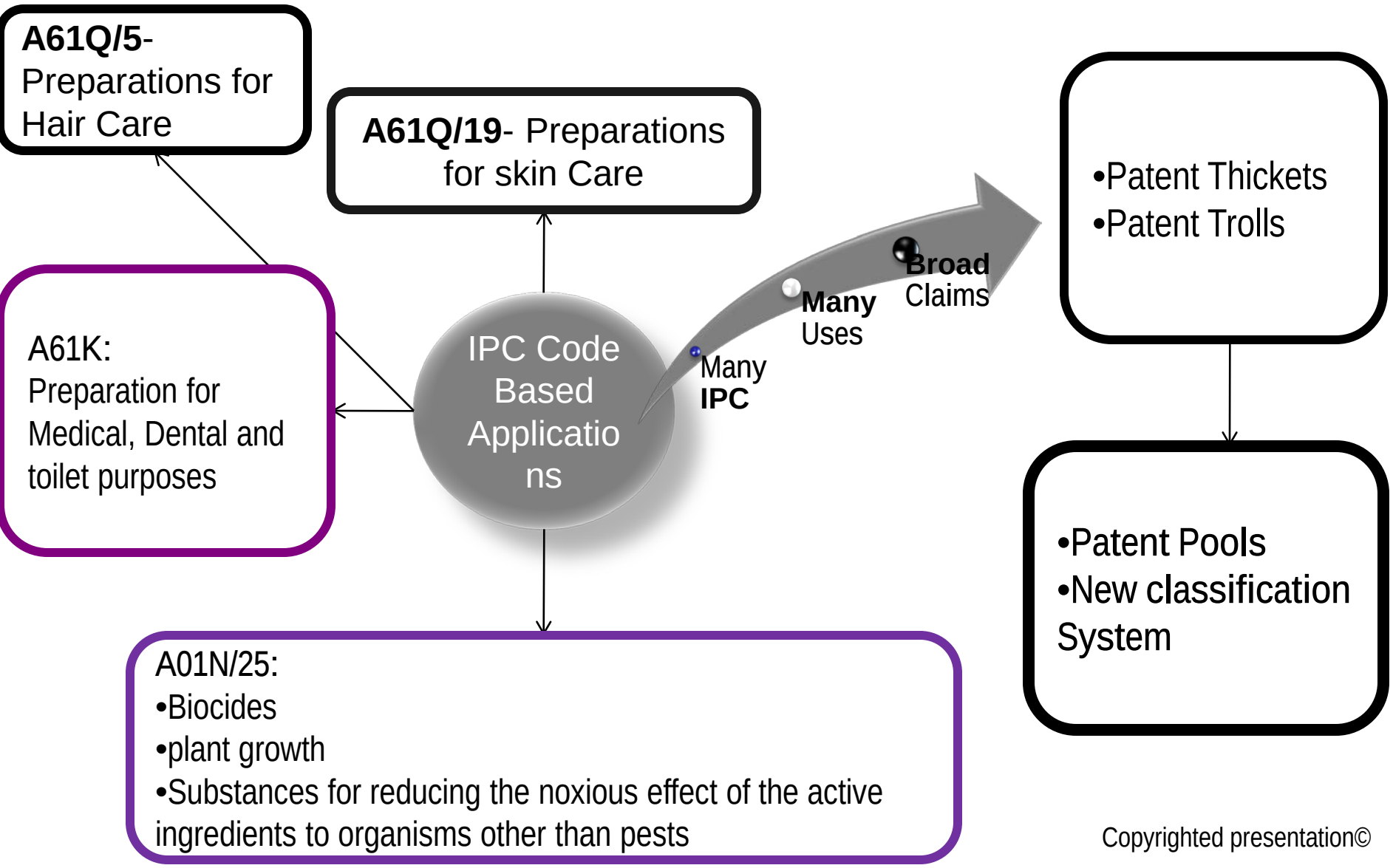


Trends in global market

- Various applications of NT
  - increased bioavailability and absorption of nutrients and health supplements, food packaging materials
  - with much improved mechanical, barrier, and antimicrobial properties, and nano-sensors
  - for traceability and monitoring the condition of food during transport and storage
- Wide application
- Anticipated that the global market for Nano-enabled Food & Beverage packaging
  - grows at a CAGR of 13% during 2009-2013

RNCOS .2011. At: http://www.nanotech-now.com/news.cgi?story_id=42522

Case Study : US20030108611A1US Based on ***IPC Class Codes***



Research Indicates

- Nanotechnology is an interdisciplinary field
- Demand on researchers an ability to interlink different knowledge domains
- Pervasive nature of technology throws challenges in search strategies of patent databases
- Intense patent filing activity for technologies
  - which have applications extendable to the agriculture value chain
- IP litigation can expected to emerge
  - Complexities seen earlier in agricultural biotechnologies may assume even a higher level in this field
  - Patent thickets can hinder the transfer; patent pools/patent commons may need to be developed

Source: Kalpana Sastry, et al.. Intellectual Property Landscape for Application of Agri-Nanotechnologies in India. Accepted Paper. in press

Nanotech Water Purifier

- Built around a bulb-like water purifier made
  - of natural rice husk ash and nano-silver particles,
  - designed for convenience and affordability
  - purifies a litre of water at 10paise
- Once the purification power of the bulb gets exhausted
  - (after around 3,000 litres), it stops functioning
- Tata Swach Lock designed
  - to safeguard customers from counterfeit products
- Around 14 patents have been filed
- Its performance capabilities [as per USEPA standards]

TATA Swach®

Source: http://www.tatachemicals.com/products/tata_swach.htm

Business Model

- Huge market
- Product helps reduce water-borne illnesses
  - for people who use surface water for drinking.
- can provide a family of five- drinking water for a year.
- Paddy husk ash used traditionally for tooth washing
  - India produces about 20 million tons of it a year.
- The filter was created in a Tata Consultancy Services lab,
  - the silver nanotechnology was added on by Tata Chemicals and Titan, made the precision machine tools to manufacture the filter
- Distribution networks of Rallis, Tata's agrochemical subsidiary with over 30,000 retailers in rural India
  - and Tata Kisan Sansar, a farm services business run by Tata Chemicals, which reaches 2.5 million farmers.
- Initial production will be 1 million units a year, with a planned ramp-up to 3 million units annually within 5 years

Agri-nanotechnologies

- At this point innovations are early-stage researches with
  - applications across the agri sector,
- Since patents are the immediate and direct outputs from research, filings for these would be a first step taken by most technology developers.
- It is probably too early to expect all types of IPs at this point
- Assembling other IPs like trade marks, copyrights etc in the portfolio for commercialization would follow
  - as the technology advances into the market and the later stages of product development processes set in

Also

- Assets like know-how or trade secrets, on inventions related to nanobiotechnologies expected to play a major role in very near future as research into nanobiotechnology advances.
- It is essential that researchers and other institutions be equipped
  - with sound knowledge of drafting and executing material transfer agreements (MTAs), confidentiality and licensing agreements while using agri-nanotechnology based products.
- Developing open access models, or encouraging use of propriety ownerships on humanitarian licensing models, can form part of technology transfer models
  - to minimize the complications on access to technologies contributing for food production,
  - through stakeholder discussions
  - negotiations from an early-stage of the development process.

Suggest

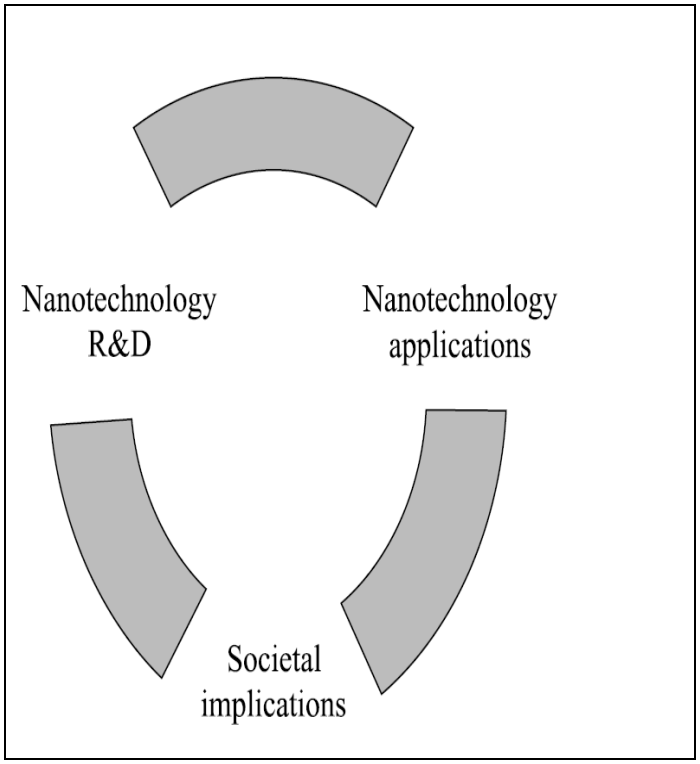
- Transfer processes of NT in this sector against the patent portfolios may need to be well understood and *policies developed before* the commercialization cycles are put in
- Complex technology transfer would need sound governance policies to address the expected and unexpected complications
- Developing open access models or encouraging use of propriety ownerships on humanitarian licensing models
- Minimizing the complications on technologies through stakeholder discussions from early-stage levels

Environmental, Social and Ethical Issues

- Environment and health risks
  - small size and large surface allow easy dispersion and bonding in environment and with human tissues
- Risks to farmers
  - handling of nanofertilizers and pesticides by millions of small farmers can lead to health risks
- Soil and water pollution
  - fertilizers and pesticides enhanced with nanomaterials can disperse into soil, water and atmosphere; nanoparticles can also bond more strongly with pollutants and transport them through soil and water
- Social risk
  - impacts on livelihoods of high cost technologies; access to technologies as most research is in private sector

ELHS Approach

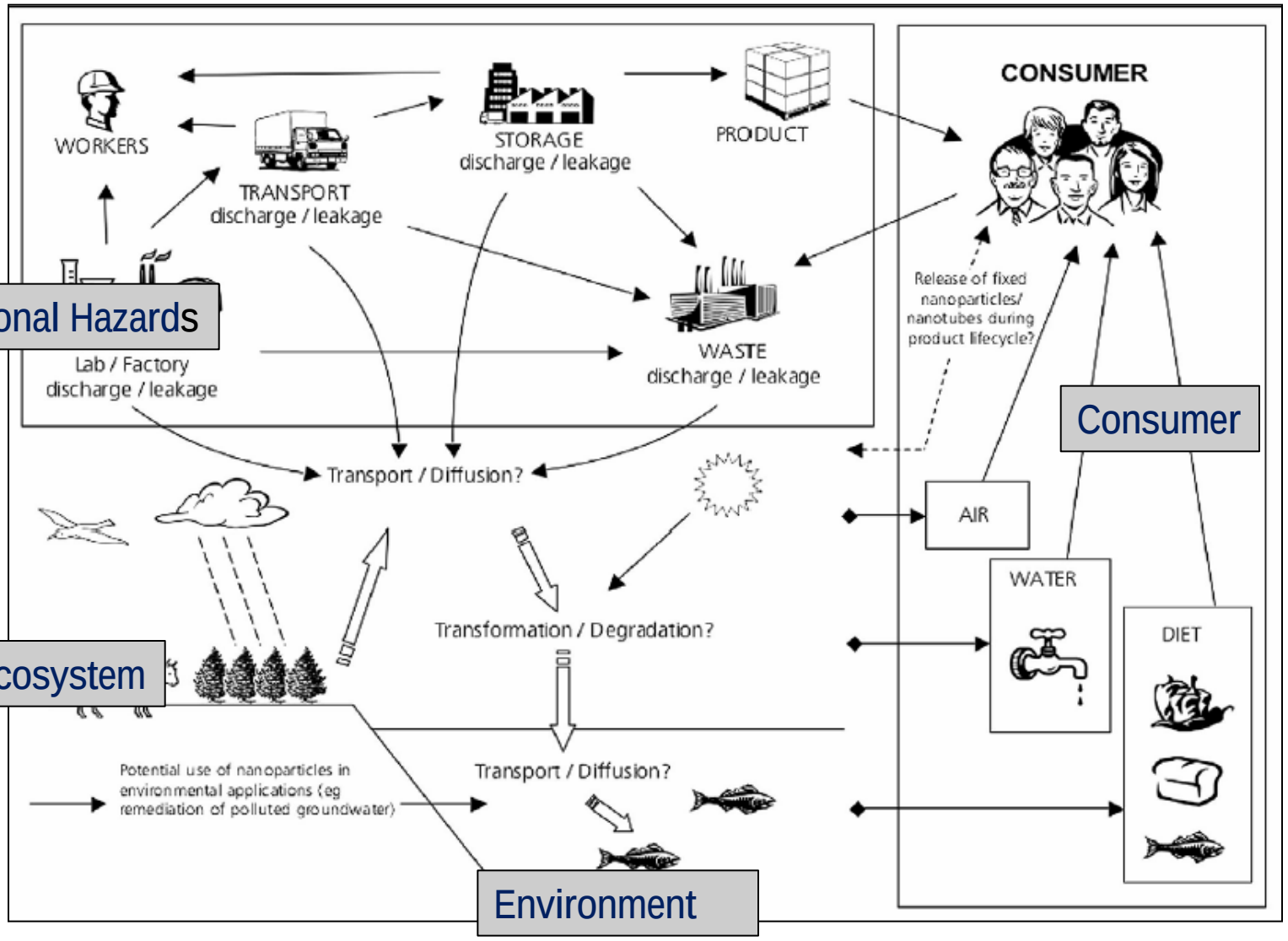
- Precautionary approach advocated globally
- R &D at the nanoscale, nanotechnology applications and societal implications
  - form a coherent and interactive system, which schematically may be visualized as a closed loop
- Nanotechnology success is determined
- by an architecture of factors
  - such as creativity of individual researchers, training of students in nanoscale science and engineering,
  - connections between organizations,
  - patent regulations, physical infrastructure,
  - legal aspects,
  - state and federal policies,
  - and the international context.
- The success of nanotechnology cannot be determined only by doing good R&D in academic and industry laboratories!



A closed loop.

Source: Roco 2003.

Sources/Routes of Exposure



Source: Royal Society Report,2004

Evidences - Translocation of Nanoparticles in non-targeted areas

- Deagglomeration, translocation, and distribution reported to play key roles in the fate of NPs once they gain entrance into the human body
  - NPs, which are smaller than 20 nm, can transit through blood vessel walls.
  - Magnetic nanoparticles, for instance, can image metastatic lesions in lymph nodes, because of their ability to exit the systemic circulation through the permeable vascular epithelium (Bogdanov et al., 2005)
- Some NPs indicate tendency to penetrate the blood-brain barrier through paracellular movement, passive diffusion, transport and endocytosis (Lockman et al., 2003; Kreuter, 2004).

Suggested Approaches

- Current approaches to risk management for engineered nanomaterials,
  - engineering control,
  - Administrative control,
  - PPE and health surveillance,
- Parallel approaches already in practice in occupational health and biosafety
- Further research and investigation is needed to evaluate the effectiveness of these approaches
  - across the spectrum of engineered nanomaterials being used and generated in laboratories and industry.
- For agri-nanotechnologies-
  - farmer /usergroups interaction a must
  - With an aim to identify the risk implications of nanotechnology for worker health,
  - and to devise ways to protect workers/farmers/end users
  - from any identified adverse health effects of working with nanomaterials by developing novel approaches to risk assessment and management.

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Suggested Approaches

- Move away from generalised discussions
  - towards a recognition of case specific differences
- Encourage better characterisation of nanomaterials with
  - Requirement of reporting on their use
- Increase funding for research
  - on (eco)toxicology and environmental fate and behaviour
- Use lifecycle perspectives when considering environmental impacts
- Develop international standards flexible enough
  - to adapt to new methods and findings
- Include social and ethical considerations in policy making, especially in the framing of priorities for risk research
- Commit to environmentally sustainable and socially robust innovation

Developing Safe agri-Nanotechnologies through Sound Science

Thank you
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