# Emerging Technologies Towards Agriculture, Food and Environment

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VISION PAPER

# From Agricultural Research to Agribusiness by Factor $C^n$: Capability, Capacity, Courage, Competence, and C… Vision 2025-2050/52*

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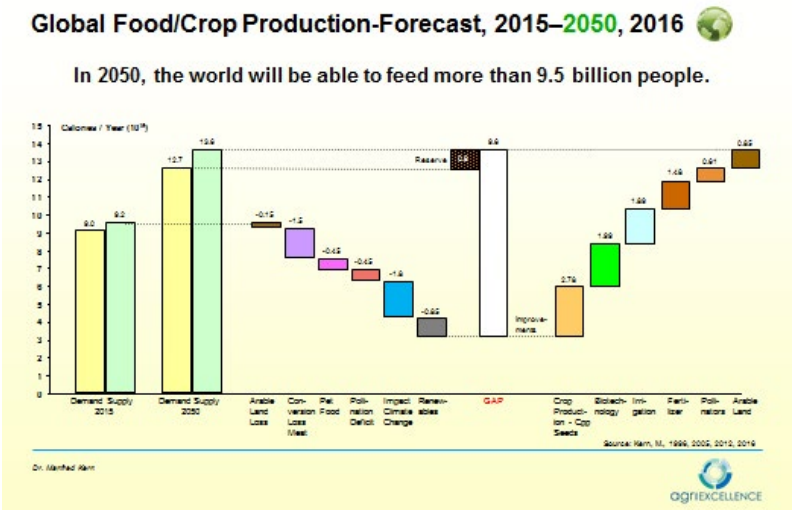
**Global Symbol for Capacity Building**

Between 2015 and 2050 more than a doubling of crop production, a tripling of plant based protein production (food & feed), and a tripling of fruit and vegetable production is necessary to feed 9.7 billion people living on the earth (*Kern, 2016*).

Africa's population is set to double by 2050, but crop production will not. The challenge is: how much improvement in agricultural production will be made and how much food has to be imported – at what price?




At present, millions of farmers are still working with obsolete agricultural technologies. Consequently, *e.g.* agricultural losses across the food value chain in Sub-Saharan Africa are 19% for stable crops, 28% for cash crops and 52% for horticulture (*UN, 2017*).

"The low agricultural productivity in poor countries is not due to poor land endowments. These seem to be large unrealized gains in productivity. Efficiency improvements in developing countries could dramatically boost crop yields by a factor of 5" (*Adamopoulus and Restuccia, 1/2018*). Furthermore, the rate of returns per year on food and agricultural R&D investments worldwide are 139.5% for applied research, 42.9% for basic research, and 72.2% for extension service (*Hurley et al., 2016*). Consequently, R&D investments are very profitable and promising.

Meanwhile, ~US$16 billion have been invested in plant-based (US$15.3 billion) and cell-cultured (US$73.3 million) meat since 2009 and a broad spectrum of start-up companies have been founded in the field of alternative meat production (*The Good Food Institute, 6/2019*).

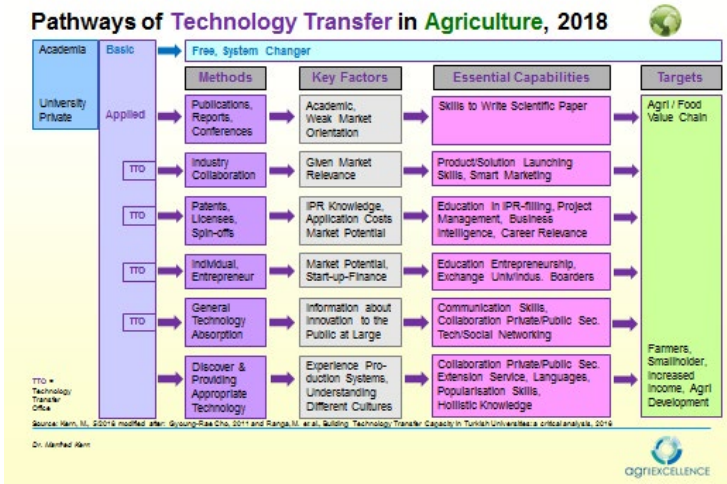
In a new report published in 5/2019 by the consulting company *ATKearney* titled: "*How Will Cultured Meat and Meat Alternatives Disrupt the Agricultural and Food Industry?*" it is concluded, that "*Meat Alternatives*" are going to disrupt the $1,000 billion conventional meat industry with all its supplier companies. The report claims, that by 2040, 35% of global meat consumption will be come from cultured meat, and 25% from vegan meat replacements. Individual enthusiasts believe, that so called "*plant-based meat*" and "*clean meat*" will be very close to 100% of the global meat market, maybe by 2100.

Today and in the future, agricultural innovations, entrepreneurship, capacity building and technology transfer of appropriate and socially adaptable technologies are and will be key essentials for the improvement

of agriculture and the food industry in developing countries. Nevertheless, it has to be considered, that technologies are part of the solution, but technologies alone cannot solve the problem of global hunger and poverty.

Furthermore, for centuries it has been well known, that "technology transfer in itself will not lead to economic growth. A successful transfer of technologies can occur only, if the recipient is sufficiently capable of maintaining an introduced production system. Without this capability, it is difficult to modify or improve agricultural production systems" (*Madu, 1989*).

A Vision named: "***From Agricultural Research to Agribusiness***" reflecting "**Factor C$^{n}$**" ("**CCCC CCCC CCCC CCCC CCCC CCCC CCCC C…**"): **C**apability, **C**apacity, **C**ourage and **C**ompetence – **C**reativity, **C**ontext, **C**ulture, **C**onscience, **C**onscientiousness, **C**ommitment, **C**omplexity, **C**larity, **C**utting-edge orientation, **C**ommunication, **C**onsensus, **C**onnectivity, **C**ooperation, **C**oherence, **C**oordination, **C**ountability, **C**apital, **C**uriosity, **C**hallenge-based, **C**limate change, **C**rop insurance, **C**limate resilience, **C**ellular agriculture, **C**ustomers, **C**onsumer interests will be given for students, scientists, university faculties, agriculture colleges, school teachers, extension staff, private sector, private sector advisers, small and medium enterprise owners, farmers, NGOs, policy makers, media, and the public at large.




## 1. CAPABILITY

Questions for consideration are the following:

- "Does your capability meet the world needs?" -
- "Are you able to use the capabilities of new technologies?" -
- "Do you have technical, social, entrepreneurial and commercial skills relevant for agribusiness?" -

  "Are you familiar with the vertical integration of the primary agricultural

input providers, with farmers' needs, the food and feed value chains and the consumers?"

These are very personal and challenging questions, but are essential în order to implement real innovations in the agricultural sector.

**An actual overview concerning the role of science, technology and innovation in ensuring food security and investments in the capacity to innovate is given by** *UNCTAD* **(***United Nations Conference on Trade and Development***) in 2017. Examples are listed in areas such as: food security, water availability, soil, the need for precise integration of inputs, farming in urban environments, post-harvest losses, food use and utilization, and food stability.**

## 2. CAPACITY

The paper of The African Capacity Building Foundation (ACBF, 2017) titled: "Youth Unemployment in Africa: Capacity Building and Innovative Strategies" sets the right frame. "Individual and institutional capacity building" are the keys to improving agriculture and the livelihood of people, especially the young. It is widespread, that the young people in a lot of African countries lack entrepreneurial skills and the ability to establish businesses. Many young people have little or no skills and are excluded from a productive economic and social life and very often they have skills which are irrelevant for the labor market or for starting an agribusiness. Consequently, education and training programs have to be implemented reflecting the inputs and needs of the young generation, specifically.

Within this context training in the use of appropriate technologies depends significantly on an effective and efficient education and extension service system. Some questions for people going into applied research or focusing on extension service activities are listed here:

- Do I have the knowledge and competence to work in extension services?
- Do I provide appropriate, proven and socially adaptable technologies?
- Do I know the real (technical) needs of farmers and the society?
- Do I have the skills to be a problem solver?
- Do I improve the farmers' income in order to reduce poverty?
- Do I have my own hidden agro-policy agenda/mission?
- Do I involve farmers from the early beginning of technology transfer?
- Do I have the communication skills to encourage and to train people?
- Do I co-develop and use modern communication tools?
- Do I improve local capabilities for technology transfer?
- Do I foster entrepreneurship in agriculture?
- Do I take over partial personal risks, if the system does not pay off?

Nevertheless, "All power is within you. You can do anything and everything. Believe in that." (*Swami Vivekanada, 1863-1902*) as well as the statement made by *Mahatma Gandhi* (*1869-1948*): "If I have the belief that I can do it, I shall surely acquire the capacity to do it even if I may not have it

at the beginning" are food for thought.

In doing this, you have to leave your comfort zone and enjoy the challenging zone and you have to be ready to exceed limits. Some relevant questions for consideration (*Lauro, 2018*) are the following ones:

- Do you have an innovative mind?
- Do you have a vision?
- Do you have the heart to lead?


## 3. COURAGE

Courage, what does it mean:

- the ability to control your fear in a dangerous or difficult situation,
- to be brave and confident enough to do what you believe in,
- the ability to control fear and to be willing to deal with something that is dangerous, difficult, or unpleasant (*Cambridge English Dictionary*, 2018).

Without courage, it is better to leave the area!

- Nevertheless, every one of us should work for young people:
- to remove fear of the future,
- to give courage,
- to be enthusiastic about science and technology,
- to take away their fear of complicated technologies,
- to have an optimistic forward view of the future,
- to encourage and to dare to do something new!

## 4. COMPETENCE

Ability, capability and capacity are key prerequisites for competence. To develop these parameters, it is essential to install an agricultural education system in LDCs as well as in Developed Countries, where future universities must provide:

- society with workers, leaders, and lateral thinkers who do not only have the ability:
- to continuously learn,
- to think critically and theoretically, but also:
- to innovate and to break the status quo,
- to encourage constructive objection to orders or guidelines, and
- to navigate in unstable waters of the global economy and local/global development, and furthermore:
- to stay going forward with the task in hand,
- to work hard and be focused,
- to be efficient and effective by using all available resources,
- to be ready to work in interdisciplinary teams or with partners,
- to steer, to coach and to encourage others,
- and last, but not least:
- to be prepared not only for jobs, but to be able to operate as entrepreneurs.

We need entrepreneurial universities, where scholarly research is combined with business acumen well described in the UN-magazine: "***Africa Renewal***", Special Edition: "***Invest in Youth***" in 2017: "In traditional universities a student attends lectures, writes exams and submits a thesis before graduating. But at entrepreneurial universities, students are trained to go a step further and turn their research papers into business ventures. "We need to shift the emphasis from theory to practice from day one, asking ourselves: 'How can we add value to society rather than to our brains only?'"

We need: '**AGRIPRENEURS**' (Kern, 2017) as well as *e.g.*, '**Agro-Bio Mechatronics and AI**"(Grieve, 2019).

Some further food for thought: Courage – Do your thing! Realize your own UTOPIA! (*Bregman, 2018*) … Go for the: "*Un- … Im-…*"

- Unexpected
- Uncertain
- Unbeknown
- Unrealistic
- Unbelievable
- Unconventional
- Unapproachable
- Unthinkable
- Unreasonable
- Uncomfortable

- Unaccompanied
- Unacknowledged
- Unafraid

…Impossible.
Last but not least, professors should ask themselves the following:

- Do I only develop knowledge?
- Do I teach science and technology only?
- Do I have students to follow my own 'great' ideas?
- Do I inspire students to go for their own way?
- Do I encourage students to go for a bigger picture?
- Do I teach and underline ethical/social standards?
- Do I have an optimistic vision of what the future can be?
- Do I propagate holistic sciences?
- Do I improve the capacity as well as capability of students?
- Do I hold at least one patent?
- Do I have the skills to guide students to focus on entrepreneurship?

What would I do, if there were no finance from tax payers' money?

"We must teach our children the skills **that will enable them to build business, not only to simply get a job.**" (*Dr. Christine Pitt, CEO of MLA Donor Company, 2017*).

**Fortunately, *AgTech* startups have been put in place in a lot of countries. For example, for smallholder farmers in Sub-Sahara Africa (*Balachandran, 2018*), a digital agriculture platform or a decentralized fertilizer and seedling warehousing system in Nigeria, an agro-tech greenhouse and drip installation company in Kenya, a '*Flying Knapsack System*' for agriculture drone applications in the precise dispersal of agro-inputs on farm fields; drones to monitor field crops/vegetative status and identify and mitigate potential diseases across fields on farms in Ghana; an insurance intermediary that implements data-driven agricultural insurance for small-scale farmers in six different countries in Africa. Or in South-Africa to add another startup "*AgriProtein*", has developed bioconversion processes which take organic waste streams from food factories, supermarkets, farms and restaurants, and recycles these into valuable products to feed insects and to produce an insect based complete protein called "*MagMeal*™".** This is a natural super feed for farmed fish, chickens, pigs and pets. Similar startups have to be fostered to occur as much as possible.

## 5. CREATIVITY

Creativity, ideals and courage of the youth of the world should be mobilized … to ensure a better future for all was claimed in Principle 21 of the Earth summit in Rio de Janeiro, 1992. This is more relevant than ever!

**Creativity, what does it mean?** Creativity is an infinitely renewable resource. Creativity comes from people, combines/creates new and useful

tools, requests the ability to take risks, is breaking generally accepted rules or even stretching them, is often downright subversive, takes confidence, requires enormous concentration, is a source of economic value, requires diversity, is open to differences, makes a difference and triggers the process of destroying one's concept … in favor of a better one.

Creative persons have above-average motivation, respond more to optical stimuli, are sensitive to trickiness, quibbles and nuances, they like interconnections, interfaces, and a free scope. Creative persons do not think in traditional terms, they shift benchmarks, assume risks, do what they want, and do it in the way they want. They desire to achieve something of permanence and seek recognition; they need coordinates and fixed points, need confidence and contribute to the question: "What is man?" (*Kern, 2013*)

Not to be forgotten: creativity takes courage!

"***The Global Creativity Index 2015***" (*Florida et al., 2015*) brings '***talent***', '***technology***', and '***tolerance***' together into a single index, the Global Creativity Index, or **GCI**. This book underlines, that creativity is increasingly the cornerstone of innovation and economic progress for nations across the globe. Impressive global 'creativity maps' in combination with R&D investments, innovation (patents), human capital, or economic output are given there.

**A challenging book titled: "*Agriculture as a Metaphor for Creativity in All Human Endeavors - Mathematics for Industry*" which promotes interactive collaborations between mathematics and industry is opening a new horizon. "The success of agricultural practice relies fundamentally on its interconnections with and dependence on biology and the environment. Both play fundamental roles including the adaption of biology to cope with environmental challenges of biotic and abiotic stress and global warming. The theme emphasizes the development of mathematics within this framework which successful agricultural practice depends upon and exploits" (***Anderssen et al., 2018***).**

## 6. CONTEXT

More than ever, the world needs agriculture to be better – more productive, more efficient, more effective, producing less waste and to be more sustainable. Technical and technological progress has to be in line with the context of Sustainable Agriculture and Sustainable BioEconomy.

## 7. CULTURE

Agriculture is the mother of all culture. Without agriculture we could not survive for long.

"Over the past decades, the modernization of agriculture in the Western world has contributed not only to a rapid increase in food production but also to environmental and societal concerns over issues such as greenhouse gas emissions, soil quality and biodiversity loss. Many of these concerns, for example, those related to animal welfare or laboratory conditions,

are embroiled in controversies and apparently deadlocked debates. As a result we observe a paradox in which a wide range of corporate social responsibility (CSR) initiatives, originally seeking to reconnect agriculture and society, frequently provoke debate, conflict, and protests. … Western agriculture is marked by moral complexity, *i.e.*, the tendency of multiple legitimate moral standpoints to proliferate without the realistic prospect of a consensus." (*Olde and Valentinov, 2019*).

In all discussions about research, development and commercial applications of new technologies in agriculture it should kept in mind ***Indira Ghandi*** (*1917-1984*):

"How can we urge the preservation of animals, how can we speak to those who live in villages and in slums about keeping the oceans and rivers and the air clean, when their own lives are contaminated at the source? The environment cannot be improved in conditions of poverty, nor can poverty be eradicated without the use of science and technology."

## 8. CONSCIENCE

Conscience is doing what you believe right even though it might be unpopular, difficult or risky.

## 9. CONSCIENTIOUSNESS

Conscientiousness is the personality trait of being careful or vigilant and implies a desire to do a task well, and to take obligations to others seriously. Conscientious people tend to be efficient and organized as opposed to easy-going and disorderly. Without conscientiousness the implementation of innovations is very fragile or not realized at the end.

## 10. COMMITMENT

Working in the area of cutting-edge technologies in agriculture, it is essential to have the unlimited willingness to spend your time and energy in what you are believe in. A full identification with the work and an engagement is expected per se and by the society, especially.

## 11. COMPLEXITY

It is a matter of fact that complexity creates fog, simplicity clears it. For clarification the following statements modified after *Sinha* (*2011*) as well as *Gerrits and Wirtz* (*2018*) are listed: Complexity …

- is looking for problems instead of solutions.
- will not go away.
- is answering *every* e-mail, *straight away*.
- is being late to meetings, letting important people down.
- means making excuses.
- is looking busy, but getting very little done.
- means hiding from doing great work that makes a difference.

- is multidimensional, dynamical and emergent.
- can induce demotivation and disengagement.
- exists, but choose simplicity!

**Nevertheless, we should consider a sentence written by *Einstein* (***1879-1955***)**: "Everything should be made as simple as possible, but not simpler." knowing, that the extreme complexity of the world is the new simplicity!

## 12. CLARITY

Questions for reflection are the following ones:

- What is your research good for?
- Do you go for basic or 'frontier' research (driven by curiosity and a desire to expand our knowledge), applied research (solving problems, does it work?), advanced development (does it take feasible solutions and cull out the best alternative(s) to achieve a target capability or feature to be incorporated into products) or product development (shaping products for release to the marketplace)? (*Kowalczyk, 2018*).
- Do you go for long-term and large-scale research goals ('Grand Challenges of our time')?
- Do you go for incremental or cutting-edge innovation?
- Do you work on innovations for poor people in low-income countries or for high-income people in industrialized countries?
- Do you prefer to convert US$s to knowledge or to convert knowledge to US$s?
- Do you want to do it yourself (authorship) or do you want to get things done (strategic)?
- Do you want to publish or perish or do you want to implement innovations or 'die'? (*Boyle, 2015*).

A merger or combination of all the four research areas is more and more desirable in order to implement the necessary agricultural innovations in time.

**Future agriculture will be a knowledge-driven agriculture, whereby we have to rely on so-called 'Explicit Knowledge', which identifies and codifies (information, documents) as well as 'Implicit Knowledge' (experience, competence, commitment, obligations), which is essential to transform a fundamentally possible technology into a truly functional application (***Labor Spiez, 2016***).**

## 13. CUTTING-EDGE ORIENTATION

**Genetics, Biotechnology, Nanotechnology, Synthetic Biology, CRISPR-Cas-Technology (***Pickar-Oliver and Gersbach, 2019),* **CRISPR-Cas-Technology in combination with other Cutting-Edge Technologies (***Zhang et al., 2019***), Cellular Agriculture, Smart Technologies, Sensors and Robotics, Physical**

**Engineering, Localized and/or Cloud-based Artificial Intelligence (AI) (*Grieve, 2019*), Internet of Things (IoT), Digitalization (*Kern, 2015*) or Agro-Apps are key technologies shaping or revolutionizing future agriculture.**

## 14. COMMUNICATION

Today, it is becoming increasingly difficult to develop and apply cutting-edge technologies and to implement innovations in time. The reasons for this are multifunctional and multivalent. Science and technology, cutting-edge technologies and the use of other technologies, *e.g.* the use of nanotechnology, biotechnology and cellular agriculture are matter of controversial discussion between many stakeholders. Very often, misinformation, misinterpretation, misunderstanding, faked papers (*Burdick, 2017*), fake scientific journals/ publishers (*Tin et al., 2014*), fake news or fluffy claims are used in different media must be dispelled.

The future of the world will significantly depend on effective and efficient new technologies which are the most powerful instruments for solving the resource and climate change problem.

Cutting-edge technologies determine the way of life and technological illiteracy is a danger to the society as a whole. This will be relevant for further progress in science and in implementing new technologies.

If we want to shape the future with the aid of new technologies, we will have to convince people, establish confidence, and communicate with people – we have to communicate science and technology as early as possible. Every person, organization, company involved in the development and implementation of cutting-edge technologies should go for the **"10 C's"** (*Kern, 2013*):

- **Certain Communication** means to share new knowledge and information based on reliable sources with others and the public at large,
- **Clear Communication** is expressing the goal and message in an understandable way,
- **Coherent Communication** sounds logical and reflects the current state of the art of science,
- **Complete Communication** includes all relevant pro and con information
- **Concise Communication** is to keep the story short,
- **Concrete Communication** is dealing with vivid and valid facts,
- **Conscience Communication** is respectful and is fully in line with ethical standards,
- **Correct Communication** is free from hidden agenda, errors and misleading or wrong data,
- **Courteous Communication** is characterized by openness and honesty,
- **Credible Communication** enables innovators to build up the level of confidence within societies for implementing new technologies.

Without science, scientists and the science industry, there would be no basis for product, process or technological innovation in agro/food production. Nevertheless, we as an integral part of the scientific community have to ask ourselves whether we are doing enough to obtain benefits from new technologies visible to and acceptable for the public.

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Communication is more than just transporting information. Communication has to inspire other people and to provide impulses for value enhancement!

To communicate cutting-edge technologies is not an easy task, but it is essential for science and technology communications, so that the issues you are talking about are understandable to non-insiders. Therefore, it is essential to find and to address the knowledge level of people you are discussing with, directly or via media, blogging and social media especially.

By organizing and structuring a light house project at the Bayer CropScience Forum "*The Molecular Future of Crop Quality*" in 2003, the presenting scientists were requested to prepare their scientific results on eight different levels. The example shown is given by *Benting et al.* (*2003*):


- **Scientific abstract**: "Molecular Diagnosis of Pest Resistance"
- **Scientific paper**: "Molecular Diagnosis of Pest Resistance"
- **Lecture presentation**: "Molecular Diagnosis of Pest Resistance-Find the

Needle in the Haystack"

- **Press release**: "Science put into practice: Molecular monitoring for resistant pests"
- **Yellow press release**: "Gene hunters chase mutants in Colorado potato beetle"
- **Text for a 16 year old student**: "Genomics in plant protection"
- **Well sounding headline**: "Gene hunters chase mutants"
- **Scientific cartoon**: "The gene hunter: chasing mutants"

Scientists have to make scientific information transparent and have to communicate with the public at large in a comprehensible way.

## 15. CONSENSUS

Agricultural interventions have to serve societies. They are expecting responsible innovations, healthy and affordable products and more and more people want to know:

- **How** the goods are made?
- **Which** resources are used?
- **Who** produces the products?
- **Where** the goods are made?
- **Which** agricultural production systems are used?
- **What** impact will it have on climate change?
- **Does** the solution fit to given environmental standards?
- **Does** the innovation respect animal welfare standards?
- **Does** the production follow relevant social/ethical standards?
- **What** are the consequences for future generations?

Consequently, agricultural research and solutions have to have a techno/socio economic orientation. Otherwise, without public acceptance, there will be no license to produce.

## 16. CONNECTIVITY

Due to the complexity of challenges in developing and implementing agricultural innovations, where a broad spectrum of disciplines and capabilities are requested, connectivity to other scientists or people in the public and private sector is a key element in order to be successful in time. Keeping in mind the following:

- Many new inventions are only improvements to existing systems or additions of new characteristics.
- Revolutionary ideas and innovations generally come about only when new people with a different scientific background bring "***a fresh breeze***" into an established discipline.

**Sometimes, inventions are based on hitherto unfamiliar technologies taken over from other disciplines. These are known as '*hybrid*'**

**inventions, with elements originating outside the previous circle of ideas and principles.**

## 17. COOPERATION

Cooperation and networking in agricultural sciences between different actors and beyond borders is a prerequisite for fostering innovations in the whole agro-sector. It will start with partnerships in the public and private sector of agricultural research (*Kern, 2001*) and end up with multi-stakeholder collaborations to implement new agribusiness concepts.

According to the FAO (*Food for All, FAO 1996*), cooperation in the transfer, adaptation and dissemination of technologies for food production in favor of the developing countries will be indispensable. The greatest challenge for the future will be to intensify the use of science and technology.

Today in 2018, 822 million people in the world are suffering from hunger (*FAO et al., 2019*) underscoring the very unrealistic target of achieving Zero Hunger by 2030. Actually, it is crystal clear, that this political target is a fiction and was not realistic from the early beginning.

***Let me quote myself:***

- "Related to higher food prices, a lot of people will explain, why the world will/could not reach the millennium target to halve hunger until 2015!" (Kern, 02/2007).
- "Related to more conflicts and climate change, a lot of people will explain, why the world will/could not reach the target "Zero hunger by 2030!" (Kern, 02/2017).

And now - there is an increase in global, regional and political instabilities, upcoming crypto currencies as well as a global economic slowdown and downturn followed by expected economic shocks, which will, beside other factors, increase malnutrition and hunger especially in low-income and middle-class income countries.

Severe hunger exists on earth and an increase in the number of hungry and malnourished people is ante portas. Political wish lists were common, but they will not work anymore in the future. Again, human mankind is at a crossroads concerning food and nutrition security (*Kern, Food Security at the Crossroads (Anno 1864, 1894, 1924, 1954, 1984, 2014, 2044, 2074) – A Wake up Call, 2012*).

There is an urgent need to bring back this inhuman problem to the center of concerns to the public at large and to foster lifesaving cooperation in the field.

Several future-oriented reports and recommendations for action have been drawn up since the publication of Agenda 21 in 1992. They are concerned mainly with describing the major goals which have to be achieved. Basically everything that needs to be done has been said, everything has been excellently described.

There is no need to write general papers about food and nutrition security. But, a strategic gap must be closed as quickly as possible. There is

an urgent need for a documentation of:

- **Why** we did not use the right and available tools (policies, technologies, finances, etc.) to overcome this intolerable situation?
- **Who** was/is responsible for this?
- **Who** has to pay the bill?
- **What** has to be done by **whom** by **when**?

The important thing, now more than ever, is to act immediately and much more quickly than in 1992, knowing that the roads to be taken will be arduous and difficult.

Please allow me to add a hopeful note with the words of ***J. W. von Goethe***: "*To act is easy, to think is hard, to act as one thinks is the most difficult.*" We've done more than enough thinking and talking, it's now 2019 and time to act!

## 18. COHERENCE

Coherence between agricultural research/development and social protection should be considered from the very beginning. Nevertheless, it has to be mentioned, that the goals of agricultural research, agricultural and rural policies are often very different, but policy coherence is essential. Otherwise it will waste resources, time and money.

## 19. COORDINATION

"***The Global Innovation Index 2018: Energizing the World with Innovation***" published by *Dutta et al.* (*2018*), documents, that the global landscape of investment in science and technology as well as in education and human capital has undergone important positive shifts over the last three decades. The estimated total of R&D expenditures has continued to rise, more than a doubling over the last 20 years. This publication is a leading reference on:

- innovation and a '*tool for action*' for decision makers wishing to improve their countries' innovation performance, and
- coordination of the innovation agenda, with consistent focus and set of priorities over time.

The coordination of international research cooperation in agriculture looks like an insolvable puzzle and suffers from the problem of a low level of transparency, and high level of complexity and bureaucracy. This important area will not be further elaborated here.

## 20. COUNTABILITY

This particular discipline or branch of learning, especially one dealing with measurable or systematic principles is a very important field to advance all of the technological platforms in agriculture.

## 21. CAPITAL

The global agribusiness market value will have increased from US$263bn in 2015 to US$326bn in 2019 (*GosReports, 2016*). As an example, the global smart agriculture market was valued at around USD 5.1 million in the year 2016 and is expected to reach approximately USD 15.3 million by the end of 2025 (*Zion Market Research, 2018*).

- **Is agriculture and agri-business attractive in the future?**

  **Yes**, because the multi-disciplinary innovations which are under development and implemented in the market are forecast to be highly profitable. However, there are threats such as: instability in national and international market policies, unpredictable regulatory procedures, unpredictable tax policies, lack of political commitments, lack of public funds or fluctuating currencies (*AgriLinks, 2019*).

- **Is agriculture financially supported by policies and public funding?**

  **Yes**, in developed countries. Agriculture investment by the European Commission is backing innovation and research in the agro-food sector with –3.6bn between 2015 and 2020 via ***Horizon 2020***. But research consortia must include key actors with practical experience in the subject such as advisers, farmers, farm organizations, co-ops and businesses (*Hogan, 2015*).

  Key fields of European Union investments are in the area of smart agriculture, plant-based proteins (*European Commission, 2018*) and cellular agriculture.

  The Government of Canada, for example, is supporting the "*Protein Industries Canada*" in order to increase value added production of plant-protein-based products and co-products by investing US$950 million in five industry-led '*multi-disciplinary superclusters*' (*Greuel, 2019*).

  It is not sufficient in developing countries. Agriculture, including Africa's agribusiness sector is predicted by leaders of top agribusiness companies to reach **US$1 trillion** by 2030. Representatives from multilateral financial institutions, pension funds, sovereign wealth funds, government officials and private investors have outlined, that actually **only US$7 billion** is invested in the agro-sector, although there is a need to invest **US$45 billion per year** to harness the power of agriculture and move up the value chain to create jobs and wealth (*African Bank Development Group, 2018*). However, many governments throughout the region are continuing to under invest in research and development directed to their food and agricultural sectors. A positive change is not recognizable, but extremely necessary.

- **Is agriculture attractive for investors?**

  **Yes**, investors expecting excellent business due to the immense potential of innovations in different areas (hybridization of smart with classical agro-technologies for business) *e.g.* cutting-edge technologies

(*AI, IoT, Agro-Bio Mechatronics, digitalization, Apps*) or potential 'game changers' (*cellular agriculture). AgTech* investment is on an exponential growth path. There is huge market of around US$3 trillion and investors can expect high returns of invest (*Monitor Deloitte, 2016*). As mentioned at the beginning, meanwhile, ~US$16 billion were invested in the field of alternative meat production since 2009 (*The Good Food Institute, 6/2019*).

Furthermore, there are more and more investors, who are investing for social and ethical reasons in agricultural production systems of LDCs as well as developed countries.

- **Is agriculture lucrative for startups?**

  **Yes**, because, there are so many opportunities to hybridize agro-technologies and the agro-businesses are changing dramatically. Startups are more innovative, more flexible and less formal.

  India has established a startup culture, which has become world-renowned. India has moved to the 3rd position of startups worldwide. But in agriculture, a lot of farmers in India are still sticking to traditional farming methods and it is not easy to implement innovations in agriculture. Most investors do not understand agriculture. Nevertheless, developing smart solutions that help the farmers are coming up more and more (*Narayan, 2016*), although governmental support of startups has declined and venture capital has to come from abroad.

  In Sub-Sahara Africa the lighthouse - ***AgTech*** startups were mentioned earlier reported by *Balachandran* (*2018*). These examples are very promising and should be blue prints for other startups in all over Africa.

  At all agricultural universities, business incubator centers have to be put in function in order to make the fields of AgTech investors transparent for scientists and to facilitate the founding of startups.

## 22. CURIOSITY

"***Serendipity"*** and ***"Mavericks"*** are indispensable in Modern Sciences. We must admit that rationality in scientific research is not everything. We should make full use of the opportunities opened to us by random discoveries. This will increasingly become an attribute of biotechnologists in the 21st century. Therefore we should always welcome creative unconventional thinkers, or „mavericks", who notice what others overlook, who perceive, absorb and wonder, who ask questions and reflect, who question the status quo, break with familiar habits and take a skeptical look at things, who venture, risk and act, who foresee, search and discover, and who have the feeling for "how everything works". We will continue to extend the boundaries of our knowledge at an ever-growing rate. Our motto should be: "***Venture courageously to the uttermost limit of necessity.***" (*Kern, 1997*).

Actually, an excellent example is provided by the Finnish start-up Solar Foods which has developed a complete protein made from carbon dioxide, air and electricity (*Southey, 2019*). This would implicate a disconnected food

production from agriculture – what an option?

Or another example, a miniaturised sensor that can be mounted on a tooth has been developed to transmit data on glucose and salt intake. The bio-responsive layer in such sensors can be changed to analyse a broad spectrum of other health relevant chemicals as well (*Tseng et al., 2018*). This innovation will significantly improve a healthy nutrition.

## 23. CHALLENGE-BASED

Key factors, which have to be considered, are the following: loss of arable land caused by urbanization, industrialization, desertification, water shortages, shrinking resources, climate change, pollution, species extinction, economic disparities, political instabilities, migration, global trade, new cutting edge technologies in agriculture and digital information systems. For orientation two Bio-Visions -2050 are presented:

- **Example No. 1** (*Kern, 2018a*): A Bio-Vision: "$F^4$: Fossil-Fuel Free Farming - 2050" focusing on:

  **Fossil-fuel-free** biomass production
  **Fossil-fuel-free** fertilization of crops by seed improvements
  **Fossil-fuel-free** crop protection
  **Fossil-fuel-free** irrigation (solar energy)
  **Fossil-fuel free** mechanical agricultural production systems (New Holland NH2-tractor, Styr biogas tractor, Deutz-Fahr Agroton biodiesel tractor, robots, no-tillage)
  **Fossil-fuel-free** smart farming (GPS, Deuterium, drones, Apps)
  **Fossil-fuel-free** new added value chains on farms (decentralized, fully integrated hybrid systems, aquaponics, aeroponics)
  **Fossil-fuel-free** cross functional functions on farms and bio-refineries (biogas, biodiesel, bioethanol, solar, wind, water)
  **Fossil-fuel-free** transportation systems
  **Fossil-fuel-free** food/goods processing
  **Fossil-fuel-free** supermarkets/distribution centers/outlets
  **Fossil-fuel-free** cooking
  **Fossil-fuel-free bioeconomy/industrial ecology**

- **Example No. 2** (*Kern, 2018b*): A **Bio-Vision: "Sustainable Bioeconomy - 2050" –** Bioeconomy is a new concept for the use of natural resources. Bioeconomy is the knowledge-based production and utilization of biological resources, innovative biological processes and principles to provide goods and services sustainably across all economic sectors, especially relevant for crop production and crop improvement. The following five areas are recommended:

  De-Materialization: "Do more with less!" Save resources by digital farming.
  De-Carbonization: "Do it better!" Replace fossil fuels in agriculture with

renewable energy.

Re-Cycling: "Do it without waste!" Establish bio-refinery systems.

Re-Arrangement of Resources: "Do it by creating values!" Use modern biotechnology methods in crop improvement.

And: "Do it at an appropriate time!" Authorize/regulate necessary methods future oriented.

## 24. CLIMATE CHANGE

On 06 August, 2018, in my home village *Loerzweiler* – around 40 kilometers southwest of Frankfurt, we have had the earliest harvesting of vine grapes ever done in Germany since 1540. This extraordinary event was documented by an uncountable number of newspapers and TV-channels worldwide. A vine plant with a vine grape I have embedded in the newly built altar milled out of different soils in the Roman-Catholic Imperial Cathedral *"St. Peter"* in the city of Worms.


In the same year, the extreme dry summer weather has caused severe damage to cereal crops in Germany and European Baltic Sea countries. There were crop losses of 50 to 60 percent in some regions, all the way to total losses. Some farmers have opted to destroy the crops instead of trying to harvest them.

Agriculture has a great potential for the mitigation of climate change through carbon sequestration into soils and crops. An interesting outlook concerning agriculture and climate change is given by *BIAC/OECD (2009)*. This recognizes an urgent need for innovations to mitigate climate change and to bring about the necessary adaptations in agriculture. Modern plant breeding and smart irrigation technologies are most notably in the duty.

Nevertheless, we should keep in mind that every ton of carbon added

to, and stored in, crops/plants removes 3.6 tons of $CO_2$ from the atmosphere *(Paustian, K. et al., 2006). Ruesch A. and Gibbs, H. (2008)* drew attention to the fact that about 500 billion tons of carbon is stored in living crops/plants worldwide – more than 60 times the annual anthropogenic emissions of carbon to the atmosphere. A large amount of this biomass is produced by agricultural activities *(Burkhardt, H., 2007)*. This highlights the critical role of farming practices in reducing fossil fuel-derived energy *(The Government Office for Science, UK, 2011)* as well as greenhouse gas (GHG) emissions but also at the same time utilizing the potential for climate change mitigation through $CO_2$-assimilation.

As an example, in the European Commission new CAP post-2020 proposal (*Loriz-Hoffman, 2019*) the new specific objectives for improving agricultural production are listed here:

- contribute to climate change mitigation and adaptation, as well as sustainable energy
- foster sustainable development and efficient management of natural resources *e.g.* water/soil/air
- contribute to the protection of biodiversity, enhance ecosystem services and preserve habitats and landscapes.

The European Commission has outlined '*obligations and incentives*' to preserve soil health, to encourage crop rotation and to adopt practices which are beneficial to the climate and the environment. The three key factors are:

- Improvement of knowledge,
- Development of smart innovations,
- Implementation of appropriate technologies.

## 25. CROP INSURANCES

Climate change causes adverse weather events such as droughts or excessive rainfall in different areas of the world, and can lead to significant volatility in agricultural production. This volatility puts farmer's income and investments in agriculture at a higher risk. Government-funded subsidies will be necessary to incentivize the uptake of crop insurance. More and more, crop insurances will be an essential and integral part in all agricultural production systems.

## 26. CLIMATE RESILIENCE

At this point, attention should be given to a wonderful book written by ***Ignaz Magini***, published in Vienna in 1819. Its translated title is: "Concerning the cultivation of cereal species – ***An attempt to answer the question: What non-indigenous cereal species would be worthy of special attention and cultivation?"*** The author shows great foresight in matters of plant breeding – reaching out, I would say, to 2050 and beyond:

"To acclimatize non-indigenous cereals in our regions, we must reproduce the conditions under which they thrive in their country of origin

and as far as possible eliminate the factors which cause them to fail. At the same time we should not subject them to excessive artificial refinements, thereby turning them into weaklings attracting a host of diseases which we seldom observe in the wild growing plants."

## 27. CELLULAR AGRICULTURE

After 125 years, the visions/dreams of the famous chemist Professor Marcellin Berthelot about "***Foods in the Year 2000***", that synthesized food will displace agriculture. This was published in 1894 and seems to be on the way to be realized. However, options are not coming exclusively from chemistry, but more and more from biology and biotechnology.

"Cellular agriculture", "labriculture", and "integriculture" are new word creations based on new production technologies named: "in vitro meat", "cellular meat", "cell-based meat", "cell-cultured meat", "cultured meat", "fermented meat", "animal-free meat", "slaughter-free meat", "cruelty-free meat", "resource-efficient meat", "ethical meat", "artificial meat", "synthetic meat", "lab grown meat", "home cultured meat", "zombie meat", "blood-free meat", "imitated meat", "simulated meat", "faux-meat", "non-meat", "methane-based meat", "processed meat", "reinvented meat", "beyond meat", "fake meat", "Frankenburger 'Shmeat'" or "clean meat" etc.

Key credos of the new spectacles in agriculture and food production are the following ones (*Radke, 2019*):

- **Go** green.
- **Go** clean.
- **Go** plant-based.
- **Do** it for your health.
- **Do** it to save the animals.

**Do** it to save the planet."

Key words such as: "***Fourth Industrial Revolution***", "***Second Domestication***" or "***2nd Red Revolution***", are intensively propagated in various media to promote "***Meat Alternatives***" and alternative meat production methods.

Key parameters for the future market of "***Meat Alternatives***" among other are the following ones: Quality, taste, flavor, texture, convenience, price, profitability, target groups in markets, affordability, availability, nature-based vs science-based, GMO-debate, natural vs artificial, nutritional profile, long-lasting impact on human health, food safety, fair regulations, appropriate labeling, progress in personalized nutrition (*Kern, 2006 & 2007*), general benefits (health, environment, animal welfare), $CO_2$ footprint, use of non-fossil energy, bio-based product manufacturing, sustainable utilization of resources, transparency, consumer acceptance, consumer preferences, consumer demand, changing eating habits, respecting religions and cultural levels, social consensus, reactions of the livestock industry, improvements in animal production, innovations in agriculture (*Grieve, 2019*), education, information, media and social media reflections, fake news, image creation,

visibility, etc.

Nevertheless, a broad spectrum of innovations can be expected from that area. Cellular agriculture will significantly shape, synergize or revolutionize future agriculture and the whole agri-business field.

## 28. CUSTOMERS

What is puzzling farmer's head? is a key question. Farmers should be involved at the very beginning of research and should evaluate the output of the research project. Solving farmers problems, which they cannot tackle themselves should be at the center of activities – in low-developed or in developed countries. It is bin self-evident that solutions have to work in the field and not just in the laboratory. Furthermore, it is essential before a new technology is adopted that the scope as well as limitations of the existing technology have to be studied. The provided technologies have to be appropriate, affordable, socially adaptable and consequences have to be evaluated.

Factors for successful technology transfer given by *Madu* in 1989 are still relevant in 2019:

- The active participants will identify agreeable needs and objectives.
- The capabilities identified can be in terms of human resources, capital (as in the case of some OPEC members), natural resources, land and others.
- There is a need for appropriate educational systems in LDCs.
- Innovation and technology modification can only exist if those concerned have a full understanding of the technology.
- Training of local manpower is necessary to provide the knowledge base for technology transfer.
- The issue of *appropriateness of technology to* an LDC may well be the most important issue in technology transfer.
- Managers must be innovation-oriented and need to be both sensitive to their environment and committed to the new technology.
- An effective management will lead to an efficient utilization of limited resources.
- Governments view technology transfer as a part of the foreign policy arena. Governments can therefore have a significant impact on promoting or hindering the transfer process.

The **EIP-AGRI** (The European Innovation Partnership Agricultural Productivity and Sustainability) seminar titled: "Promoting creativity and learning through agricultural knowledge systems and interactive innovation" held in Dublin, Ireland in December 2015 was highlighting practical examples of the changes taking place in agriculture and how farmers and researchers across Europe can learn from each other and how all together can tackle the complex challenges in agriculture. It should be used as a blue print to trigger creativity, cooperation, networks, and knowledge transfer within the agricultural production systems of the future (eip-agri, Europe, 2016,2018).

As another example, "a new coalition of agriculture and finance industry players is working together to find new ways to get appropriate technologies into the hands of smallholders farmers. Global crop inputs provider *Bayer AG*, irrigation technology company *Netafim*, global reinsurer *Swiss Re* and the *International Finance Corporation* (*IFC, Worldbank Group*), have joined forces to form the *Better Life Farming* initiative in order to find holistic, market-based solutions for improving the productivity of farmers in developing countries" (*Cosgrove, 2017*).

If you are going for technology transfer as a game-changer for new agribusiness, such as bioeconomy you should follow the recommendations given by *Borge and Bröring* (*2018*). In this multi-stakeholder concept it is underlined, that the highly interdisciplinary emerging knowledge area requires a combination of cross-disciplinary, inter-sectoral and multi-stakeholder collaborations to enable successful commercialization (*Maine et al.*, *2014*). The integration of knowledge and competence of all involved stakeholder groups is pivotal for implementing the technology transfer process in an appropriate time.

## 29. CONSUMER INTERESTS

Today, and in the future, consumers expect to get healthy and affordable food and goods from agriculture. But more and more, consumers want to know what was mentioned under "***consensus***". Without the license to produce, there is no chance to implement innovations in agricultural production systems.

Nevertheless, consumer societies, organizing their own passiveness and only considering their own interests, should not make decisions for developing countries. Well-fed people in developed countries may have problems, but hungry and malnourished people in a lot of developing countries have only one – how to feed themselves and their families.

However, new technologies oftentimes suffer from a lack of public acceptance, because the issues are multi-complex. But scientist must learn to demystify science for the general public and demonstrate the pros and cons of the presented innovation. Journalists and the media are instrumental in facilitating the process of communication between science and the public at large.

## 30. CONCLUSION

The task ahead of us is to develop new technologies in an economically sound and ecologically sustainable way in compliance with the corresponding standards and values. In this process, it is important to develop environmentally sound solutions that address the requirements of the innovators and producers, the needs and interests of consumers, and the collective needs of societies. We will be entitled to make use of new technologies in agribusiness only if a harmonious balance is achieved in the three key areas: our planet, mankind, and profits.

By pushing the techno-cultural innovation forward in agriculture

through appropriate technologies by creative and responsible scientists, the changing world will be able to address the Vision: "**Factor F**$^{n}$ ("**FFFF FFFF FFFF FFFF**"): **F**uture **F**arming, **F**ood, **F**eed, **F**itness, **F**uel, **F**iber, **F**lowers, **F**reshwater, **F**ishery, **F**orestry, **F**lora, **F**auna, **F**un, **F**ortune, **F**reedom, which are milestones on a roadmap for tackling the challenges of the 21$^{st}$ Century (*Kern, 2010, 2012*).

**The all overall key challenges ahead of all stakeholders should be kept in mind:** "We have to deliver "values" in good time to farmers, to agricultural production systems, to the society and the environment!

### *Furthermore, we should reflect the following:*

"Quae sint in quoque agro serenda ac facienda, quo terra maximos perpetuo reddat fructus" *Varro, M.T.*, *Rerum rusticarum (First Century BC)*.

When he wrote these words, ***Marcus Terentius Varro***, a Roman landowner of the first century BC, was eighty years old and had recently remarried. *Rerum rusticarum*, one of a number of Latin treatises on agriculture to survive to the present day, was written for his wife as a handbook of advice on how to run the estate he had purchased for her. In this passage he defines, for the first time, the concept of sustainability.

He says: "Agriculture is a science which teaches us what crops are to be planted in each kind of soil, and what operations are to be carried out in order to that the land may produce the highest yields in perpetuity".

Or '*sustainability*' in other words: "As for the future, your task is not to foresee, but to enable it" *(The Wisdom of the Sands, Saint-Exupéry, 1948).*

Agriculture will be a new global mega-trend in the coming decades, and will be triggered by sustainable food and feed, fiber and energy production! Urbanization, globalization, planetarization (*PSL University Paris, International Conference 2018*), increasing aging of societies (*Veselkov et al., 2019*), changing eating patterns, new cutting-edge technologies and climate change will shape the whole of agriculture – from cellular agriculture, field agriculture, green house agriculture, agri-robotic agriculture via urban agriculture and vertical agriculture to space agriculture.

The agribusiness sector has to reflect all these parameters and generate the capability to be in line with the following vision 2050:

### *Vision 2050:*

**C**n: **C**apability, **C**apacity, **C**ourage, and **C**ompetence to implement a functioning bioeconomy

- Installation of **F**ossil **F**uel **F**ree **F**arming (**F**4) systems
- Implementation of biotech/cellular/robot/digital farming systems
- Installation of space-based production systems
- N2-fixation from the atmosphere by all key crops
- Drought resistance of all key crops
- Doubling of crop production
- Tripling of plant based protein production (food & feed)

- Tripling of greenhouse production systems
- Tripling of fruit and vegetable production
- Tripling of pollination services
- A functioning personalized nutrition system
- Installation of space agriculture

***"Zero" hunger in 2060.***
***Vision - what does it mean?***

Visions are outlines of the future made visible, showing us pathways into the future and stimulating us to take positive and courageous action.

- The word "Vision" has its roots in the Latin word "visio" and is connected with "to see", "to appear", "to have an idea of", and "to form a picture of what lies in front of us".
- To "have a vision" is ultimately nothing other than "making ideas visible". This means: What do we have to do, what must we bring about – and when, where and how?
- To "implement a vision" means a constant willingness to learn, a sense of responsibility, setting a positive example, being credible, and engaging together with others in constructive actions (Kern, 2010).

***Last, but not least, we need a spiritual guide (****Kern, 2018c****):***

- The world needs leaders looking ahead and not reacting lightly, who are inspired and not only about the feasible but who think long term for future generations of which we have only borrowed the present.
- The world needs leaders who are empowered by a vision, inspired by ethical considerations and possess the political courage to look beyond the box of the next elections.
- The world needs leaders who make accountable and responsible decisions, although there is discontinuity, instability, uncertainty, incalculability and unpredictability in order to avoid chaos, anxiety and to safeguard a positive future.

***Personal Remarks***

The chief editor of this book, Prof. Dr. Rishi Kumar Behl, Assoc. Dean Retd., CCS Haryana Agricultural University, Hisar, Haryana, India is the awardee of the ***Bharat Ratna C. Subarmanyam*** award - the highest civilian award in India, for outstanding teachers in the field of plant sciences in 2018!

***Personally, I could learn a lot from him – my deepest thanks!***

* In the year 2052, the author would be 100 years old.

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## DR. MANFRED JAKOB KERN

Dr. Kern was born in Bodenheim/Rheinhessen, Germany, where his family operated a wine-growing estate. He is married and has two daughters.

He did study zoology, botany, physiology, biochemistry, microbiology, wine chemistry and genetics at the Johannes Gutenberg University in Mainz, Germany.

In 1982 he earned his doctorate in Mainz on the subject of "Brain Aging in Insects".

Two years later he joined Hoechst AG in Frankfurt, where he worked in Biological Research Department (Crop Protection) in the areas of insect physiology, resistance, selectivity and integrated pest management.

In 1995 he became global head of the project "Future of Agriculture: Vision

2025/2050", a comprehensive and still running study on the safeguarding of world food supplies.

When Bayer CropScience AG was set up in 2002, Dr. Kern headed the Department of Executive and Technology Communications. Since 2005 he was Global Head of Business Relations at Bayer CropScience AG in Monheim/ Germany. Since 2010 he was Head of Project: Agriculture 2025/2050 at Bayer CropScience Germany GmbH in Langenfeld.

Over the foregoing 30 years he has held key positions in science and technology, strategy, marketing and communications.

Since 2004 he is teaching as Senior Fellow of the Centre for Development Research (ZEF) at the Rheinische Friedrich-Wilhelms-University of Bonn/ Germany.

Since 2011 he is managing director of agriExcellence e.K. (former agriExcellence GmbH), an international communication & consulting company in the field of global agriculture, located in Lörzweiler, Germany.

Dr. Kern has more than 160 publications to his credit and has given over 1200 presentations at international congresses, conferences, symposia and workshops.

He was awarded by different organisations for significant accomplishments in the field of innovations in agriculture.

In 2007, the secretariat of UNCCD (United Nations Convention to Combat Desertification) recognized Dr. Kern by upholding his title as *"Eminent Person"*.