ESTIMATING THE OPPORTUNITY COST OF CONSERVATION TILLAGE ADOPTION AS CLIMATE CHANGE MITIGATION OPTION IN TANDJOARE-TOGO

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BACKGROUND & OBJECTIVES

The economic development of developing countries depends on the performance of the agricultural sector, and the contribution of this sector depends on how the natural resources are managed. Unfortunately, in majority of developing nations, the quality and quantity of natural resources are decreasing resulting in more severe droughts and floods (Fikru, 2009). It is possible to achieve the objective of sustainable production in agriculture while solving the problem of soil erosion, natural resource degradation and related problems through some agricultural practices like conservation tillage. Conservation tillage has been tested in US and was declared as "win- win -win" strategy by President of the Soil Science Society of America, Professor Rattan Lal (Ohio State University) because it mitigates climate change, improves productivity and enhances ecosystems". Also conservation tillage practices helps improving soil quality through the degradation of organic matter which are left on the soil surface for a given period before planting date. Many study are conducted world widely but there are very few studies which have estimated the cost of conservation agriculture adoption and factors explaining the opportunity cost of adoption of this climate smart practice by farmers in Tandjoare-Togo. This study is an attempt to fill this gap by analysing the adoption decision of farmers and factors that motivate farmers to receive a payment to renounce tillage and other practices which increases land degradation. Also this study will help Tandjoare-Togo farmers in their choice of farming methods to use to improve their land quality, the agricultural output, their livelihood and mitigate climate change.

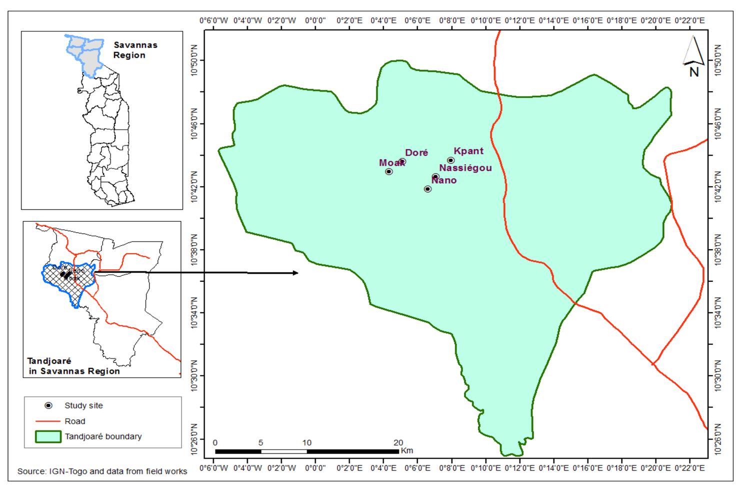
This study aims to estimate the opportunity cost of conservation tillage adoption and factors explaining this opportunity cost in Tandjoare-Togo.

ACTIVITIES

The activities of this study consist of data collection procedure and data analysis.

DATA AND STUDY AREA

This study uses primary data collected from farmers in april 2014 when they have just finished harvesting.450 farmers were surveyed in Tandjoare. The following villages were surveyed. Dore, Moak, Kpante, Nassiegou and Nano.



Study area Map

Methods and Econometric tool used to estimate the opportunity cost and its explanatory factors.

A contingent valuation approach was used to get the opportunity cost and the Heckmann two step model was used to estimate the explanatory factors of the opportunity cost.

Variables used in the study

The dependent variables is C-CT ADOTP(Opportunity cost of conservation tillage adoption)

The independent variable are age, gender, farm size, income, awareness to climate change, awareness to conservation tillage goodness, familly labour availability and hired labour availability, increase in rainfall length and increase in temperature, access to credit, soil fertility and ethnicity.

The questionnaire

To estimate the opportunity cost of conservation tillage adoption we ask farmers who are not willing to adopt conservation tillage the amount of payment they were willing to receive to adopt conservation tillage. This means that the opportunity cost of a farmer who is willing to receive a payment before adopting conservation tillage opportunity cost is higher than zero and that of the farmers who is willing to adopt the new farming system without payment opportunity cost is equal to zero. Thus, the heckman two stage model helps in estimating coefficient of factors explaining the opportunity cost of adoption since this cost is obtained from farmers who are not willing to adopt conservation tillage.

Econometric tool

The Heckman selection model was developed to study the factors explaining the opportunity cost of conservation tillage adoption in Tandjoare-Togo.

RESULTS

1 Estimation of the cost of conservation tillage adoption in Tandjoare-Togo

According to the survey results the mean opportunity cost of conservation tillage adoption is about 31,35 USD per year. The estimation of the cost of conservation tillage adoption in Tandjoare-Togo is made possible by extrapolating the results from the sample to the population. Therefore the economic cost is obtained by multiplying the mean cost by the total population of farmers in Tandjoare-Togo. According to The statistics in Togo farmers population in Tandjoare-Togo is about 39,190. Thus we obtain a cost of 125,431USD per year. The amount obtained in CFA is then converted to dollars with the mean exchange rate obtain in April 2014.

CT = Mean WTA * N

CT = 14,832, 24 * 39 190

CT = 581.275.485, 6 F CFA

= 125,431USD

The estimation of the Heckman two stage model shows that factors such age, Income, increase in Soil Fertility, Access to credit, and an increase of temperature positively affect farmers opportunity cost for adopting conservation tillage while the variable education, Farm Size, Family Labour Availability and Hired Labour and Awareness of the Benefits of Not Tilling, Awareness of climate change negatively affects farmers opportunity cost.

LESSONS-LEARNED & RECOMMENDATIONS

We found that the total cost of conservation tillage adoption in Tandjoare-Togo is about 125,854.00 USD yearly.

Furthermore, we found that education and awareness of not-tilling benefits could substantially contribute to the acceptance of conservation tillage at lower costs. These results show that training and advocacy may reduce the opportunity costs of protecting the environment and creating green jobs in agriculture while promoting bio-economy since the use of cultivation systems under conservation tillage increases the degradation of organic matter in the soil surface which enrich the soil.

REFERENCES & ACKNOWLEDGEMENTS

Abdalla M., Osborne B.,G.Lanigan, D.Forristal,M.Williams,P.Smith &M.B.Jones (2013), Conservation tillage systems: a review of its consequences for greenhouse gas emissions, Soil Use and Management doi: 10.1111/sum.12030,pp2.

Astatke, Abiye, Mohammad Jabbar, and Douglas Tanner. 2003. "Participatory conservation tillage research: an experience with minimum tillage on an Ethiopian highland Vertisol." Agriculture, Ecosystems & Environment 95 (2-3): 401-415.

Brabant P. et al., 1996 ; Etat actuel de dégradation des terres au Togo

Fernandez-Cornejo J. , Ch. Hallahan, R. Nehring, S. Wechsler, and A. Grube(2013),Conservation Tillage, Herbicide Use, and Genetically Engineered Soybeans in the U.S.A., ISB News report.

Heckman J. 1979. Sample selection bias as a specification error. Econometrica 47:153-161.

Langmead, P. 2001. Does Conservation farming really benefit farmer? In GART Year book 2001, pp.58.64. Lusaka, Zambia: Golden Valley Agricultural Research Trust

CLIMATE CHANGE AND SUSTAINABLE ECONOMIC DEVELOPMENT:A CASE STUDY OF THE HORTICULTURAL CONVENTIONAL AND ORGANIC FARMING SYSTEMS IN THE NIAYES REGION IN SENEGAL.

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BACKGROUND / INTRODUCTION

Climate change is one of the most important issues that the world is currently facing. The concept of "Bioeconomy" has recently emerged and is becoming a common term much used in discussions around solutions to a growing number of environmental and economic challenges, including climate change. The aim of the bioeconomy is to help keep world economies competitive, innovative and prosperous, by providing sustainable, smart and inclusive economic growth and jobs, and by meeting the need of a growing population whilst protecting our environment and resources.

Horticulture production in Senegal is an important economic activity that is mainly located in the Niayes zone which is the Atlantic coastal stretch between Dakar and Saint-Louis. The increasing use of chemical fertilizers and pesticides to meet a growing demand has led to a number of environmental issues. Therefore, the rising level of environmental hazard from conventional farming has made it attractive to farmers in the Niayes to adopt sustainable farming system based on organic farming. Moreover, the development of organic farming in the area will not only help producer to get more profit in a sustainable way, but it will give also new business opportunities to livestock farmers through the sale of organic manures and to some industries that are madding irrigation engines based on renewable energies such as wind and solar.

MATERIALS AND METHODS

A whole farm model is used to study the economic and environmental performances of the organic farming system compared to the conventional farming system in the horticultural production system in the rural community of Diender in the Niayes region in Senegal. The analysis is undertaken in two representative farms (conventional and organic). Gross margin is regarded as economic indicator while carbon emissions are regarded as environmental indicators.

We conducted a survey on a sample of 40 farms consisting of 20 each from conventional and organic farms. A farm of 1.5 ha from each system (organic and conventional) is selected as a representative farm in the study area to apply linear programming approach that reflects the situation of organic and conventional farming systems. Data is also collected through semi-structure interviews with experts, heads of farmer's organizations, marketers and focus group discussions.

PRESENTATION OF THE STUDY AREA

Located in the southern half of the Sahel, the climate of this Sahelian area is characterized by a long dry season from October to June and a short, three month rainy season.

The Niayes is a region or depressions between dunes from which it takes its name and is characterized by shallow basins with rich soils that are favorable for a wide variety of horticultural production.

OBJECTIVES

The main objective of the study is to investigate the present production and marketing systems of off-season vegetables in the Niayes so as to analyze the potential of organic farming to enhance framers' productivity and to boost the development of the bio-economy in Senegal. Consideration of the general objectives above led to the following specific objectives:

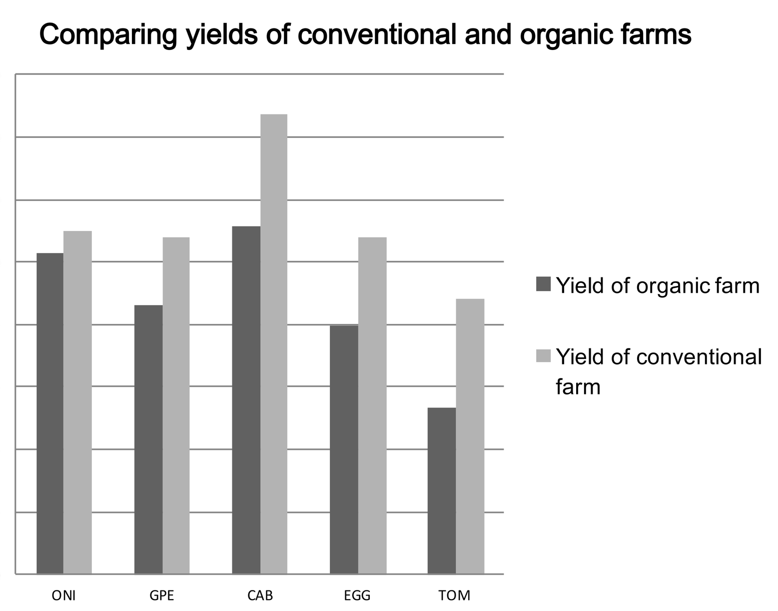
- To conduct a detail investigation of the current status of production and marketing systems of the vegetable industry in the Niayes Region.
- To analyze the economic performances of organic farming compare to conventional agricultural system in the horticulture sector;
- To analyze the environmental performances of both conventional and organic farming systems;

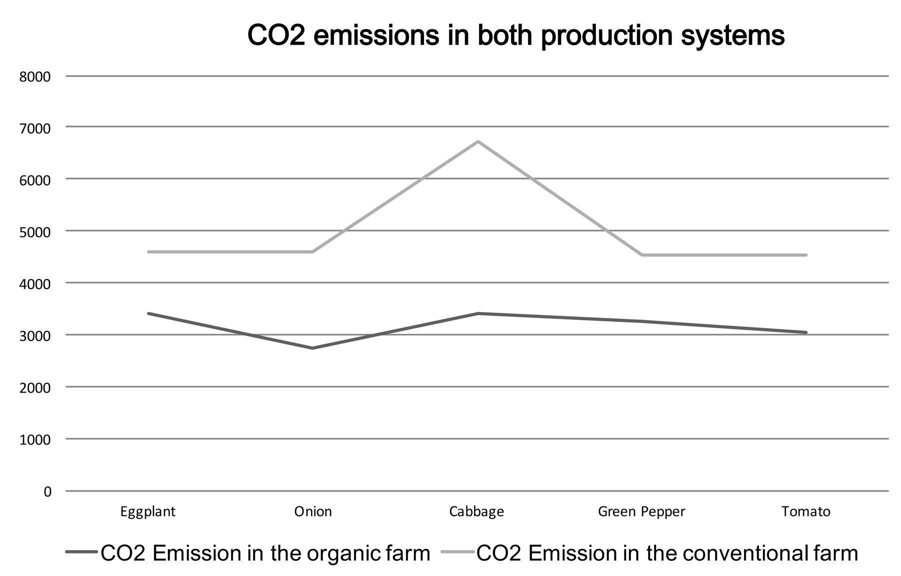
RESULTS

The findings of the study reveal that vegetable production and marketing is a very attractive enterprise for farmers and marketers. Simulation results indicate that the conventional farming system is still more attractive to farmers in the Niayes compare to the organic farming system.

But, environmental results in terms of carbon emissions reduction and carbon sequestration reveal that the organic system is found to be more effective in mitigating climate change. The organic system is found to be less emitter of carbon dioxide.

In addition, simulation results show that there is a "win-win" situation for conventional farmers when they partially adopt organic farming system. The adoption of organic farming has also led to new business opportunities for livestock farmers, specifically poultry farmers who sell the poultry dung to organic farmers. Besides, organic farmers are progressively using irrigation engines based on renewable energies such as wind and solar.





LESSONS LEARNED / RECOMMENDATIONS

From this study, we have learnt that horticulture production is an important economic activity in Senegal which is very beneficial to farmers and marketers. In addition, we have learnt that organic farming can help actors of the sector to move toward a more sustainable production in the face of climate change.

Our study suggests that, through appropriate investment in agro-ecological research to improve organic management and the establishment of a local market for organic crops, organic farming can become a competitive alternative to conventional farming, when it comes to healthy food production with less environmental impact in the horticultural sector. In addition, specific actions are needed to promote bioeconomy research and innovation to help the country to move toward a better and more sustainable economic development.

Substituting some Technological Links of the Wheat Classic Yielding System with Bioeconomic Technological Models

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BACKGROUND & OBJECTIVES

Apparently, obtaining high yields in wheat crop is determined by two major factors (Teixeira Filho et al., 2011):

1. the use of varieties with high productive potential;
2. the implementation of an optimal nitrogen management.

It is already known that the optimum nitrogen supply is essential not only for high wheat yields, but also for an increased level of protein (Orloff et al., 2012), so for a better quality.

Furthermore, we can say that all the technological links are important and connected to each other. It has been found that the wheat crop can be directed toward a version which corresponds, as faithfully, to a bioeconomic model for the future simply by changing/substituting certain managerial actions (Berca, 2011).

Additionally, this system would have a triple positive effect, reflected in:

- increasing the company profits;
- ensuring population food security – high yields with high quality, for long periods of time (Berca et al., 2012);
- protecting the environment and the natural resources involved.

These so called effects or results can also be considered as objectives, since they emerge from the main aim of the research, that of demonstrating that the transition to the conservation agriculture is a necessary step on our way to a bioeconomic agriculture and this must be done using natural patterns.

ACTIVITIES

Long-term research conducted in an area from southern Romania with classic and conservation agriculture systems aimed to demonstrate that crop rotation, tillage, nutrition and maintenance systems (diseases, pests, weeds control) can bring, by substitution, significant benefits in favour of the biological agricultural economy.

The study began 11 years ago in a farm with a surface of 1200 ha. In order to avoid monoculture, it has been proposed a rotation of four crops that succeed: rape – peas – wheat – corn (sunflower). Effects of avoiding monoculture have immediately appeared, especially in diminishing the diseases, pests and weeds percentage.

Continuing, conventional tillage system has been substituted by a new, conservative one – plowing and disking removal, replaced by a scarification work at every 3 years, followed by grubber works in vertical plan.

An essential part of the whole algorithm is represented by the crop nutrition, mainly by the nitrogen one for wheat, since it directly affects the quantity and the quality of the yields.

Thereby, a part of the nitrogen currently applied from bag (synthesis nitrogen) has been replaced with biological nitrogen, obtained from the input provided by using peas as preceding plant (130 kg N/ha, which means an average of 32.5 kg N/ha/year) and by the association made by wheat with the *Azospirillum brasilense* bacteria (90 kg N/ha, namely an average of 22.5 kg N/ha/year). In total, the amount of nitrogen substituted is 55 kg N/ha/year.

RESULTS

In order to emphasize the actual results of the proposed pattern, it has been chosen the graphics presentation, as seen in Fig. 1.

Under the spirals, the conservation interventions on the technological links, per steps, are inserted.

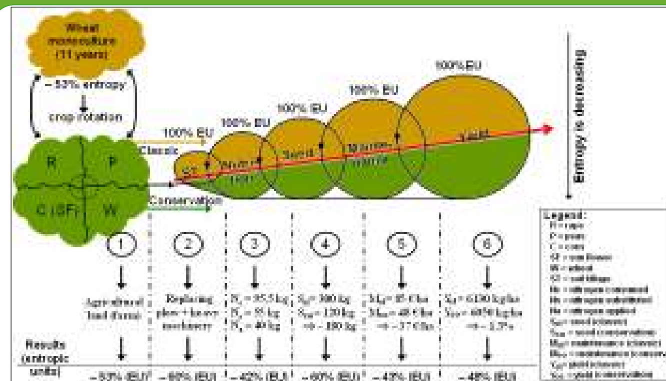

Fig. 1. The entropy decrease and the bioeconomic value increase of a crop rotation system in southwestern Romania – Burnas Plain

It is shown that a 4 years crop rotation system, compared with a wheat monoculture, reduces with about 53% the problems, by decreasing the entropy (expressed in entropy units), calculated using the Boltzmann constant from the equation:

$$S = k \ln W \qquad (1)$$

, where: S = entropy (in EU, entropic units);
k = Boltzmann constant, with a value of 1,3806504 x 10^{-23} JK^{-1};
W = disturbed energy value (negative effects of classic agriculture).

Replacing the classic tillage system with a conservative one will decrease entropy by 60%, so this is the plus in value and energy.

For nitrogen nutrition, 42% is earned from atmospheric nitrogen, obtained as presented in the "Activities" chapter.

On the 4th step, the entropy decreases with 60% only by using a high genetic seed, with good twinning and resistance to biotic and abiotic factors, leading to a reduction of 180 kg seed/ha.

Regarding crop maintenance, reducing the number of treatments offered another 43% in anthropic value.

For the entire period (11 years), the average yields for both systems are around 6000 kg/ha, with only 1.3% in favor of the classic version, so with a negligible difference.

LESSONS-LEARNED & RECOMMENDATIONS

1. Using conservation agriculture, the crop ecological value increases, on average, by 51% (percentage of entropy reduction). Yield remains constant. The same inputs of nitrogen fertilizers and energy have been used. Only the applied doses were different.
2. Substituting synthetic with natural nitrogen has been possible to a rate of about 42%.
3. Increasing ecological value of wheat technology, correlative with the entropy reduction into the system, can be identified as having a contribution of over 50% to the sustainable development towards bioeconomic agriculture.

REFERENCES

1. Berca M., 2011 – *Agrotehnica – transformarea moderna a agriculturii*. Ceres Publishing House, Bucharest
2. Berca M. et al., 2012 – *World's and Romania's Food Safety Insurrance*. Ceres Publishing House, Bucharest
3. Orloff S. et al., 2012 – *Nitrogen Management Impacts on Wheat Yield and Protein*. Proceedings of the 42nd California Alfalfa & Forage Symposium, 103-109
4. Teixeira Filho MCM et al, 2011 – *Application times, sources and doses of nitrogen on wheat cultivars under no till in the Cerrado region*. Cienc. Rural, vol. 41, no. 8, Santa Maria

FACTORS EXPLAINING LAND ALLOCATION DECISIONS OF JATROPHA CURCAS BY SMALLHOLDER FARMERS IN NORTHERN GHANA

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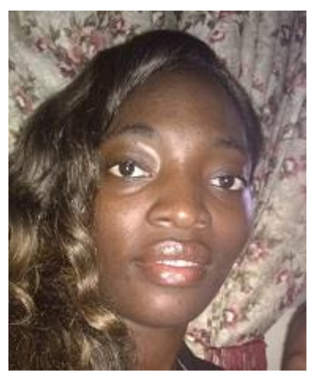

BACKGROUND & OBJECTIVES

The Jatropha projects started in Ghana from 2005-2006 and there are about seventeen commercial biofuel developments (Schoneveld et al. 2011). Over twenty foreign companies acquired land to cultivate non-food crops and other crops for ethanol and biodiesel production in Ghana mainly for exports (Dogbevi, 2009). In developing countries, the consequences of Jatropha development raises the issue of the negative impact of high food prices due to the increased competition from biofuels for agricultural output and resources on income poverty and food security (FAO 2008). If energy crops are located on marginal land, they can integrate and complement conventional food crops cultivation rather than conflicting with them (Caracciolo and Lombardi 2012). The use of marginal lands could also avoid the displacement of food crops from fertile agricultural land and hence reduce associated negative impacts of land use change (FAO 2008). The cultivation of Jatropha on marginal lands could so avoid the stress on food availability. The conflict food vs fuel could be solve by intercropping food and energy crops (Janssen et al. 2009) and defining the amount of land that should be used for biofuel production (Escobar et al. 2009).

The main objective is to assess the factors explaining land allocation decisions of Jatropha Curcas depending of the type of land (fertile and marginal land) in Northern Ghana

ACTIVITIES

According to Bocquerot et al. (2011), the adoption problem of a perennial crop such as Jatropha can be divided into three different decisions:

- participation stage to Jatropha activity (a decision-making stage of adopt of not to adopt stage),
- amount of land allocated to the activity (a decision-making stage of land allocation) and
- location of the activity on marginal or non-marginal land (a further decision making of land location).

The participation variable on fertile land is denoted by yi and the participation variable on marginal land is denoted by zi. They are binary variables taking on the value 1 if the farmer i grows Jatropha on the given land type and 0 otherwise.

We assume that the two decisions are taken jointly, and thus that some unobserved factors may influence both decisions

We deal with this joint decision by estimating a **bivariate probit model**. Let Xi be a vector of all observable explanatory variables (farmer and farm characteristics, farmers' individual preferences). The bivariate probit is written:

Participation equation for fertile land: $y_i^* = \beta X_i + \varepsilon_i \qquad y_i = \begin{cases} 1 & \text{if } y_i^* > 0 \\ 0 & \text{otherwise} \end{cases}$

Participation equation for marginal land: $z_i^* = \alpha X_i + v_i \qquad z_i = \begin{cases} 1 & \text{if } z_i^* > 0 \\ 0 & \text{otherwise} \end{cases}$

Where β and α are vector of parameters to be estimated and ,v_i and ε^1 are random error terms.

DATA

Primary data have been used . The sample size consists of 400 farmers (200 adopters and 200 non- adopters) in Northern Ghana.

Adopters: The stratified two stages random selection has been used.

The initial population of this study consists of a pool of farmers from 14 communities involved in the Ghana Jatropha (GHAJA) project in the West Mamprusi District (Northern Region). **1st stage:** We randomly selected 10 communities within the 14.

2nd stage: We randomly selected 20 adopters within each community from the GHAJA List of Jatropha growers

Non Adopters: 20 non adopters have been selected within each community

EXPECTED RESULTS

- We expect off farm income and livestock to be significant and negatively influence Jatropha adoption on marginal and fertile land in the sense that getting off farm income and having livestock lead to not view Jatropha production as an attractive activity because their marginal land is already used for fodder.
- Farm experience is expected to be significant and to have negative effect on Jatropha land decision making on fertile lands. The more the experience farmers' have in agriculture, the less they allocate fertile land to non food bioenergy crops such as Jatropha.
- Group membership is expected to influence positively marginal land allocated to Jatropha and negatively fertile land allocated to Jatropha. In the sense that, being member of a group leads to acquire knowledge on some new crop like Jatropha, its opportunities and challenges too. The Group could provide advices to members in growing on marginal land

LESSONS-LEARNED & RECOMMENDATIONS (POTENTIAL OUTCOMES)

- Understanding drivers of and barriers to perennial bioenergy crop adoption would be highly relevant for food security. We recommend that policymaker promote bioenergy crops adoption on marginal land rather than fertile land to avoid food security issues.
- Policy could focus on enhancing household's capital because a farmer who do not get off farm income or livestock will need capital to start Jatropha activity whatever the type of land. This could be done by facilitating the access to credit.
- We could recommend policymakers and processors to target areas where farmland is heterogeneous, adoption being more probable on marginal land than on fertile land. Promoting these crops in areas where growing conditions are too drastic may be useless because farmers would be paralyzed by the fear of loosing the whole plantation.

REFERENCES & ACKNOWLEDGEMENTS

Bocquehot et al. (2011), Determinants of miscanthus adoption: an empirical investigation among French farmersPaper submitted to the the 5èmes Journées de recherches en sciences sociales INRA / SFER / CIRAD December 8-9, 2011 - Dijon, France.

Caracciolo, F. and P. Lombardi (2012), A new-institutional framework to explore the trade-off between agriculture, environment and landscape. *Economics and Policy of Energy and the Environment* 3:135-154.

Escobar, J.C., Lora, E.S., Venturini, O.J., Yañez, E.E., Castillo, E.F. (2009), Biofuels: Environment, technology and food security, Renewable and Sustainable Energy Reviews 13, p. 1275-1287.

FAO (2008), Biofuels and agriculture – A technical overview, in The state of Food and Agriculture 2008. Biofuels: Prospects, risks and opportunities. Rome: FAO.

Janssen, J., Rutz, D., Helm, P. (2009), Bioenergy for sustainable development in AfricaEnvironmental and social aspects, A paper presented at the 17th European Biomass Conference, 29June-3 July 2009, Hamburg, Germany.

Schoneveld, G.C.,German L. A., Nutakor, E. (2011), Land-based investments for rural development? A grounded analysis of the local impacts of biofuel feedstock plantations in Ghana. Ecology and Society. 16(4), pp. 10.

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Diversifying Food Systems - Horticultural Innovations and Learning for Improved Nutrition and Livelihood in East Africa (HORTINLEA)

HORTINLEA
DIVERSIFYING FOOD SYSTEMS

Food Systems Overview Poster

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Problems of Food Security

Hunger and malnutrition: Approximately 900 million people suffer from hunger worldwide, and 2.5 billion from micronutrient deficiencies due to low intake. In Kenya, one third of the population is malnourished.

Poverty: Nearly half of the country's 43 million people live below the poverty line. More than three quarters of the population lives in rural areas.

Biodiversity: 90% of the calories in the human diet come from 15 crops and 60% from 3 crops (wheat, rice and maize).

Climate: Kenya is already extremely susceptible to climate-related events. Droughts and floods in particular are having a devastating effect on the environment, society and the wider economy.

General Potential of Horticulture

Provide essential micronutrients to millions of people and

- Reduce child mortality and improve maternal health
- Improve immune systems and reduce prevalence of infectious diseases in population
- Reduce obesity and related diseases
- Reduce anaemia

- **Become an engine for economic growth (Vision 2030),**
  - providing a lucrative market
  - offering opportunities for women and youth
  - generating new income opportunities by value added activities

- **Contribute to biodiversity of agricultural production systems**

The underutilised potential of indigenous vegetables

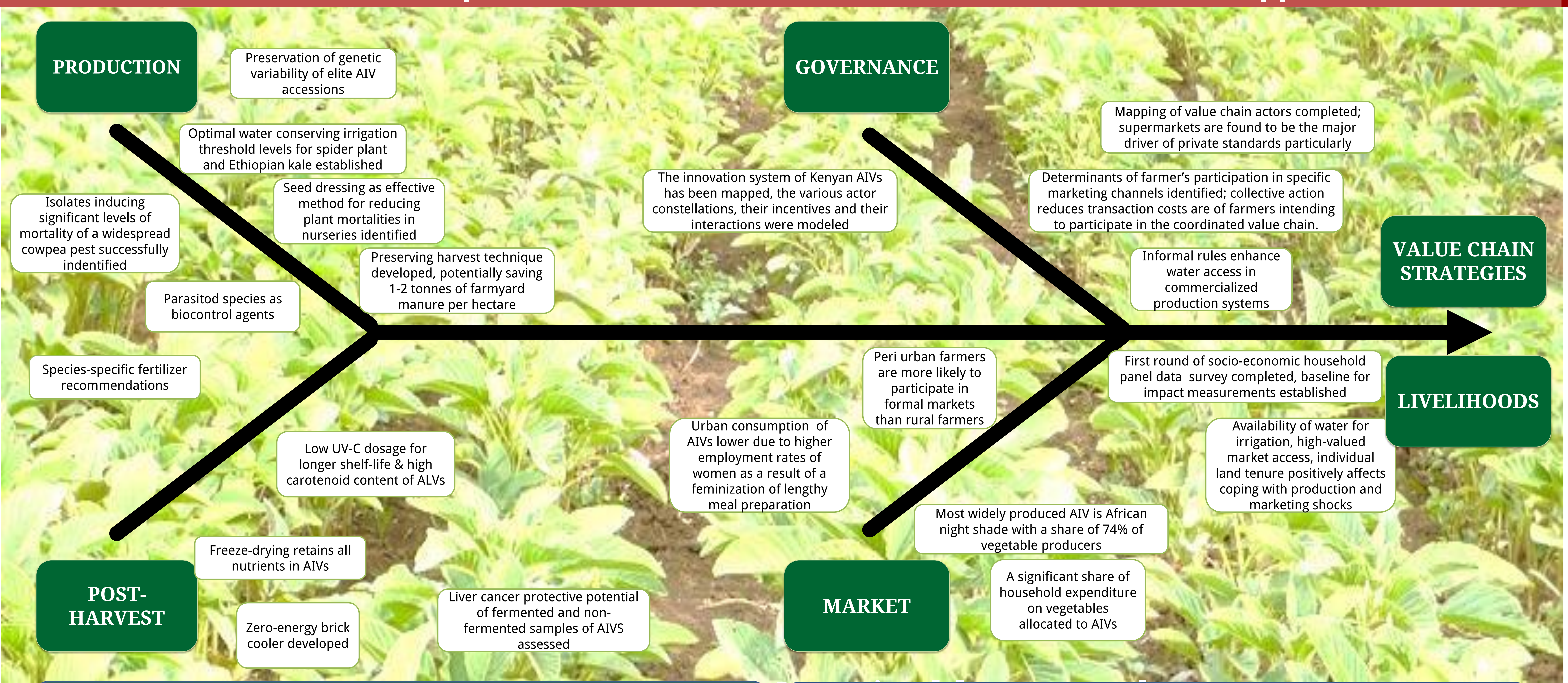
Production:
- Crop yields and quality are below their potential,
- Poor distribution of farm inputs, high input prices,
- Shortage of water, unreliability of rainfall.

Postharvest handling, processing:
- Processing and other value-addition activities are poorly developed,
- Food losses of up to 50%.

Marketing
- High prices, inadequate infrastructure, poorly organised markets.

Consumption
- Per capita consumption is much less than required - 31 kg compared to 73 kg
- Consumption habits, sociocultural factors and lack of knowledge negatively affect consumption

Value chain development: Selected innovations and results (Fishbone approach)



A locally adapted trans- and interdisciplinary research approach to food security

Solving multidimensional problems of food security requires research that addresses the following aspects:

1) **Interdisciplinarity:** Integrating contributions from water management, soil science, plant physiology, plant nutrition, post harvest processing, nutritional sciences, marketing, development economics, climate science, agricultural science, gender studies, resource economics, development studies, political science, communication.

2) **Participation and locally adapted solutions:** All activities are joint achievements by a diverse range of stakeholders, from the inception of the approach to the utilisation of results. The proposal was developed jointly by researchers from Kenya and Germany (18 partner organisations). PhD research almost exclusively with young candidates from Kenya who will embark on careers in the Kenyan agrifood sector and science in the future.

3) **Dissemination:** In order to enable real changes, the elaborated knowledge will be problem orientated, relevant, applicable, gender sensitive and financially affordable to the target group of poor farmers. It will be communicated, translated and understood by the recipients, i.e. the policy makers and/ or practitioners or by suitable knowledge brokers.

Selected project results

1) **Project specific outcomes:**
- 25 flexibly adapted bilateral subcontracts and a cooperation agreement with 18 partner organisations from Kenya, Tanzania and Germany.
- 14 deliverables completed, 59 on track
- Project expenses until 2014 at 40% of overall 3-year budget.

2) **Scientifc-technical results:**
- 15 peer reviewed papers published or submitted, 67 in planning.
- Partnerhips in knowledge dissemination with GIZ- ITAAC, Bioversity International, Kenyan Ministry of Agriculture, KALRO, Sustainet, KENRIK, KAPAP
- Approx. 31 young scientists (mostly) from Kenya and Germany active in project
- First round of socio-economic panel data survey with 1,500 households in southwest – Kenya completed
- Comprehensive transdisciplinary study of the innovation system of African leafy vegetables in Kenya

Project HORTINLEA is funded by the German Federal Ministry of Education and Research (BMBF) and the German Federal Ministry of Economic Cooperation and Development within the framework of the program GlobE – Global Food Security

Federal Ministry of Education and Research
Federal Ministry for Economic Cooperation and Development

A policy and research agenda for an Organic Agriculture Bioeconomy

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BACKGROUND & OBJECTIVES

Organic Farming (OF)

„Organic Agriculture is a production system that sustains the health of soils, ecosystems and people . It relies on ecological processes, biodiversity and cycles adapted to local conditions,rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved.“ (IFOAM 2008)

Bioeconomy

"The knowledge based production and use of biological resources, to provide products, methods and services in all economic sectors for a future capable economic system." (German national research strategy on Bioeconomy)

- OF is frontrunner for sustainable agriculture and food production. It is defined according to ethical foundations that are summarized in the IFOAM Principles.
- Bioeconomy originated in the efficient use of biomass for industrial purposes.
- Both concepts have overlaps, but also stark differences.
- With the increasing political and societal focus on Bioeconomy it makes sense to ask how an organic Bioeconomy is to be defined?
- We identify the foundations of a policy- and research agenda for an organic agrofood Bioeconomy (OB) consistent with the IFOAM Principles.

ACTIVITIES

Identification of possible foundations of an OB policy- and research agenda, by comparing the German national research strategy on Bioeconomy (BMBF s.a) with the IFOAM Principles. In this strategy five main activity fields for a Bioeconomy have been identified: Securing global nutrition, ensuring sustainable agricultural production, producing healthy and safe food, using renewable resources for industry, developing biomass-based energy carriers.

We took an in-depth look at each of the activity fields and asked how each of the four IFOAM Principles could contribute to them. The IFOAM Principles are:

- **Principle of Health:** OF should sustain and enhance the health of soil, plants, animal, human and planet as one and indivisible.
- **Principle of ecology:** OF should be based on living ecological systems and cycles, it should work with them, emulate them and help sustain them.
- **Principle of fairness:** OF should build on relationships that ensure fairness with regard to the common environment and life opportunities.
- **Principle of care:** OF should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment.

(Luttikholt 2007)

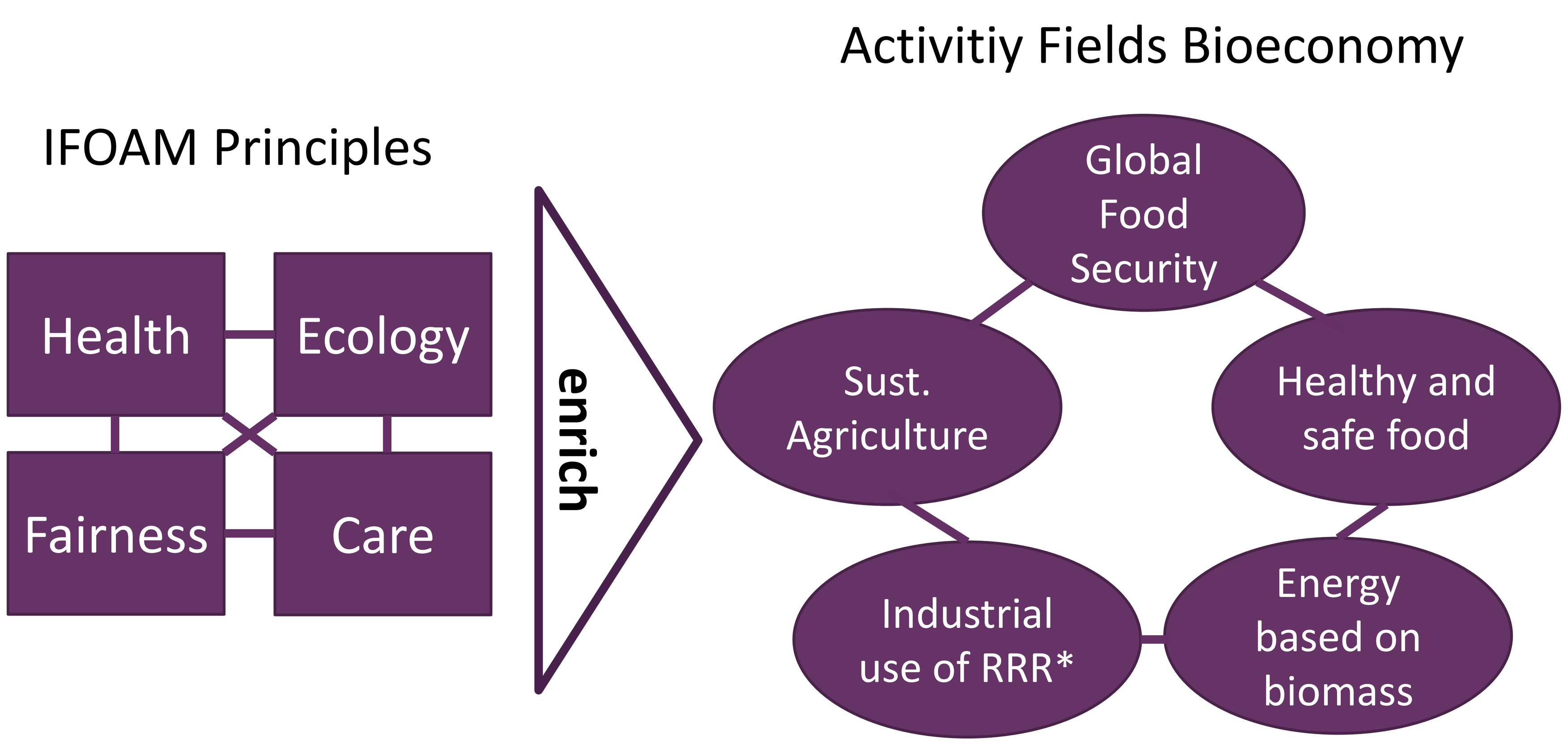

Figure 1: Contribution of IFOAM Principles to Bioeconomy – Activity field

The comparison enabled us to postulate first ideas about an OB policy and research agenda.

*Renewable Raw Resources

RESULTS–ELEMENTS OF AN OB POLICY

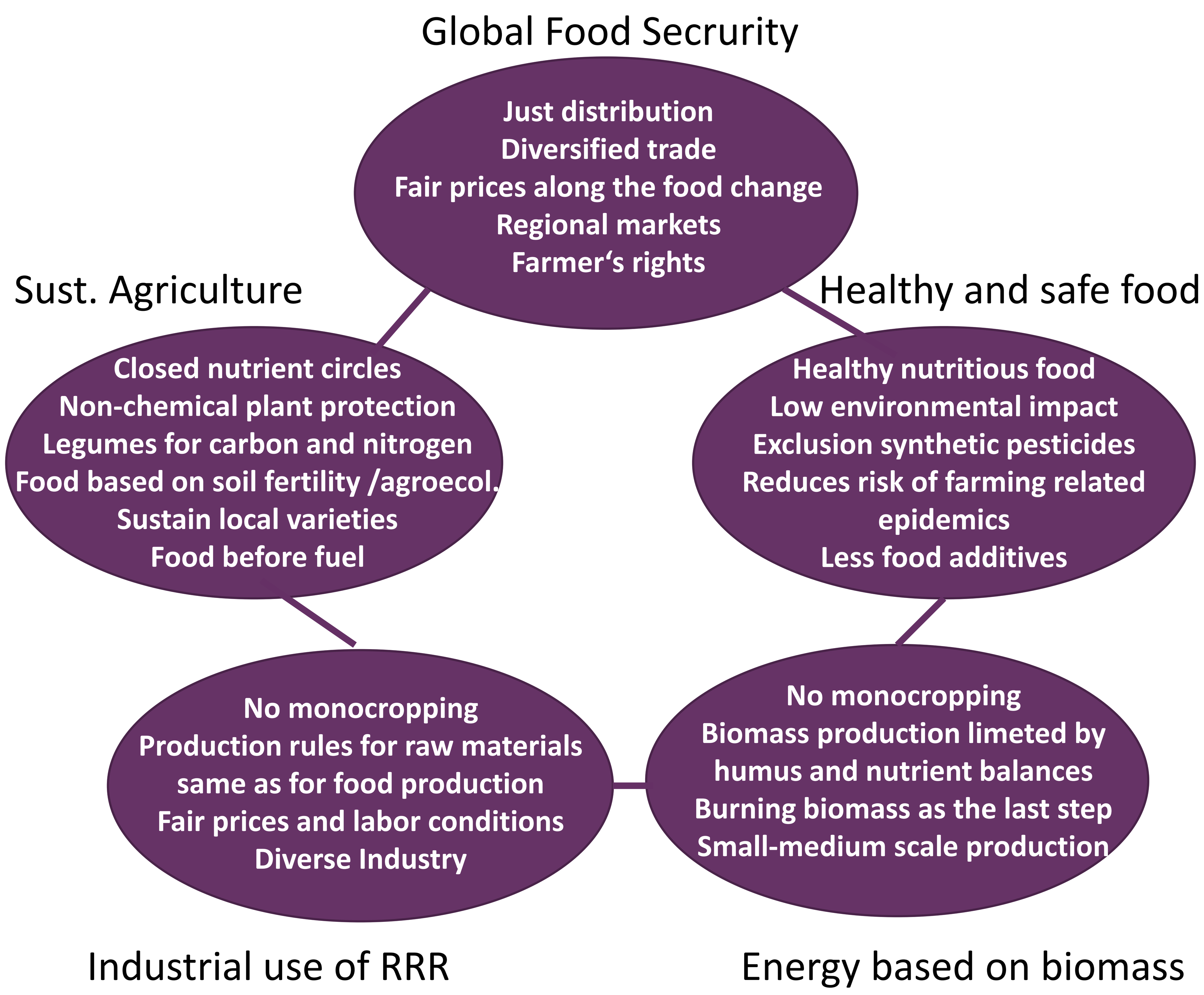

Figure 2: Important elements of on OB policy - grouped according to the five general Bioeconomy activity fields.

RESULTS-RESEARCH AGENDA FOR AN ORGANIC BIOECONOMY

- **Development of an detailed organic Bioeconomy concept on the foundation of IFOAM principles**
- **Development of guidelines for an organic Bioeconomy especially for non-food products**
- **Developments of techniques for production of RRR under organic conditions**
- **Assessment of RRR in regard of ethical and systemic impacts**
- **Work on integration of RRR and energy production in a broader OF system**
- **Extensive discussions with Stakeholders along the organic value chain about bioeconomy**

LESSONS-LEARNED & RECOMMENDATIONS

- OB differs from other conceptualizations of Bioeconomy because its ethical-systemic approach documented by the IFOAM Principles
- Potentials of an OB in general are not researched - consequences of this for policy has to be further develop with organic stakeholders
- A comparison between different Bioeconomies has to be studied within an ethical-systemic framework. Thus we are at the beginning to a deeper understanding of Bioeconomy conditions and consequences for human and nature as a whole, even beyond the organic approach

REFERENCES & ACKNOWLEDGEMENTS

BMBF - Bundesministerium für Bildung und Forschung (s.a.). National Research Strategy BioEconomy 2030 - Our Route towards a biobased economy. Berlin: BMBF

IFOAM. (2008). Definition of organic agriculture Retrieved 1.9.2015, from http://www.ifoam.bio/en/organic-landmarks/definition-organic-agriculture

Luttikholt, L. W. (2007). Principles of organic agriculture as formulated by the International Federation of Organic Agriculture Movements. NJAS-Wageningen Journal of Life Sciences, 54(4), 347-360.

Aquatic agricultural systems - the key for a sustainable agriculture

A multiple-disciplinary project of partners within the Bioeconomy Science Center (BioSC)

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BACKGROUND & OBJECTIVES

Feeding a growing population without destroying the environment is perhaps the greatest challenge for this century. Reaching this ambitious goal will require saving limited resources such as phosphorous and opening new areas for biomass production. Aquatic ecosystems cover more than 2/3 of the earth's surface, but this resource is not yet efficiently used for biomass production in most regions of the world. Combining terrestrial food crop production and aquatic agricultural systems lead to a self-sustaining agricultural system in the future. Aquatic agricultural systems

(i) enable recycling of limited resources (e.g. phosphorous)

(ii) provide new areas for biomass production and reduce the need for terrestrial bioenergy crops

(iii) produce biomass with less lignin that is easier to process, compared to terrestrial crops

ACTIVITIES & RESULTS

We will develop a aquatic system for the cultivation of:

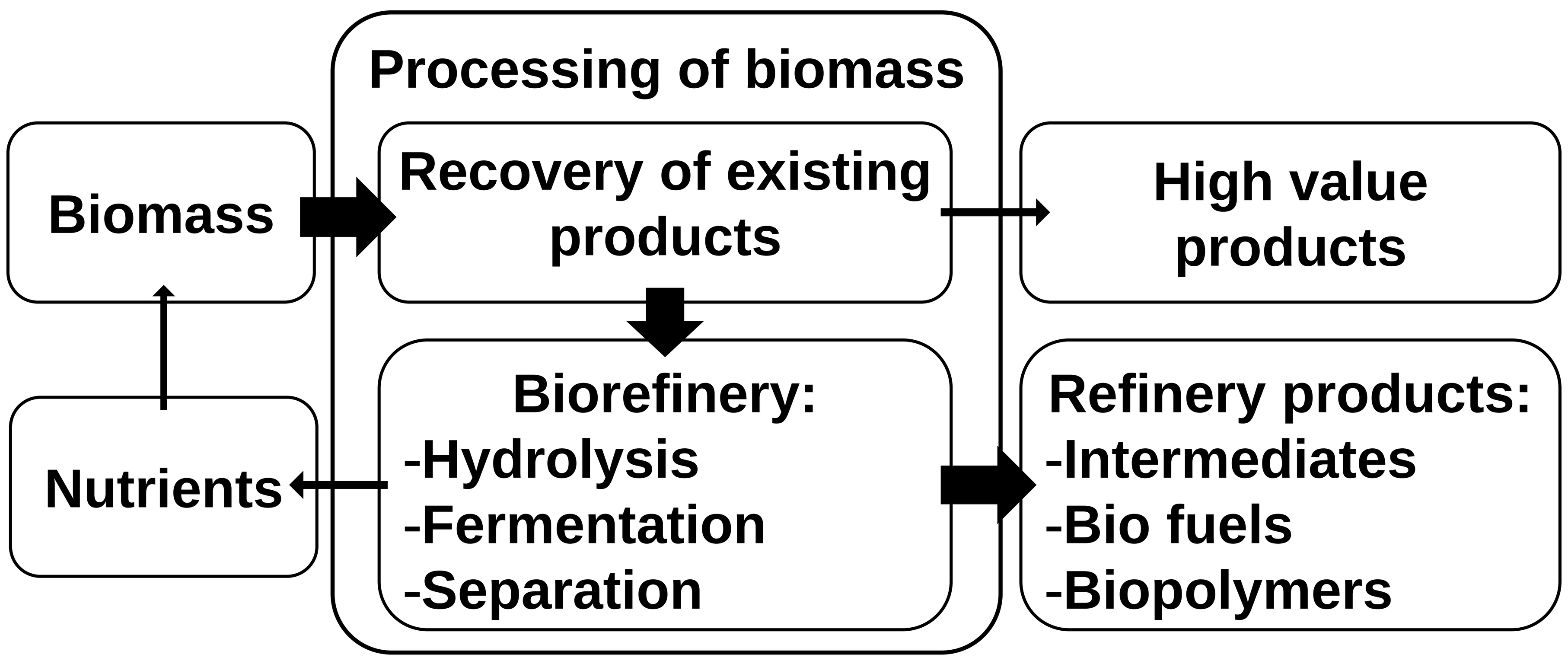
phototrophic bacteria | **cyanobacteria** | **algae** | **aquatic macrophytes**

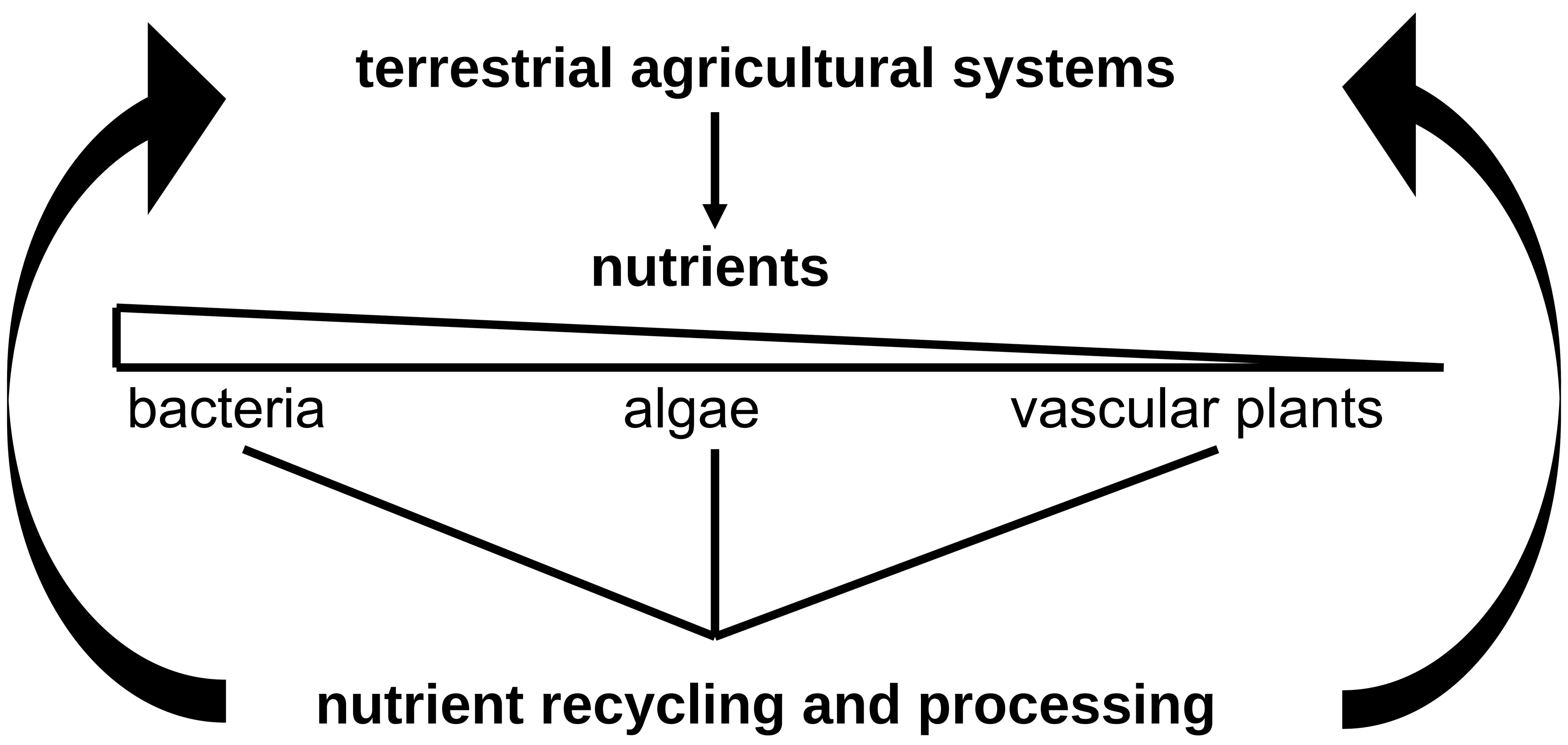
Production of high value products

Protein-engineering and forward evolution will develop new products and improve the quality of products, such as vitamins, antioxidants or omega-3 fatty acids. Innovative separating processes will be used to reach a selective, energy efficient extraction of high value products with a high purity from these highly diluted aquatic systems.

Nutrient recycling

Innovative cascades will provide a high valuable tool for nutrient recycling, which will be closely linked to existing wastewater treatment to get a high efficient nutrient recycling.





LESSONS-LEARNED & RECOMMENDATIONS

The increasing demand for food crops and the limitation of nutrients cause the need for a sustainable agriculture. Aquatic agricultural systems will provide new and valuable additions to its terrestrial counterparts. Combining terrestrial food crop production and the nutrient-recycling, aquatic biomass production for bio fuels and high valuable chemical and pharmaceutical products will lead to a sustainable, nutrient recycling and thus self-sustaining agricultural system in the future.

The economic success of such a closed agriculture system is based on the simultaneous co-production of food, bio fuels and high valuable chemical and pharmaceutical products, which will be reached by the close linkage between terrestrial and aquatic agricultural systems.

REFERENCES & ACKNOWLEDGEMENTS

The BioSC is supported by the federal state of North Rhine-Westphalia on a long-term basis within the framework of the NRW-Strategieprojekt BioSC.

Exploiting the microbial resources on our doorstep

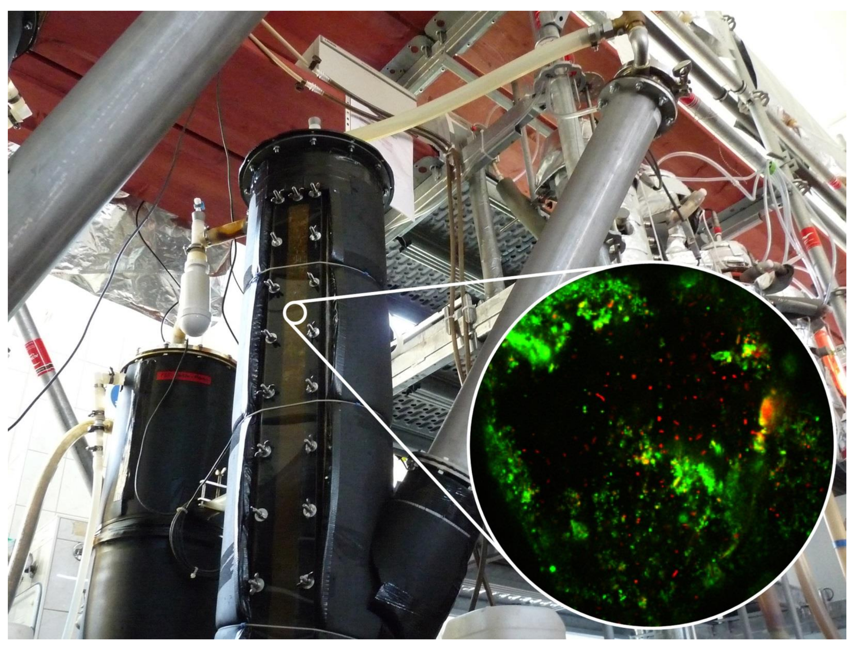
What lessons are still to learn from environmental microbial systems for bioeconomy?

Michael Klocke, Sarah Hahnke, Susanne Theuerl
Leibniz Institute for Agricultural Engineering Potsdam

BACKGROUND & OBJECTIVES

Besides procedural and chemical processing, nearly **all bioeconomic concepts include at least one biological, microbial-mediated conversion step**. It is a well-known fact that microorganisms are able to conduct a virtually unlimited number of enzymatic reactions within their (extra-) cellular metabolism.

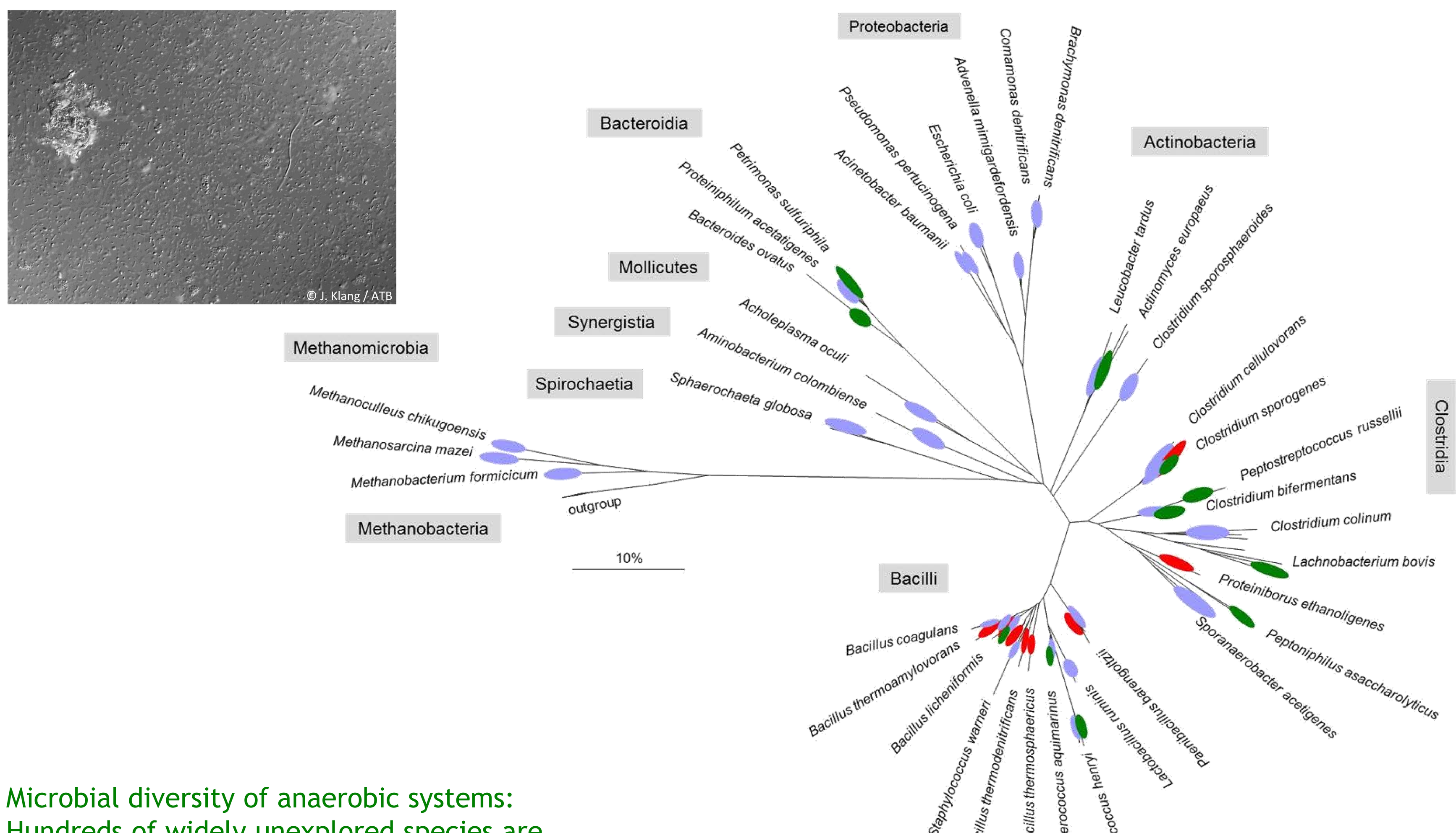
Despite more than hundred years of microbiological research, **the vast majority of the microbial biodiversity is still unknown and remains hence unexploited**. This is especially true for the microcosm right on our doorstep. With an increasing demand on new bioeconomic concepts and new conversion pathways, **there is a raising interest in microorganisms and microbial systems with distinct and well-defined metabolic capacities**.



This include (i) the exploration of microbial diversity and the microbial tree-of-life, (ii) the characterization of hitherto unknown microbial species with respect to their genetic potential and the corresponding metabolic properties, (iii) the understanding of microbial growth and inter-species interactions, and (iv) the utilization and transfer of microbial ecosystem services to biotechnological solutions for bioeconomy.

ACTIVITIES

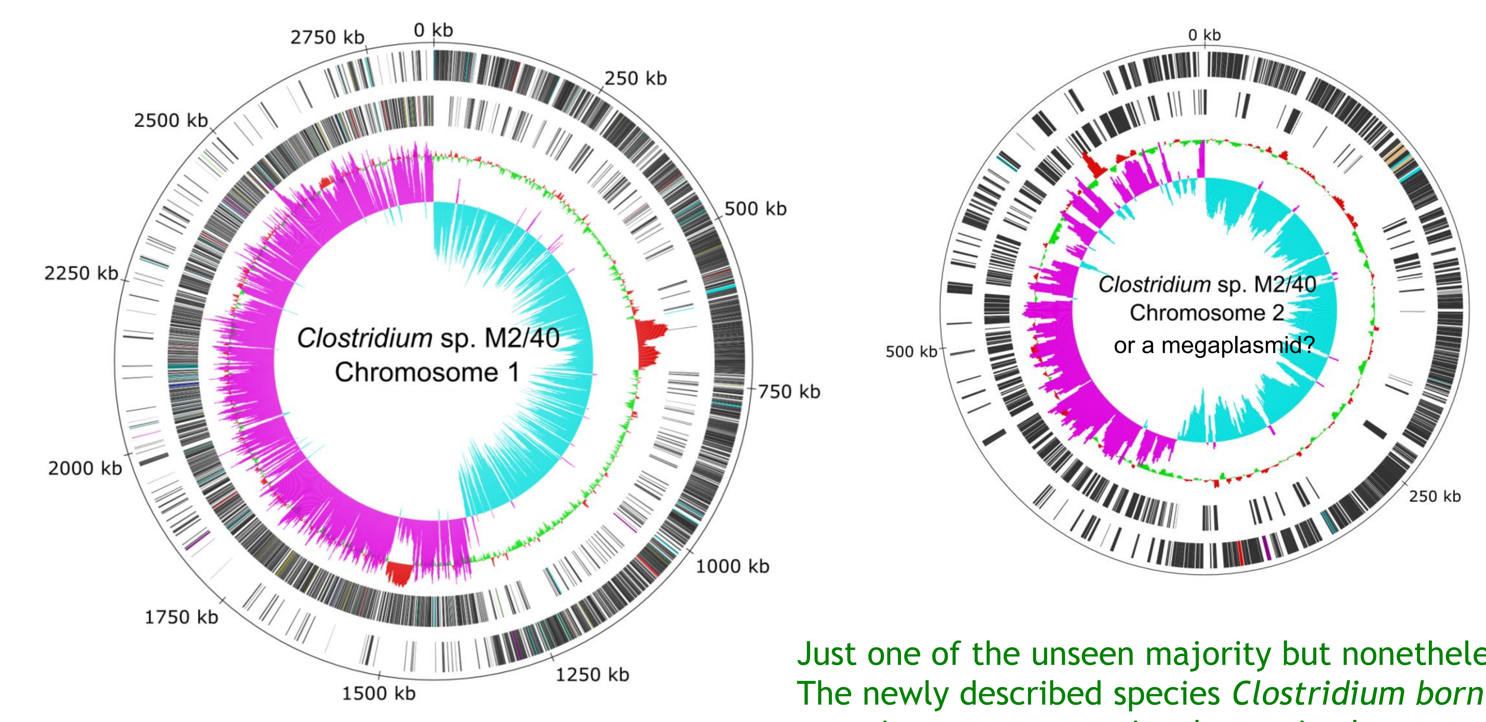
Our recent research activities supported by the German Federal Ministry of Agriculture and Consumer Protection (BMEL) and the German Federal Ministry of Education and Research (BMBF) **focus on the implementation of a well-balanced Microbial Resource Management in bioeconomy strategies** as proposed by Verstraete et al. [1]. As model system, the anaerobic digestion (AD) of biomass to precursors for energy production and carbon-chemistry is investigated.



Microbial diversity of anaerobic systems:
Hundreds of widely unexplored species are participating in utilization of biomass.

In particular, currently research projects are conducted on

- the microbial systems ecology of biogas plants (e.g. BMEL 22013913),
- the isolation and characterization of new and hitherto unknown microorganism from AD environments (e.g. BMEL 22017111),
- the characterization and modelling of metabolic pathways in AD (e.g. DFG KL2069/3-1), and
- the development of diagnostic methods for process control in AD (e.g. BMBF 03SF0440A, VDI 16KN017629).

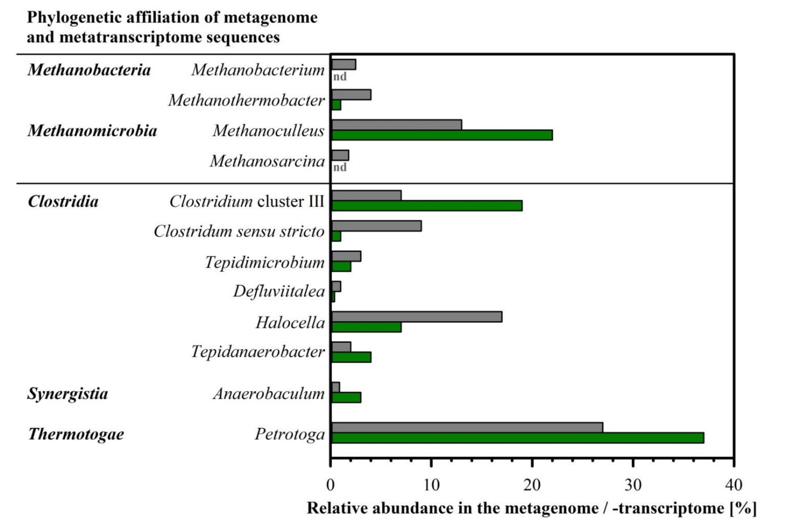


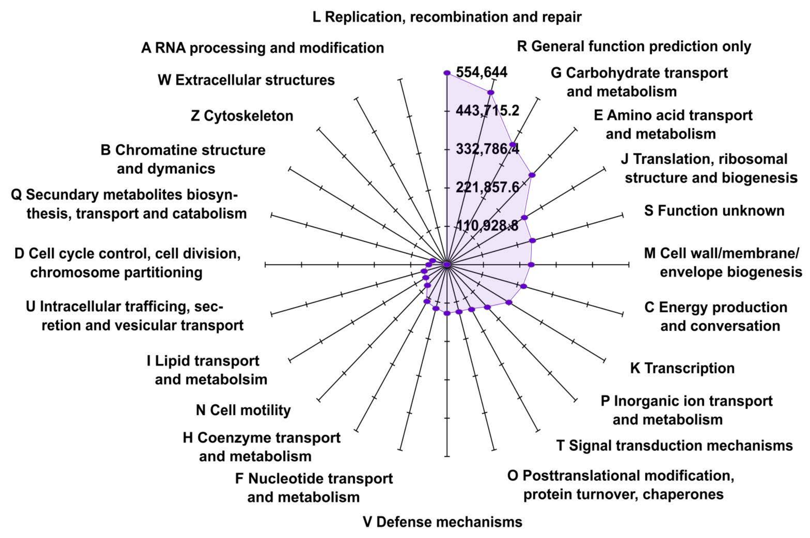
Just one of the unseen majority but nonetheless surprising: The newly described species *Clostridium bornimense* contains an unconventional genetic element - Not a chromosome but not a plasmid, too.

RESULTS

Even though AD is a microbial process studied since Pasteur, our research revealed that **major parts of the microbial community and the microbial genetic material present in AD are still unknown** [2]. In detail, only 15 - 20 % of microbial 16S rRNA gene sequences determined by high-throughput sequencing are assignable to known species, and just 60 % of gene sequences can be affiliated with a known metabolic function. Hence, to create a backbone for advanced molecular studies, traditional cultivation-based microbiological work is indispensable. Exemplarily, we described a number of new microbial species up to new microbial genera [3, 4].

Besides the metabolic profiling of microbial trophic networks, also the discrimination of metabolically active and inactive microorganisms is crucial for understanding their functional role in AD and further knowledge-based process optimization [5, 6].





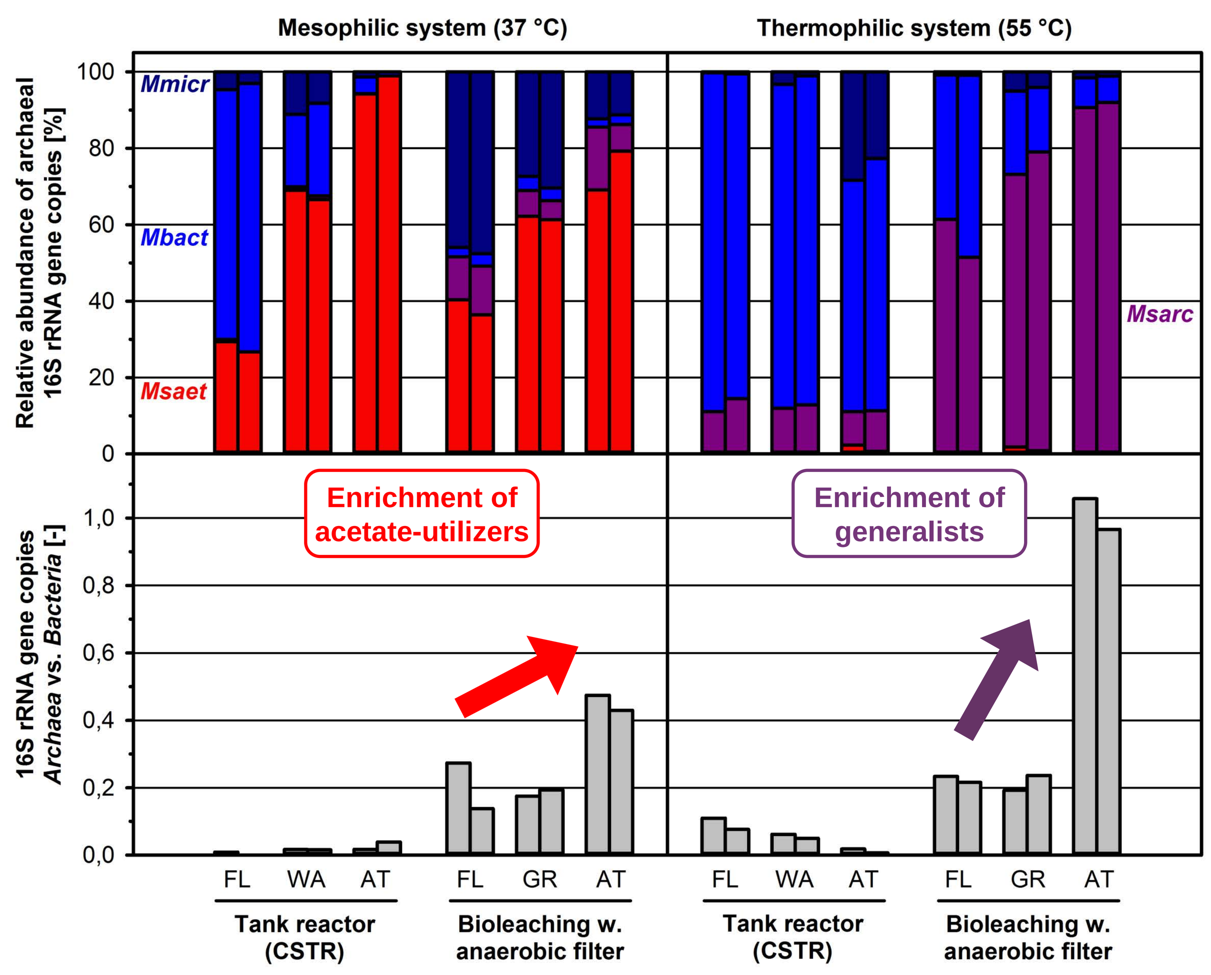
Total *vs* metabolic active microbial community in thermophilic AD (top) and gene functioning (bottom)

LESSONS-LEARNED & RECOMMENDATIONS

The implementation of Microbial Resource Management strategies is an indispensable task for bioeconomy. The natural microbial resources need to be explored and characterized in detail. The knowledge of microbial inter-species interactions is crucial for utilizing defined microbial consortia in biotechnology. **Understanding the natural microbial ecosystems services will open the door for new and innovative concepts in bioeconomy.**

With respect to the widely unknown microbial microcosm it is highly recommended to increase the efforts in microbiological basic and applied research. Therefore, existing networks such as the **Leibniz Network on Biodiversity** and the **Biogas Competence Network** need to be strengthened.

Not only the biodiversity of animals and plants is an indispensable resource for the human future. **Also the often neglected and widely ignored microbial world offers a broad range of unexplored and, hence, unexploited opportunities.**



Microbial resource management in anaerobic digestion: Enrichment of functional microorganisms promoted by the reactor design leading to better process performance.

REFERENCES

[1] Verstraete W, Wittelbolle L, Heylen K, Vanparys B, de Vos P, van de Wiele T, Boon N (2007): Microbial resource management: The road to go for environmental biotechnology. Engineering in Life Sciences 7: 117-126

[2] Rademacher A, Zakrzewski M, Schlüter A, Schönberg M, Szczepanowski R, Goesmann A, Pühler A, **Klocke M** (2012): Characterization of microbial biofilms in a thermophilic biogas system by high-throughput metagenome sequencing. FEMS Microbiology Ecology 79: 785-799

[3] **Hahnke S**, Striesow J, Elvert M, Mollar XP, **Klocke M** (2014): *Clostridium bornimense* sp. nov., isolated from a mesophilic, two-phase, laboratory-scale biogas reactor. International Journal of Systematic and Evolutionary Microbiology 64: 2792-2797

[4] **Hahnke S**, Langer T, Koeck DE, **Klocke M** (submitted): Description of three novel *Porphyromonadaceae* isolates, *Proteiniphilum saccharofermentans*, sp. nov., *Petrimonas acetigenes*, sp. nov. and *Fermentomonas caenicola*, gen. nov., sp. nov. isolated from mesophilic lab-scale biogas reactors and emended description of the genus *Proteiniphilum*. Unpublished manuscript under review

[5] Hanreich A, Schimpf U, Zakrzewski M, Schlüter A, Benndorf D, Heyer R, Rapp E, Pühler A, Reichl U, **Klocke M** (2013): Metagenome and metaproteome analyses of mesophilic biogas-producing anaerobic batch fermenters indicate concerted plant carbohydrate degradation. Systematic and Applied Microbiology 36: 330-338

[6] **Theuerl S**, Kohrs F, Benndorf D, Maus I, Wibberg D, Schlüter A, Kausmann R, Heiermann M, Rapp E, Reichl U, Pühler A, **Klocke M** (2015): Community shifts in a well-operating agricultural biogas plant: how process variations are handled by the microbiome. Applied Microbiology and Biotechnology 99: 7791-7803

Photosystems from extremophilic photosynthetic organisms for biotechnological applications

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Background:

Cyanobacteria - ubiquituous oxygenic photosynthetic prokaryotes

- evolutionary old (~3.5 billion years)
- only known prokaryotes with oxygenic photosynthesis
- oxidation of Earth's atmosphere/ responsible for every 2nd oxygen molecule produced
- ancestors of modern day chloroplasts
- occur almost everywhere, also in **extreme** habitats

Hot volcanic spring with thermophilic cyanobacteria

Versatile Metabolism:

- photoautotrophic
- mixotrophic
- heterotrophic

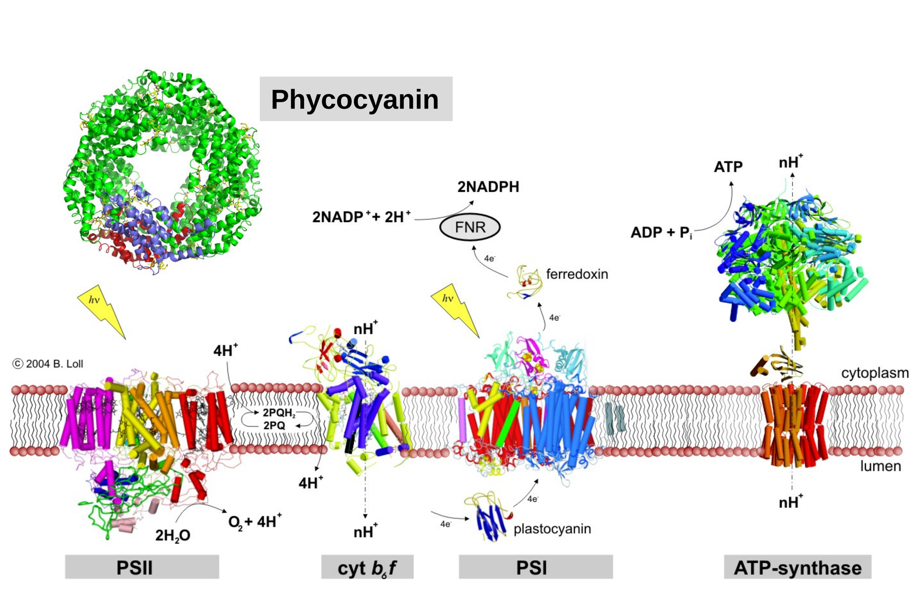
Advantages:

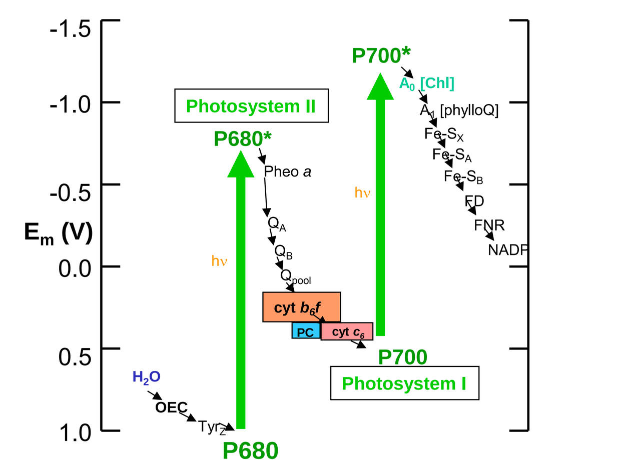
- CO_2-fixation
- O_2-evolution
- no arable land required
- sea water use
- high(er) efficiencies of solar energy conversion into biomass
- many genomes available
- transformable

Advantages of photosystem I from thermophilic cyanobacteria for hybrid assemblies

- extremely stable (as compared to PS I from other sources)
- direct production of NADPH for input into redox enzymes/different redox-potentials available

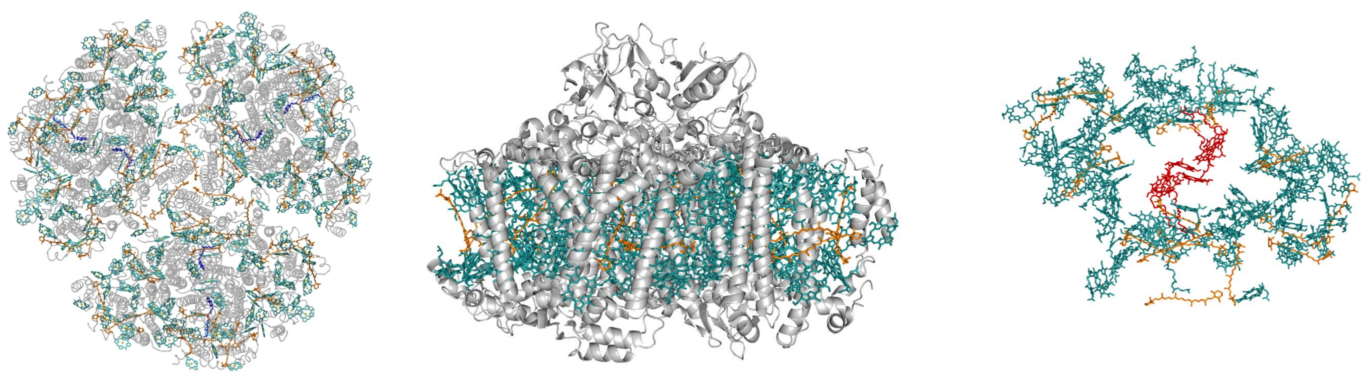
Molecular view of the oxygenic photosynthetic apparatus:





Electron transport in oxygenic photosynthesis

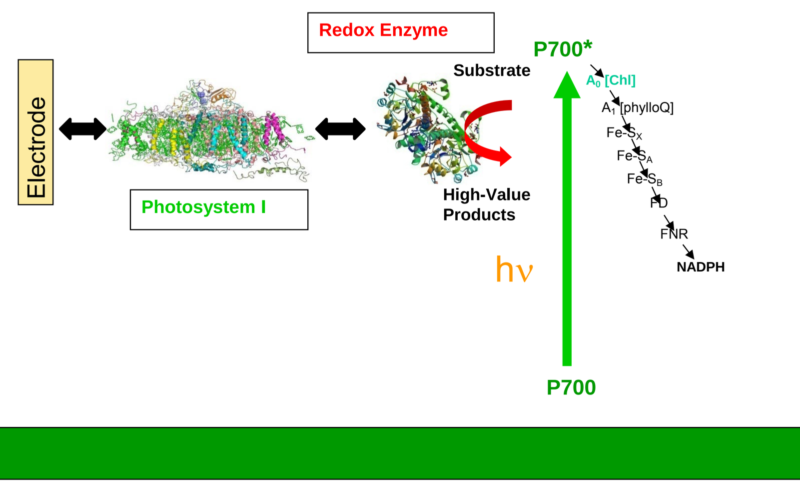
The high-resolution structures of both, Photosystem I (PSI) and PSII, were determined from the highly stable supercomplexes isolated from *Thermosynechococcus (T.) elongatus* [1,2], as well as the major antenna complex, phycocyanin [3] & Lokstein, *et al., unpublished*.



Structures of trimeric (top view) and monomeric (side view and pigment arrangement, including the electron transfer chain) of PS I from *T. elongatus* [1]

Objective:

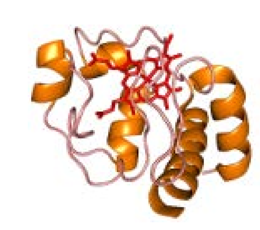
Coupling of Photosystem I into Hybrid-Assemblies for the Production of High-Value Products/"Solar Fuels"



The Tandem project „Photobioelectrodes" is aimed at developing modular hybrid (assemblies photocathodes) coupling PS I onto different electrode materials. The light-induced redoxpotential/electrons/NADPH will be used by (redox-) enzymes to produce high-value products (HVPs) such as carbon-neutral solar fuels.

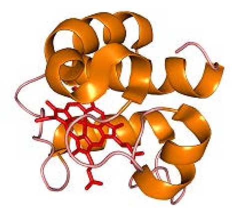
Activities: Coupling of Photosystem I to Electrodes

Results: Coupling of Photosystem I via Cytochrome *c*

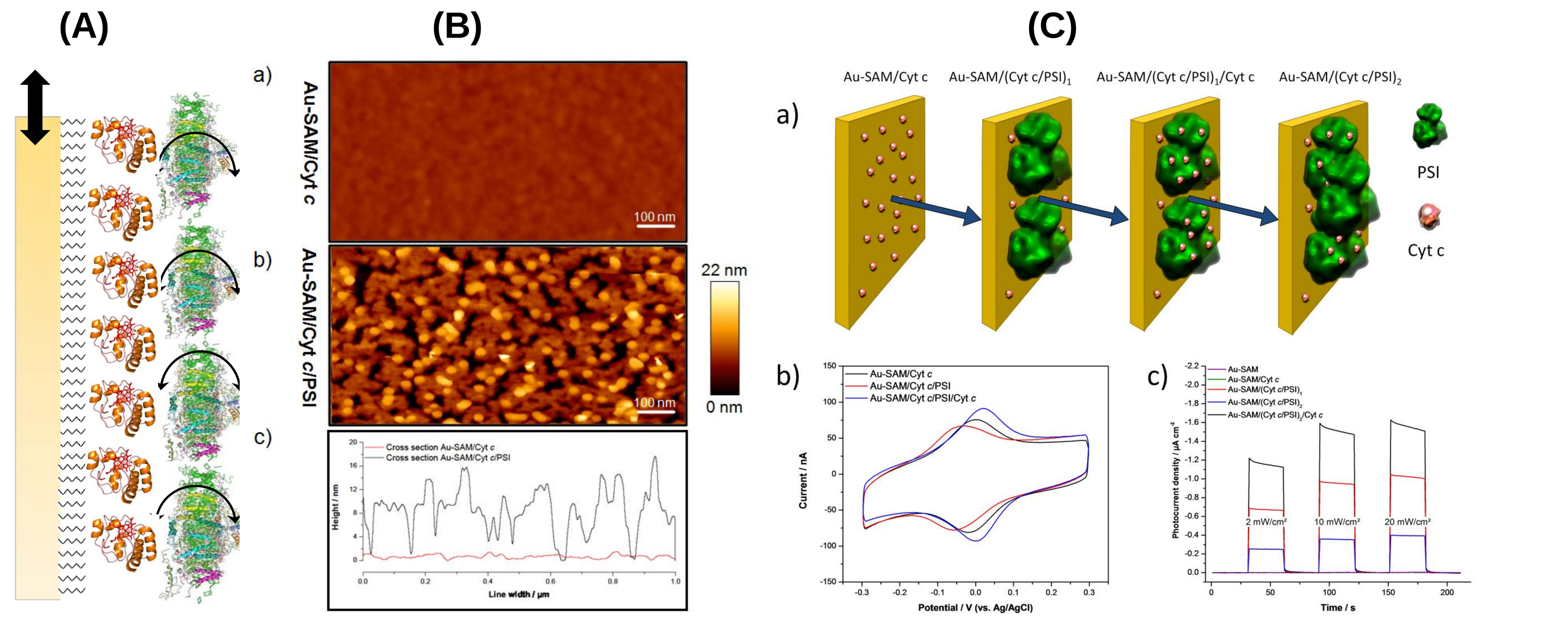


Cytochrome *c*

- small redox protein with heme co-factor
- Cytochrome c_6 is natural electron donor for PSI
- dipol character
- effective electron-transfer with modified electrodes
- best rates with horse-heart cytochrome *c*
- reaction capabilities with several enzymes



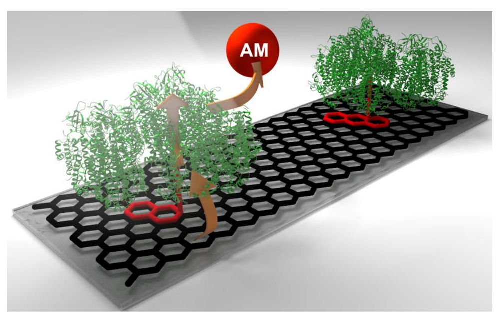
Cytochrome *c* (horse heart) — **Cytochrome c_6 (*T. elongatus*)**



Coupling of photosystem I of *T. elongatus* onto gold electrodes via cytochrome *c* [4].

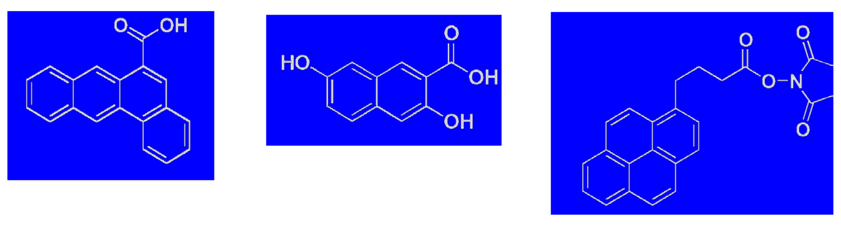
(A) Coupling of PSI onto a gold electrode via (horse heart) cytochrome *c* (Cyt *c*) - schematic.
(B) Atomic force microscopy of hybrid assemblies: (a) Monolayer of Cyt *c*, (b) Cyt *c and* PSI.
(C) Cyclic voltammetry (b), and (c) photocurrent generation.

Coupling of Photosystem I onto Graphene Electrodes



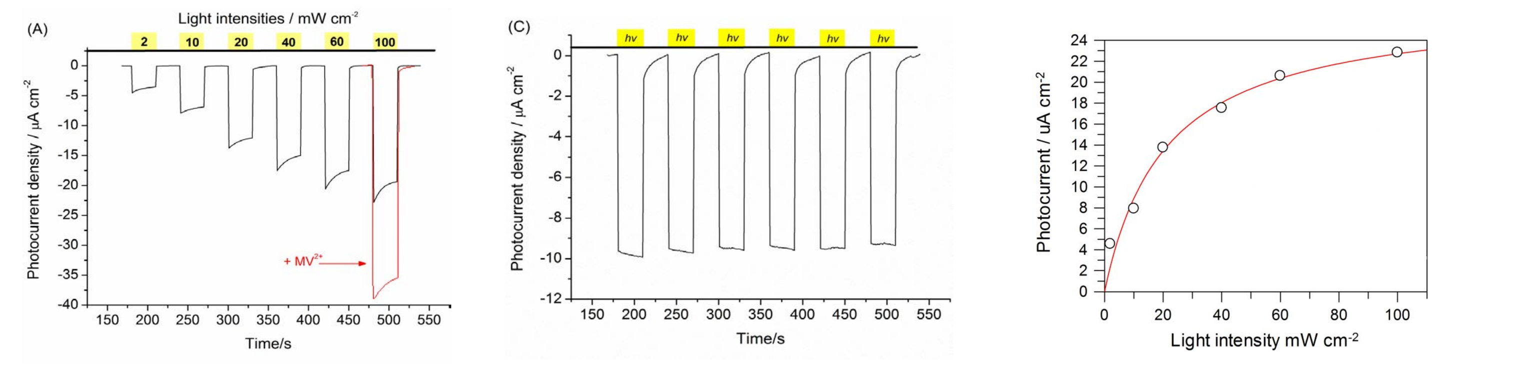
Using:

Anthracene- Naphthyl- Pyrene-Derivatives



PSI was successfully coupled to other electrode materials, like graphene, yielding long-term stable unidirectional [photocurrents 5,6]:

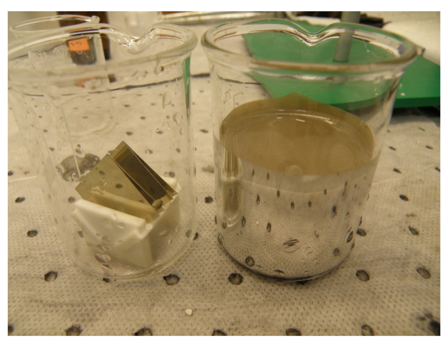
PSI:Graphene/Pyrene-NHS



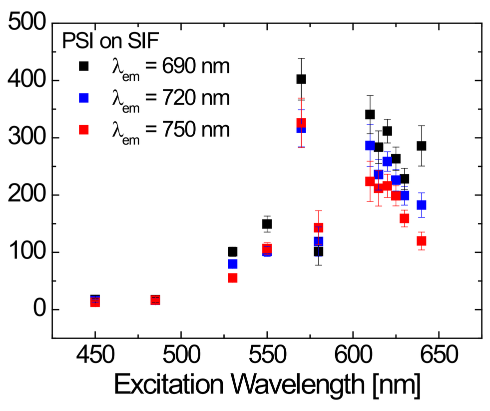
Photocurrent at OCP (-260 mV) | Photocurrent stability at OCP | Michaelis-Menten-Plot: K_M =20 mW cm^{-2}

Coupling of Photosystem I to Plasmonic Nanostructures

(A)



(B)



(A) Silver island films (SIFs) on glass. **(B)** Plasmonic fluorescence enhancement factors for PSI on SIFs at different excitation wavelengths [7].

Lessons-learned and Recommendations:

PSI (and other pigment-protein complexes) from phototrophic organisms are promising for biotechnological applications with the prospect of coupling to (redox) enzymes for direct light-powered HVP production.

Acknowledgements:

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Bundesministerium für Bildung und Forschung

Strategieprozess Biotechnologie 2020+

References:

[1] P. Jordan, P. Fromme, H.T. Witt, O. Klukas, W. Saenger, N. Krauss, ***Nature 411*** (2001) 909-917.
[2] A. Zouni, H.-T. Witt, J. Kern, P. Fromme , N. Krauß, W. Saenger, P. Orth, ***Nature 409*** (2001) 739-743.
[3] J. Nield, P.J. Rizkallah, J. Barber, N.E. Chayen, ***J. Struct. Biol. 141*** (2003) 149-155.
[4] K.R. Stieger, S.C. Feifel, H. Lokstein, F. Lisdat, ***ChemPhysPhysChem 16*** (2014) 15667-74.
[5] S.C. Feifel, K.R. Stieger, H. Lokstein, H. Lux, F. Lisdat, ***J. Mater. Chem. A 3*** (2015) 12188-96.
[6] S.C. Feifel, H. Lokstein, M. Hejazi, A. Zouni, F. Lisdat, ***Langmuir,*** *in press.*
[7] N. Czechowski, H. Lokstein, K. Ashraf *et al.*, ***Appl. Phys. Lett. 105*** (2014) 043701
[8] C. Oesterhelt, E. Schmaelzlin, J.M. Schmitt, H. Lokstein, ***Plant J. 50*** (2007) 500-511.
[9] V.E. Zagidullin ... H. Lokstein, V.Z. Paschenko, ***Biochemistry (Moscow) 79*** (2014) 1183-1191.

The increase of the crop yield by electromagnetic influence and agrolandscape productivity

Volodumyr Paraniuk, Orest Mukha

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BACKGROUND / INTRODUCTION

The introduction of biotechnology in economy allows much more efficient using of natural resources and diminishes the human influence on the environment.

The solution of the food problem of humanity and development and use of new biotechnologies can be carried out most efficiently by increasing the yield of crops and agricultural landscapes productivity. Seeds of crops are one of the main components of a bioeconomy development. The increasing of reproductive capability of seed crops after their preplant electrostimulation leading to a significant increasing of their productivity (up to 30%) was established.

Based on the new knowledge technology the preparation of seed crops by corona discharge increases their yield and thus reduces the costs for storing seed grain, improves land use, saves energy for growing and harvesting. This makes possible essentially increase the productivity of plants that are used in biotechnology.

ACTIVITIES

The influence of electrostimulation by corona discharge on different types of plants and the separation possibility of seeds unable for germinating and weed was investigated. The experiments were conducted on the same land in two soil-climatic zones (forest-steppe and subcarpathian) of Ukraine.

Declaration of Scientific Discovery:

Reproduction of agrolandscapes productivity by electromagnetic action on seeds of cultivated plants.

https://www.infona.pl/resource/bwmeta1.element.agro-71163a23-ec46-4035-a209-f42818456baa?locale=en

Figure 1. Electric-corona "slope"

a – scheme and principals of functioning of electric-corona "slope"; b – photo of the acting model with power pack (left), miliampermeter and kilovolt meter; c – photo of the acting model of the power pack (high voltage source); 1 – batcher; 2 – high voltage source; 3 – corona discharge field electrode; 4 – remains; 5 – lead transverse; 6 – brushes; 7 – ground surface (sedimentation electrode); 8 – endless bent; 9 – splinter; 10 – batcher with cleaned conditioning seeds.

OBJECTIVES

The goal is to apply the knowledge and experience of using guided electromagnetic spectrum for:

-Presowing electroseperation and electrostimulation of seed grain;

-Optimizing technologic electrostimulation processes for various seed grain;

- Fulfilling soil by the biomass and renewing of the agrarlandscape productivity;

- Assistance economically efficient and ecologically substantiated cultivation of the energy plants.

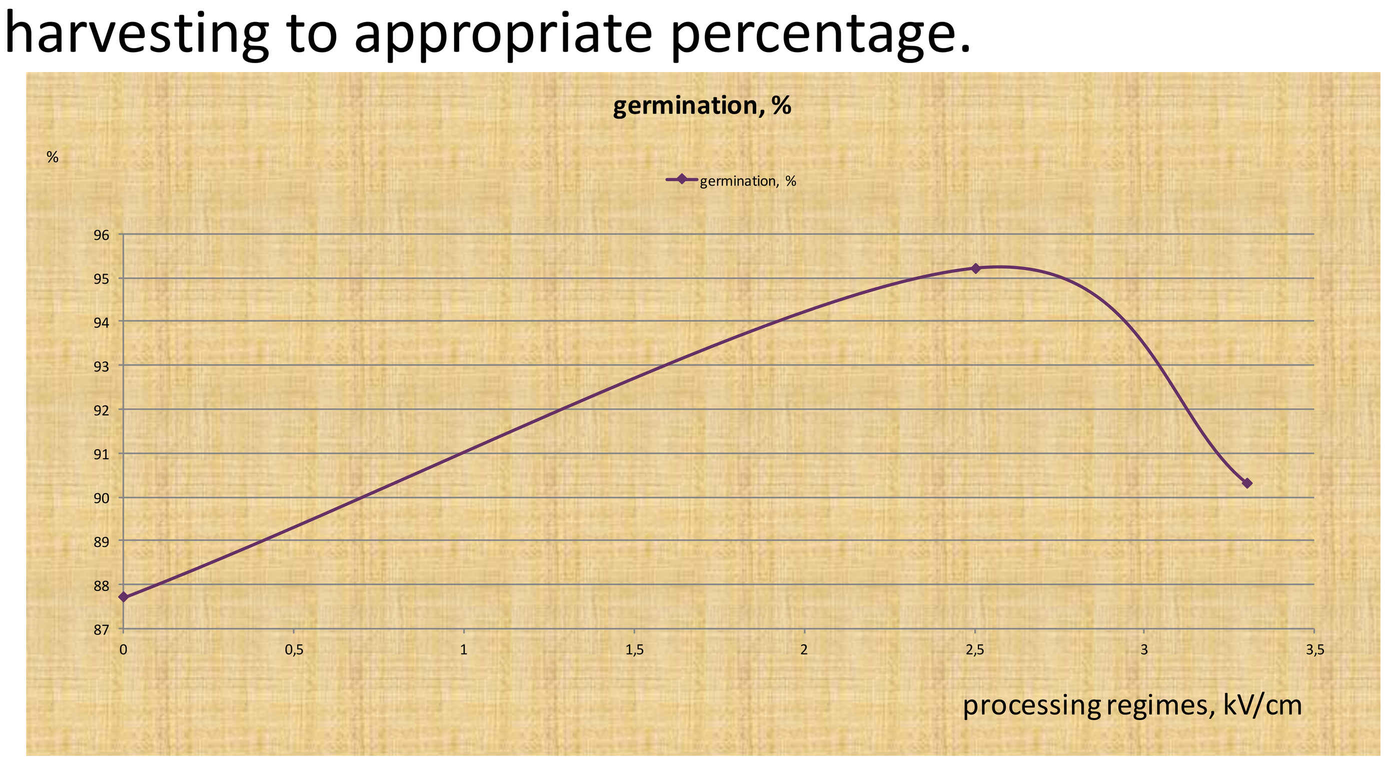
- Simplifying the economic, environmental and social problems of land use by virtue of increasing the yield.

RESULTS

The electrostimulation of selected seeds of forage grasses (legumes and cereals) was conducted. The innovative technology for preparing of plant seed was developed, which includes electric separator and devices for testing seeds by mode selection of production line.

The resulting seeds represent set of seeds of the cultivated plant genotype with increased yield.

An additional increase of forage and seed yields (green mass, hay, seed yield), and the root system, which updates soil biomass was received. In all cases, the effect of seed treatment is between 15 and 30% in comparison to the control variant, which allows reducing the use of crop areas and energy resources for growing and harvesting to appropriate percentage.



LESSONS LEARNED / RECOMMENDATIONS

The methods of experiments with electric separating and electrostimulation of seeds in research seed farms were developed.

It is proposed

-to use certified seed grain by farmers in order to increase the efficiency of crops growing;

-to conduct further joint research with scientists for the implementation of innovative technologies for increasing the yield of crops;

-to create a network of research institutions and universities, public structures for dissemination and implementation of the results in bioeconomy.

Technology for mitigation and adaptation to climate change: the use of bio-digesters on farms of small farmers in Canton Turrubares, Costa Rica

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BACKGROUND & OBJECTIVES

Costa Rica has led the use of biodigesters as a technology to reduce the negative environmental impact of livestock activities. The adoption of these technologies by small producers has been limited because there are few studies that show the economic feasibility of this investment. That means the studies show the environmental benefits but not the socio-economics as well. Additionally, it is important to note that today the second most expensive production factor is electricity. This cost affects directly the competitiveness of family agribusiness.

The core question is: How to improve the competitiveness of the small farmers and at the same time to contribute to avoid the negative impact to the environment and the climate change?

ACTIVITIES

Based on the WOCAT methodological approach and a participatory workshop a small famer was choosen as a study case. The WOCAT- Technology questionnaire was adapted to this case to pick up the core information. The main results of this first study case were divided in two dimensions: environmental and financial.

From the environmental dimension the benefits can be summarized as follows: a- reduction of the negative externalities (organic waste, diminishing of gases emission, reduction in the use of firewood); b- source of renewable energy (biogas); c- source of organic fertilizer.

From the financial dimension is necessary to consider the following assumptions: a- the biogas is used in the household for cooking in order to reduce the costs of the energy (electricity and firewood); b- this reduction costs was introduced as a income in the financial analysis

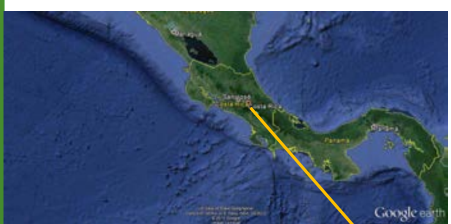

Fig 1 Research zone:
Canton Turrubares, Costa Rica

RESULTS

Using the traditional financial indicators the results have showed Internal Rate of Return (IRR) was 11% (two points better than the opportunity cost of the capital which was 9,25%) and the Net Present Value (NPV) was ₡ 142.409,12 (US$ 266,18). The study shows the economic benefits through saved costs by the use of biogas.

Fig. 2. The smallholder (farmer) and the biodigestor.

Fig. 3. The adapted stove to use the biogas.

Preliminary environmental impact assessment

	Dimension		
Item	**social**	**economic**	**ecological**
Reduction cost at home level	+ + +	+ + +	-
Improved knowledge	-	-	+ + +
Technical advice	-	-	+
Improved technology	+	++	+++
Increase in soil fertlility	+	+ + +	+ + +
Reduction of the negative externalities	++	+++	+++
Source of renewable energy	+++	+++	+++

+: positive/ -: negative

LESSONS-LEARNED & RECOMMENDATIONS

As a concluding remarks of this study case are: a- new communication strategies to encourage families in the use of biogas in the household are needed; b- rural extension programs can be very important in achieving this goal; c- the social dimensión is not taking in account until today. Its approach is necessary to achieve a greater acceptance from family farmers. Small farmers could get additional benefits from the incentive programs that exist in Costa Rica like the "Payment for environmental services" due the reducing the emission of greenhouse gases.

REFERENCES & ACKNOWLEDGEMENTS

WOCAT (World Overview of Conservation Approaches and Technologies((2007) Where the land is greener. Case studies and analysis of soil and water conservation. CTA/ FAO/ UNEP/ CED. Bern. (www.wocat.net/en/methods.html)

TORRES, C. (2014) Manual técnico para la implementación de energía renovable en la agroindustria. CEELEQ/ UCR. San José. 134 p.

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Bioresource insects

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Leibniz Research Alliance "Sustainable Food Production and Healthy Nutrition"
Leibniz Network on Biodiversity

BACKGROUND & OBJECTIVES

Due to the growing world population there is an increasing demand in alternative protein sources whereas the available land for the production of plant and animal protein decreases owing to desertification and urbanization. Furthermore, the rapidly decreasing resources of fossil fuels necessitate a more sustainable land use. This includes the establishment of novel utilization pathways of hitherto not or not optimally used biomass. Here insects offer prospective alternatives. With almost one million described species and presumably five to ten times more unknown species, insects are a vastly underutilized bioresource and can be utilized for the bioconversion and valorization also of hitherto not usable organic residues to food, feed, protein, lipids, chemicals, enzymes, and bioactive substances and other targeted ingredients. For example, insect antimicrobial peptides as transgenes could be applied to engineer disease resistant crops [1]. And omnivorous insects such as the Black Soldier fly *Hermetia illucens* can be utilized for the bioconversion of organic residues such as supermarket waste or even manure into valuable biomass rich in protein that can be utilized as feed and for example replace fishmeal in aquaculture. In comparison to conventional livestock, insects have higher feed conversion efficiencies, lower water and land requirements, and lower greenhouse gas emissions.

The objective is the sustainable valorization of organic residues by suitable insect species into safe, high quality insect-based products such as food, feed, protein, functional biopolymers, and enzymes using a holistic approach. This encompasses a screening for to date unexploited suitable insect species for a bioconversion, the optimization of the value chain biomass-insect-product, the development of appropriate process technology for an industrial production, and the establishment of safe and resource-efficient production concepts. Furthermore, the environmental and economic impact of the utilization of insects is investigated.

ACTIVITIES

Policy measures include collaboration on a study on the regulatory frameworks influencing insects for food and feed by the FAO and participation in the writing of an opinion paper on safety aspects concerning the production of food and food ingredients from insects by the Permanent Senate Commission on Food Safety of the German Research Foundation (DFG).

Vast research is and will be performed concerning insect production, insect processing, insect fractionation, microbial safety and life cycle and technical assessment. It is aimed for a holistic approach taking into account all mass and energy flows in a sustainable production process. Exemplary insects investigated so far include larvae of the Black Soldier fly *Hermetia illucens* and the Mealworm beetle *Tenebrio molitor*.

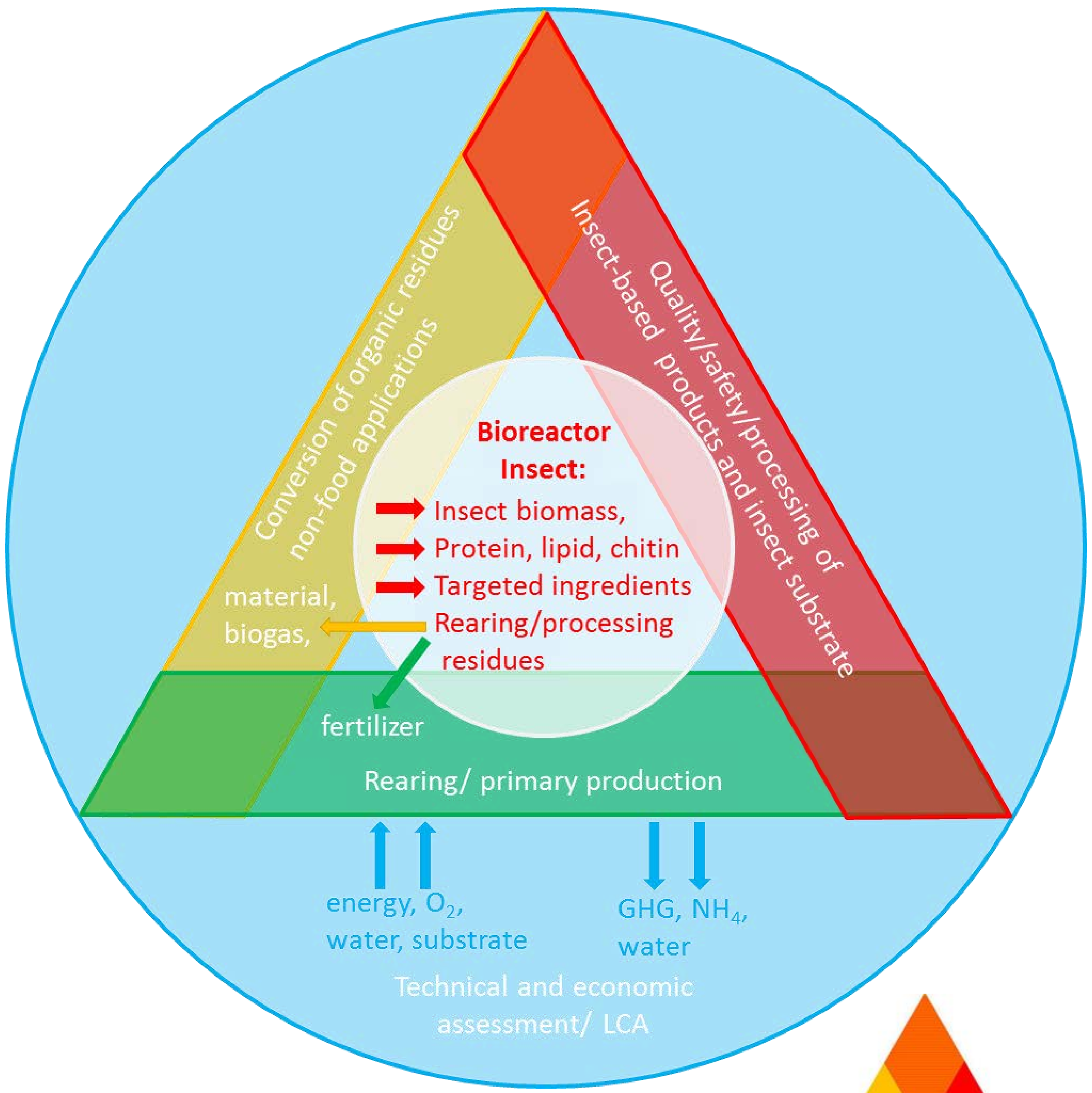
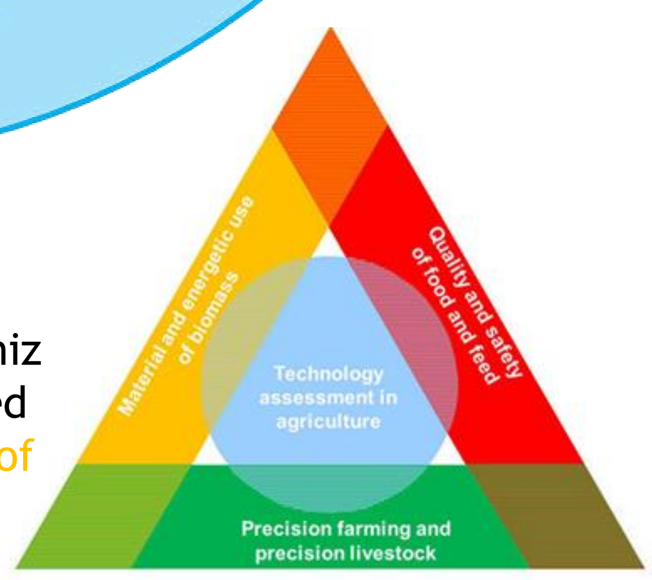


Figure 2 -Research questions around the bioresource insects schematically depicted as a bioreactor, embedded in the four research programs of the Leibniz Institute for Agricultural Engineering (ATB) represented by the four colors yellow (Material and energetic use of biomass), red (Quality and safety of food and feed), green (Precision farming and precision livestock) and blue (Technology assessment in agriculture).



Research programs of the ATB.

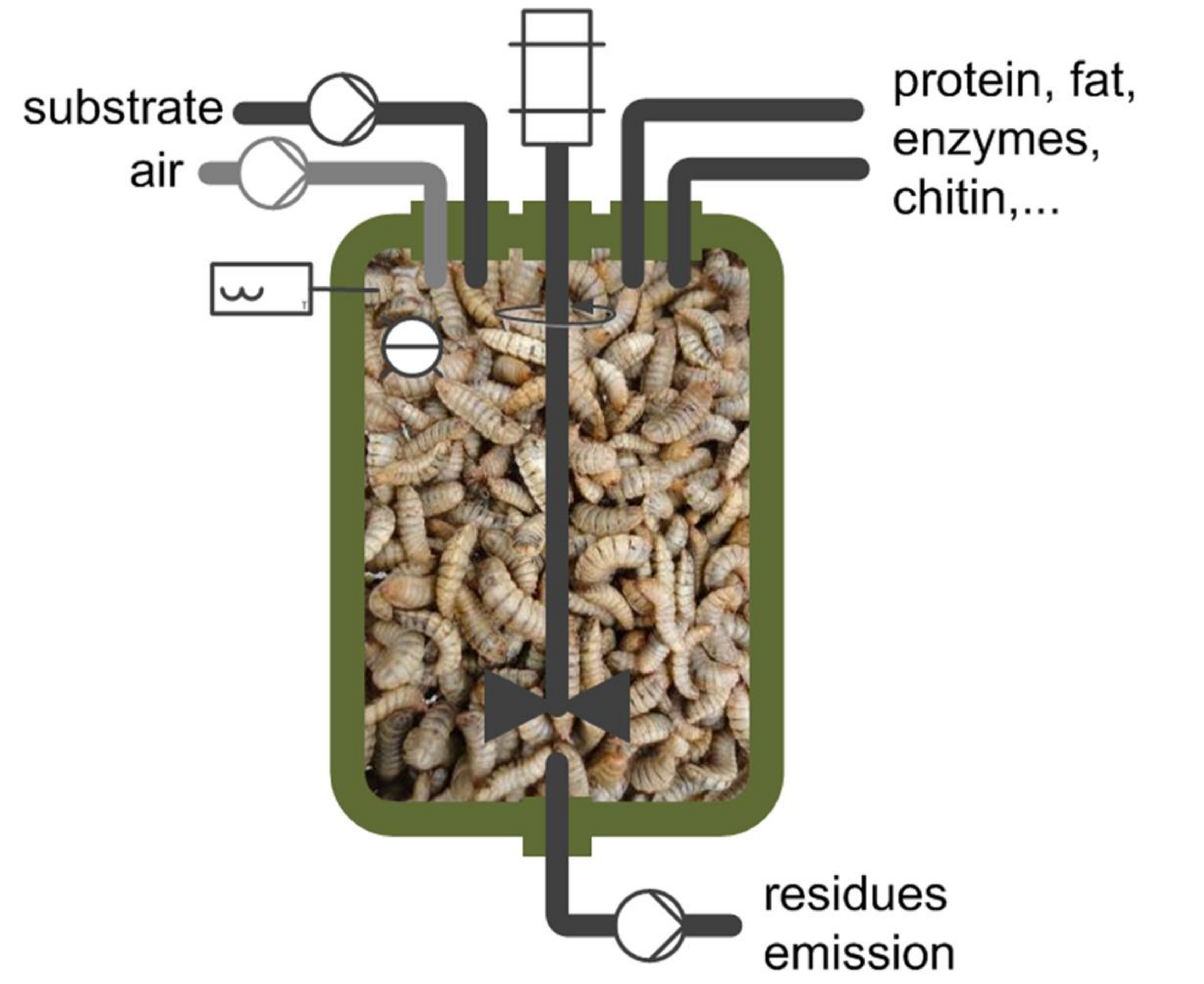


Figure 1 - Bioresource insects schematically depicted as a bioreactor using Black Soldier Fly (*Hermetia illucens*) larvae as an exemplary insect species.

RESULTS

There is immense potential in insect biodiversity and the use of to date unexploited insect species. Consequently, there is still a large amount of research required regarding identification, composition [2] and application of known and to date unknown insect species appropriate for respective bioconversion processes in order to extensively exploit the potential of insects as a bioresource.

In order to produce insects sustainably on an industrial scale, technological improvement of rearing facilities for automated, cost-effective production processes and the development of resource-efficient and safe processing steps are required [3].

In the food and feed sector, where insects represent a valuable alternative animal protein source, there are immense knowledge gaps as recently acknowledged by the EFSA in a risk profile related to production and consumption of insects as food and feed [4].

An investigation of different decontamination technologies including thermal processing and larvae non-thermal processing such as cold plasma and high hydrostatic pressure on the microbial safety of Mealworm showed the most effective decontamination for thermal treatments. More research is needed in order to develop effective decontamination methods and ensure the microbial safety of mealworm larvae and other edible insects as food and feed. [5].

LESSONS-LEARNED & RECOMMENDATIONS

There are numerous regulation gaps and knowledge gaps as well as emotional concerns regarding the production and use of insects as food, feed and other applications. Additional comprehensive applied and fundamental research is recommended in order to contribute to closing those gaps.

REFERENCES & ACKNOWLEDGEMENTS

[1] Vilcinskas & Gross (2005). Drugs from bugs: the use of insects as a valuable source of transgenes with potential in modern plant protection strategies. J Pest Sci (2005) 78: 187-191. (doi: 10.1007/s10340-005-0114-5)

[2] Rumpold & Schlüter (2013). Nutritional composition and safety aspects of edible insects. Molecular Nutrition and Food Research 57 (5), 802-823. (doi: 10.1002/mnfr.201200735).

[3] Rumpold & Schlüter (2013). Potential and challenges of insects as an innovative source for food and feed production. Innovative Food Science & Emerging Technologies 17 (1): 1-11. (doi:10.1016/j.ifset.2012.11.005).

[4] European Food Safety Authority (EFSA) (2015). Risk profile related to production and consumption of insects as food and feed. EFSA Journal 13(10), 4257. (doi: 10.2903/j.efsa.2015.4257).

[5] Rumpold et al. (2014). Comparison of volumetric and surface decontamination techniques for innovative processing of mealworm larvae. Innovative Food Science &Emerging Technologies. 26 : 232-241 (doi: 10.1016/j.ifset.2014.09.002)

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Mangroves defoliation effects on the productivity and rural economy, in Tabasco Mexico.

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BACKGROUND & OBJECTIVES

In 2010 the mangrove area of the state of Tabasco was threatened by the presence of voracious caterpillar's moth of the genus *Anacamptodes*. Its presence was detected in May 2010 in the Ejido Sinaloa as an isolated outbreak. It was subsequently dispersed along the mangrove area, affecting the black mangrove (*Avicennia germinans* L.).

The seriousness of the damage was such that trees colonized by caterpillars were defoliated in whole or almost entirely in other cases. The invasion of caterpillars held June-2010-febreo 2011. Affected communities were: Aquíles Serdán, El golpe, El Mingo, Las Coloradas, Las Azucenas, El Alacrán y el Manatinero. After this period, the damage recognition activities began. By air flight and mapping it was concluded that the affected area was very big. Damage in a community were assessed and it was found that this was type II, it means that requires the help of the man to have restoration (Sol *et al.*, 2002).

Assess the impact of defoliation of black mangrove productivity and the rural economy in the Ejido Las Coloradas Cardenas Tabasco. Mexico

Life cycle of the pest species mangrove (*Anacamptodes* sp)

ACTIVITIES

A Damage assessment was conducted by establishing 10 permnent Sampling Plots 20 m x 50 m (Cox 1970). Height, diameter, degree of damage and tree species was measured.

Air flight and mapping was done in the affected area in May 2011 and helped to identify the affected area and estimate damage and establish programs to support those communities affected. Restitution in maps allowed calculate the relevant affected area and the level of damage.

Establishment of a nursery

To reforest part of the affected area, a rustic nursery with capacity for 50,000 plants was established. The seed was collected of which brought floating the tide of the Machona lagoon and was collected ans sowed before 24 hours in germination beds. Then it was preceded to the bagging and to the nursery stage. This plant was in nursery for 7 months, during this period the plant received two fertilization doses between 5 and 7 grams plant. One was buried in the root and other foliar with Groo Green. For this case 2 grams of groo green were diluted with a liters of water and applied as a spray with knapsack.

The planting was done at 7 months of age, at a distance of 3.5 m x 3.5 m. for planting, weeds were removed, and the plants were planted at a density of 816 plants / ha.

This was done at the beginning of the period of regular rainfall. The stroke was real framework. Plants height was between 67 and 107 cm. Later maintenance work is performed. From planting, diameter and height measurements were performed every three months.

To assess the impact of this activity on the family economy, 31 interviews were held with local fishermen and 3 intermediaries to assess impact on fisheries, the species affected, and income. Also, the area of the lagoon fishermen ran to corroborate information.

Photos 1. Death of the mangrove, photo 2. Invasion of species, Photo 3.black mangrove seeds

Photo 4. nursery. Photo 5. reforested area. Photo 6. New individual of black mangrove

RESULTS

The impact in fishing in the Ejido Las Coloradas was significant. The applied questionnaires indicated that all the fishing men were directly affected due to the mangrove death.

Las Coloradas has approximately 600 hectares covered by black mangrove which were affected almost in a 75 %.

Fishing is in the only one economic activity in this region and the mangrove provides refugee for fish, shrimp, crabs and others. However with the mangrove death in this community approximately 450 mangrove hectares were affected.

Affected species were: shrimp, crabs, blue crabs and fish. All fishermen interviewed mentioned the fall of the catch of species of commercial value and its impact on the family economy.

The income of fishermen from selling their products declined from 800 on average per day to 250 or 300 Mexican pesos for those with boats and fishing nets in good conditions. For fishermen with their boats and small networks revenues fell from 350 to 70 pesos per day. This was during the first and second year after the caterpillar damage to mangroves.

Also, intermediaries saw their income diminished by the purchase and sale of fish, crabs and oysters. For this reason buyers stopped coming to the community and the sale was carried out three times a week was reduced to once a week.

Likewise, this mangrove defoliation affected to the blue crabs gatherers, because their revenue from 80 o 90 Mexican pesos it was reduced to Zero.

LESSONS-LEARNED & RECOMMENDATIONS

This is the first work done on restoration of the black mangrove ecosystem in Mexico and the first investigation of this pest species. There is no previous evidence of such severe damage and that the caterpillar population has been so high and so harmful. Nor exist recorded economic about damage to fisheries caused by the pest population.

As experience, not to have tended this pest in time brought serious consequences to black mangrove ecosystem and its productivity.

However, this first approach has been successful, first mangrove recovery. The survival rate of planted mangroves was 98%, growth was twice faster than mangle from natural regeneration and flowering was obtained 2.5 years. This means that the management of mangrove nursery accelerates their growth and reproduction.

Management after planting mangrove has favored the creation and development of glass and turn and construction of blue crab burrows, very important for the most vulnerable population in the area. Although not stabilized plant growth or production, there is a trend towards recovery in the capture of species as, oysters, shrimp and crab.

To achieve these results the cooperation of the local population was necessary. Part of the activities undertaken at the global level was the training of the population in various areas.

As recommendation it is necessary to restore at least 50 percent of affected surface in the state to help restore the ecological balance and promote reproductive cycles of commercial species.

Photo 7. Ecological Authorities checking the project. Photo 8 restored area.

REFERENCES & ACKNOWLEDGEMENTS

Sol, S. A., R. C. E.M. Zenteno, C. L. F. Zamora y R. E. Torres. 2002. Modelo de restauración ecológica de áreas alteradas. Kuxulcab' Revista de divulgación. Volumen XII. Número 14. Tabasco, México. Pp. 48-60.

Cox, G. W. 1970. Laboratory Manual of General Ecology. 4 edition. William C. Brown company publisher. Dubuque Iowa, 165 pg.

Ángel Sol Sánchez, Facundo Sánchez Gutiérrez, Gloria Isela Hernández Melchor, Luis Felipe Zamora Cornelio, Oreste Sardiñas Gómez, Carlos Rivera Pedro José Toruño 2014. Volumen maderable de mangle negro (Avicennia germinans L.) Impactado por herbivoria de Anacamptodes sp en Cárdenas Tabasco. Revista Iberoamericana de Bioeconomía y Cambio Climático. Vol. 1. núm. 1 2015. pp 115-133. Colegio de Postgraduados. UNAN-León. Nicaragua. Centro de Investigaciones en Ciencias Agrarias y Economía aplicada.

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The economic, social and environmental value of plant breeding in the European Union: An ex-post evaluation and ex-ante assessment

Plants for the Future
European Technology Platform

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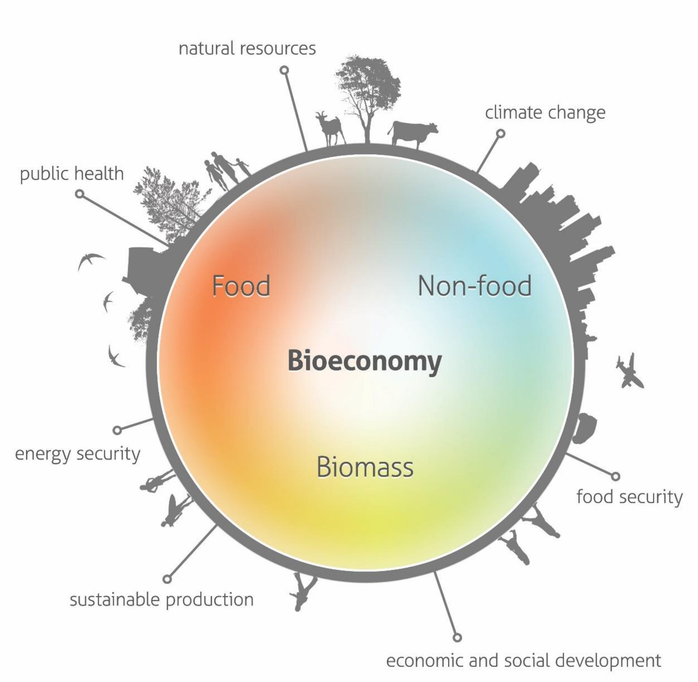
European Technology Platform 'Plants for the Future' www.plantetp.org

BACKGROUND & OBJECTIVES

Sustainable supply of biomass is one of the cornerstones of the Bioeconomy



The increasing demand for food, feed, fibre, industrial products and energy requires a multidisciplinary approach driven by science, technology and innovation

The prime drivers for success - sufficient biomass of the right quality and at the right time - are plant breeding and breeding innovation

Plants are in the centre of our daily life and welfare

The contribution of these drivers are recognized by many, yet so far **a proper qualification and quantification of the benefits of plant breeding** has not been carried out. This is why the European Technology Platform 'Plants for the Future', which represents industrial, academic and farming communities, decided to commission a study on the economic, social and environmental benefits of plant breeding in the European Union (EU)

The study aims to provide reliable, science-based and well-understandable quantitative and qualitative insight on the benefits that plant breeding offers to societies and to the Bioeconomy

ACTIVITIES

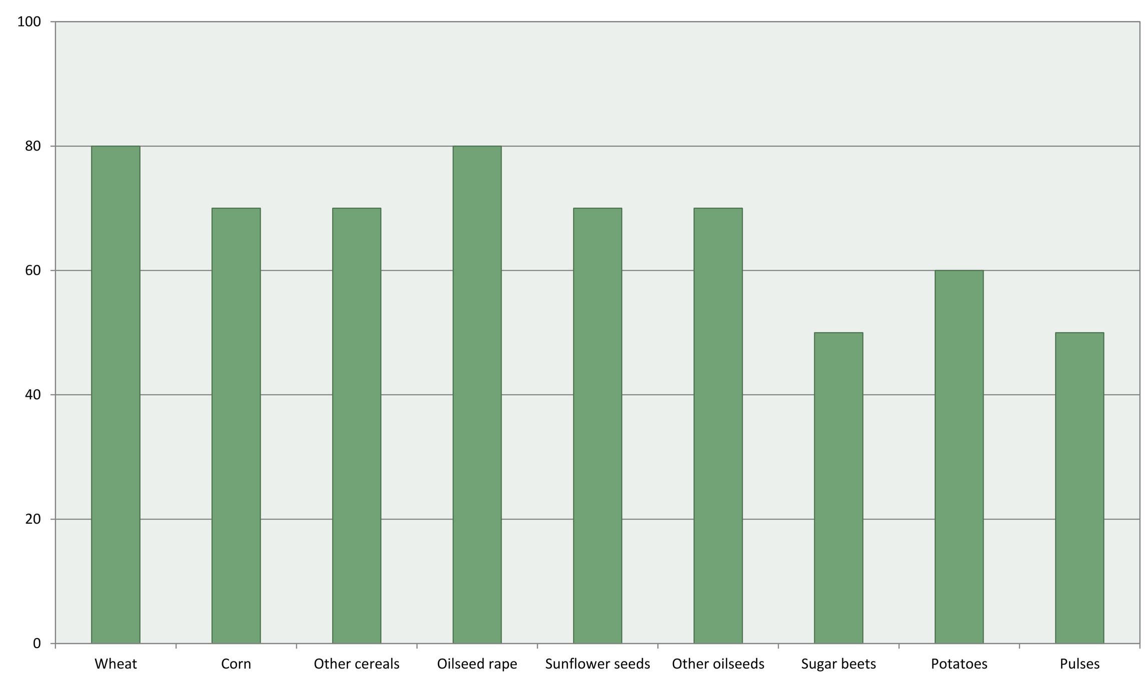
A meta-analysis on the impact of plant breeding in the EU is providing reliable data on the effect of breeding on European crop production. The breeding effect - primarily a yield impact - will be calculated using the total factor productivity (TFP) approach

Various target indicators are used, e.g.:

- Socio-economic: P, Q_s, Q_d, Q_t, kcal, EUR/AWU, GDP
- Environmental: land use, GHG emissions, biodiversity loss, water usage

RESULTS ACHIEVED SO FAR

TFP (i.e. innovation) shares of EU plant breeding: currently between 50% and 80%



Higher shares expected for future years: WHY?

WITHOUT plant breeding innovation since 2000:

‼ Yields in arable farming would be **15% lower**
‼ **150 million** people would not be fed
‼ Agricultural market prices would be **6% higher**
‼ EU' GDP would be **EUR 14 billion lower**
‼ Average farm income would be **30% lower**
‼ EU would become **a net importer** in all arable crops
‼ **18 million ha more** arable land used outside the EU
‼ Equivalent to all **GHG emissions** from traffic in DE/y
‼ Biodiversity loss ≈ **deforesting 6,2 million ha** of Amazon
‼ **Water loss** ≈ sizes of Lago Maggiore+Como (50 billion m^3)

PRELIMINARY SUMMARY

Modern plant breeding in the EU allows:

- To increase yields and overall agricultural productivity
- To enlarge agricultural crop supply

Plant breeding acts:

- To increase rural welfare
- To increase social welfare
- To provide greater quantity of less expensive food
- To enhance world food security
- To stabilize agricultural commodity markets

Genetic crop improvements permit:

- To preserve valuable natural resources
- To reduce GHG emissions
- To protect and enhance biodiversity around the globe

REFERENCES & ACKNOWLEDGEMENTS

This study is realized by Steffen Noleppa from HFFA Research GmbH. It will be finalized by the end of 2015. The research has been initiated and financially supported by the European Technology Platform 'Plants for the Future' (Plant ETP). Plant ETP is a platform bringing together public and private researchers, industry and the farming communities in order to align research priorities and set up strategic action plans to promote research, innovation and education in the plant sector

BEEKEEPING IN THE TROPICS: THE CASE OF HONEY TABASCO, MEXICO

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BACKGROUND & OBJECTIVES

Beekeeping in Mexico is an activity of great economic importance because 45 000 producers realize this activity distributed in all states of the country, who work with 1.9 million hives.

Mexico held the 5th place worldwide in production with 57, 200 tons in 2014 and was the 4th exporter of honey in the world in that year.

Germany tops the list of buyers of Mexican honey, because it acquires 43 per cent of production exported; USA, 25 percent, followed by Belgium with 12 percent.

Tabasco State noted for its biodiversity and is suitable for beekeeping development zone, although its production was low of in 2014, about 272 tons.

The beekeeping chain in the state needs to organize and increase the number of hives to produce honey differentiated, in addition require collection centers for honey and produce organic honey.

On the other hand Tabasco needs to develop strategies to mitigate the effects of climate change, due to phenomena such as flooding and prolonged drought in the state have a negative impact on honey production and quality.

ACTIVITIES

Clasification of Honey It was performed using Erdtman Techniques (1960) and Loveaux *et al*. (1970). Honeys were classified as multifloral and monofloral.

Phenolic profile of honey. The total phenolic content (Singleton and Rossi, 1965) and the flavonoid content (González-Aguilar *et al*. (2007) were obtained. The phenolic compounds profile was obtained by HPLC (Ferres *et al*., 1994).

Antioxidant capacity of honey. Assays DPPH (Brand-Williams *et al*. 1995) and ABTS (Miller *et al*., 1993) were used.

Training workshops for beekeepers. They were on topics such as Good Manufacturing Practices Honey, Good Manufacturing Practices Honey, Honey Safety, Labelling Honey, Industrialization of bee products and Organization producers.

Photo 1. Training of producers in the management of the hive

Photo 2. Training of producers in the management of the hive

RESULTS

The Tabasco honeys that have been classified is 3 monofloral (coconut, guava and bush) and 12 multifloral.

It has the phenolic profile and the antioxidant properties of honey cited.

We are trained 123 men and women to have a better performance in their beekeeping work.

Photo group 3. Types of honey, pollen grains, and hive management training

LESSONS-LEARNED & RECOMMENDATIONS

Tabasco has the potential to produce differentiated honeys. Also Tabasco has bee flora areas to increase honey production.

Beekeepers have improved their ability to diversify their production and honey products: royal jelly, pollen, honey, syrups, cosmetics, sweets, etc.

It has now been given added value to the honey with obtaining the color, phenolic profile, label design, and other

Photo 4. Instructor and producers during hive management

Table 1. Antioxidant activity of honey from different regions of the State of Tabasco, México.

Honey sample	DPPH µM Trolox/100 g of honey	ABTS µM Trolox/100 g of honey
H1	20.2 ± 5.2 a	36.9 ± 1.9 ab
H2	20.6 ± 7.5 a	71.5 ± 0.0 c
H3	15.7 ± 1.3 a	64.5 ± 8.1 c
H4	16.8 ± 3.3 a	38.9 ± 3.1 ab
H5	57.2 ± 6.7 b	69.5 ± 2.0 c
H6	23.9 ± 2.4 a	29.0 ± 2.1 a

REFERENCES & ACKNOWLEDGEMENTS

Ferreres, F., Tomás-Barberán, F. A., Soler, C., García-Viguera, C., Ortiz, A., & Tomás-Lorente, F. (1994). A simple extractive technique for honey flavonoid HPLC analysis. Apidologie, 25, 21-30.

González-Aguilar, G. A., Villegas-Ochoa, M. A., Martínez-Téllez, M. A., Gardea, A. A., & Ayala-Zavala, J. F. (2007). Improving antioxidant capacity of fresh-cut mangoes treated with UV-C. Journal of Food Science, 72, s197-s202.

Miller, N. J., Rice-Evans, C., Davies, M. J., Gopinathan, V., & Milner, A. (1993). A novel method for measuring antioxidant capacity and its application to monitoring the antioxidant status in premature neonates. Clinical Science, 84, 407-412.

Singleton, V. L., & Rossi, J. A. Jr., (1965). Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. American Journal of Enology and Viticulture, 16, 144-158.

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