FELLOWSHIP SUMMARY REPORTS

- Please submit this Summary Report in Word, in Times New Roman, font size 11, using UK English spellings.

Cover page – which should include:

- Meinhard Breiling
- OECD CRP Biological Resources in Agriculture, Year 2017, Contract TAD/CRP JA 00092576
- Gyeongsang National University GNU
- Prof. Dr. Hyeon Tae Kim, Facilility Environment Bio Systems Engineering Lab, FEBS
- Feb. 28th, 2017 to June 21st, 2017
- Yes

1. What were the objectives of the research project? Why is the research project important?

Vulnerability of Agricultural Production Networks and Global Food Value Chains due to Natural Disasters in Korea and Austria: ICT Roles

Extreme climate events damage agricultural production and are likely to cause even more damage with enhanced climate change. The role of ICT in reducing risks and to save harvests must be highlighted. We indicate the transferability of ICT applications from Korea to Austria. We show that ICT can increase the agricultural and food value chain on a regional and global scale but currently it a huge investment that has to be supported by state and provincial programs.

2. Were the objectives of the fellowship achieved?

1) To assess in how far extreme climate events have damaged or can damage production at Korean sites and to assess what is the role of ICT in reducing risks and to save harvests. My stay included several research visits to national and provincial research institutes such as the visit to Gyeongsangnam-do Agricultural Research and Extension Services on March 9th, 2017 (www.breiling.org/events/2017/0309/index2.html). Different methods on smart farm methods are promoted and taught to farmers. Since 20 years the national and provincial government support farmers when they decide to switch from conventional to smart farming. This includes glasshouses for smart horticulture and products such as paprika, tomatoes, cucumbers, melons, strawberries and plant factories for salad. The investments are huge and initially the state supported the farmers with 80% when they decided to switch from conventional to smart farming. Currently the concern is on how to reduce energy inputs and related costs. Smart farms can obtain cheap agricultural electricity for their operations. They need to optimize production conditions in glass houses, such as temperature, humidity, CO2 concentration. This requires adjustment to the actual conditions at the place like warming during winters and cooling during summer. In glasshouses natural light remains while plant factories additionally simulate different light intensities. The conditions on several farms with varying environment and climate conditions were examined. Two paprika farms near Jinju were visited on March 16th (http://www.breiling.org/events/2017/0316/index.html) and two more on March 23rd in Uiryeong gun (http://www.breiling.org/events/2017/0323/), a fifth farm on March 30th in Hapcheon gun (http://www.breiling.org/events/2017/0330/) . The natural landscape conditions vary and each place has different conditions to be successful in smart farming. With regard to paprika in principal six harvests a year are possible if environment conditions are adjusted. The farms near Jinju only slightly elevated have very difficult summer conditions as the weather gets very hot and cooling is a most difficult task. This is different at the farm in Hapcheon in 900m altitude where summer conditions are much better and cooling is not so difficult. Uiryeong climate condition is in between Jinju and Hapcheon. Farmers in Jinju decide to stop smart farming during summer. They consider winter the better season as all environment conditions can be controlled while the summer peak cannot. The farmer from Uiryeong had particular high costs during winter as the place is very cold and heating the glass house in winter costs a fortune. In fact he never makes profits during the winter harvest, in the best case his sales profits equal costs the but for labor logistics and customer relations it is better to have six harvests.

Interviewing South Korean paprika farmers provided insights that smart farming is a very close cooperation between private farm businesses and public support units. The provincial and state institutions collect huge amounts of farm data - Big Data - that is the basis for continuously improving the performance of smart farms. This data is combined with other data from state agencies - such as the Korean Meteorological Administration (KMA), the Korean Rural Development Agency (KRDA) and others.
The role of natural disasters came in particular in during two visits to the Protected Agricultural Research Institute in Haman gun (http://www.breiling.org/events/2017/0427/ and http://www.breiling.org/events/2017/0523/). Three particular climate events leading to disasters are typhoons, strong winds and heavy snow. Much damage can be avoided by building more stable glasshouses. There are particular experimental halls where disaster conditions and stresses can be simulated. The results lead to guidelines for a more resilient construction of greenhouses. Furthermore, this national institute promotes research on ever more precise plant sensors to track the metabolism of tomato and other plants. This will lead to continuously optimized growth processes. The role of smart farming under subtropical conditions was experienced by a visit to the Citrus Research Institute, a state institute in Jeju Island (http://www.breiling.org/events/2017/0609). In fact it might become possible to produce any kind of tropical fruit locally in the country of consumption if growth conditions can be sufficiently well simulated in glass houses or plant factories. A second group of applications of smart farm is animal husbandry or to produce meat and other animal products with smart farming methods. Large groups of animals are kept in a small area. We visited three swine farms in Gimhae (breiling.org/events/2017/0525), in Sacheon gun (http://www.breiling.org/events/2017/0606) and Jeju island (breiling.org/events/2017/0609) but were not allowed to enter the stables due to the given infectious risk. Instead we could watch the animals via monitors. The spread of diseases is a major hinder in a rapid expansion of animal smart farm units in South Korea.
Aditionally, I was invited to conferences and research meetings of the Korean Society of Agricultural Machinery Engineering (www.breiling.org/events/2017/0406 and 0609). This gave sufficient possibility to discuss even with more scientists from South Korea doing research in applied agricultural ICT applications.

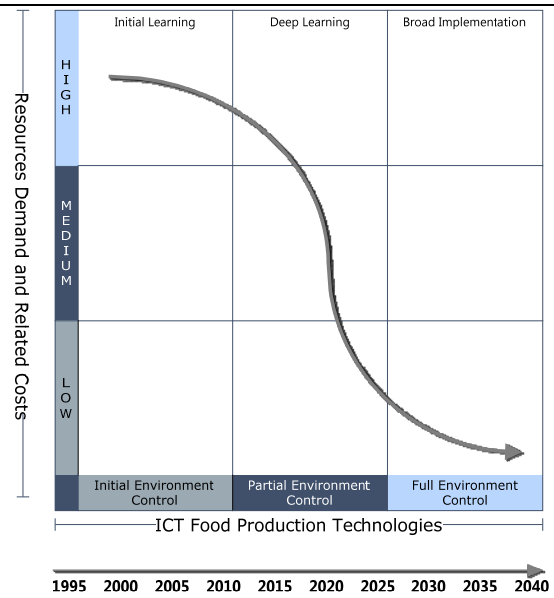
2) To identify the possible role of ICT to reduce vulnerabilities and increase resilience in selected food value chains taking the Wachau Cultural Landscape in Austria as an example.

One particular task was to judge in how far an assumed technological advantage - as compared to Austria - could have benign effects even in Austria during frost episodes. The late April frost in 2016 caused a damage of 30 million Euro and a complete fall out of the apricot harvest. A means to counter a frost warning was to heat the area assumingly threat by frost. In 2017 this procedure was undertaken during frost events in April, but the efficiency is very low. The area is too large and if no appropriate heating infrastructure is in place, the success is marginal. The price of the fruits might not justify the investment into heating infrastructure. A better means to counter frost is the application of straw to improve the local climate. However, this is to laborious and might only be applied in some special cases.
While ICT at the moment cannot reduce vulnerabilities or increase the resilience in selected food value chains, it could be used to estimate the damage by using optical sensors. Applications to sensor frost damages can be developed. For example drones in a reference altitude can register the flowering area of trees (or even flower volumes) under normal and frost conditions. This information might tell in how far baseline conditions are changing and what is the particular effect of frost episodes. This information can be used for decision making and in the long run to breed more frost resistant apricot varieties.
Yet another alternative might be the growing of apricots in closed glasshouses including the possibility of heating. The greenhouse based cultivation requires in particular a lot of energy. The amount of energy is less if the required climate within the glasshouse is close to the actual climate outside. Climate information is necessary to locate the spots that are best suited for this kind of adaptation to more frequent frost events.
In summary, ICT in its current form and technological maturity could not have helped in the case of the observed frost events.

3) To anticipate the likely importance of ICT on larger regional and global food value chains and under what conditions a global implementation is possible

In a global context the importance of ICT and smart farming are growing quickly. Just the promise to provide disaster information for agriculture or to have a means to regulate ever more climate fluctuations is a promising idea. Governmental and provincial programs are very important here to get initial results and experiences. The costs of ICT applications are currently still very high but a sharp decrease in prices is expected for the near future. This may lead to a broad and fast implementation of ICT technologies in agriculture.

Figure 1: Expected direction of ICT in South Korea: optimal environment control at acceptable cost



Source: Breiling and Kim 2017, (developed in relation to OECD co-financed activities)

ICT in agriculture was introduced in South Korea during the 1990ies. Major applications were paprika, tomatoes, cucumbers, melons, oriental melons and strawberries. For each fruit or variety of a fruit separate glasshouse is used. The optimal environment conditions demand for a targeted control specific to the fruit. The idea of ICT in greenhouses was to optimize temperature, the supply of water and nutrients, the control of pests and the accounting for material inputs to produce the fruit. Instead of carefully observing the environment conditions by the producer, sensors are now used to assess the environment conditions and actions are partly undertaken automatically. Currently ICT and smart farming is considered in a new phase. Many countries in Asia and Europe have launched programs promoting ICT and smart farming going beyond the scale of horticulture. The profitability is not yet reached but in a not too distant future this may change. A sharp decrease in prices for systems and devices related to ICT in smart farming is on the way.

The globalization of agriculture and the increase of trade with food and agricultural commodities which was 70% in the decade 2006 to 2016 (WTO 2017) indicates that agriculture and food are gaining importance and in general higher value. Saver and more reliable food production will become a more important topic, in particular in situations when global climate change is likely to increase disaster frequencies.

3. What were the major achievements of the fellowship? (up to three)

I become familiar with the ongoing research at FEBS, the general structure of the South Korean academic system at universities and public research agencies, both national and provincial, as well as the embedding in research and implementation programs and related business and industry cooperation. Here I got a lot of support and learning was much more than what I initially expected.

Several study tours and participation in two conferences organized by the South Korean Society of Agricultural Machinery brought many in depth insights in how far research is organized.

Further co-operation between the host and recipient institutions, namely the Gyeongsang National University (GNU), Facility Environment Bio-Systems Engineering (FEBS) and Technische Universität Wien (TUW), Technology.Tourism.Landscape (TTL) is possible. A letter of intent for further and intensified cooperation was signed in November 2017 and a memorandum of understanding is currently subject for approval from the directorates of both universities.

4. Will there be any follow-up work?

- Is a publication envisaged? Will this be in a journal or a publication? When will it appear? **Yes** - A conference publication appeared were the fellow presented.
- Is your fellowship likely to be the start of collaboration between your home institution and your host? **YES**
- Is your research likely to result in protected intellectual property, novel products or processes? **YES**

5. How might the results of your research project be important for helping develop regional, national or international agro-food, fisheries or forestry policies and, or practices, or be beneficial for society?

The research relates to ICT and smart farming and is in line with the current trend to make agricultural and food production more valuable. Controlled, standardized and optimized conditions for plant and animal products are a way to ensure food quality. So far underrepresented is the role of ICT in increasing the resilience of agricultural production areas. Here we wanted to emphasize on a range of possibilities, testing them if they are suited or not to lessen disaster impacts. This in turn will help local and regional decision makers to formulate policies accordingly.

6. How was this research relevant to:

- The objectives of the CRP?
  Important insights on the possibilities of ICT to counter disaster events, such as floods, droughts, extreme temperatures were developed and can inform future policy decisions related to the sustainable use of natural resources. Smart farming and ICT will respond to varied demands of increasing the value of agricultural production and to increase the resilience of agricultural production systems and global food chains taking into account the various interests of stakeholder groups.
- The CRP research theme?

a) Contributions to the aim of the programme MANAGING NATURAL CAPITAL FOR THE FUTURE
   To secure harvests and to prepare against risks is deeply rooted within the managing natural capital for the future

b) Relevance to the theme objective
   Several theme objectives are covered, landscape is a 30 years research domain of the applicant and even without naming landscape explicitly, it is always present in this research proposal. The applicant works at the landscape division of TU Wien and his projects are considered to reflect light on various elements of landscape namely soil, water, biodiversity, forests, aquaculture, integrated agricultural production systems, and more issues.

c) Scientific excellence
   The applicant has led several international research projects and organized several international conferences. He also received the Austrian innovation prize PRIZE 2009 which led to an international patent for the artificial cloud or “dendrite generator”

d) Feasibility
   The fellowship is part of a larger cooperation that started in June 2016 and the research is not considered to be finalized directly after June 2017 while important milestones for future cooperation are on the way. Basic data from Wachau region will be collected before departing to Korea.

e) Scientific records of the applicant

The applicant has published more than 50 publications either articles in scientific journals, books, book chapters; he was editor of several conference proceedings. A list of publications is enclosed.

f) Crossing disciplines

Agricultural engineering, landscape architecture, risk research and abatement as well as economy are included in one research proposal.

g) Dissemination

Results will be disseminated at joint conferences of TU Wien, National University of Geongsang, ERIA, OECD CRP program co-sponsored conferences and others. Additionally publications in scientific journals are targeted.

h) Potential impact

The potential impact of ICT in countering risks from extreme weather events is very high. In particular if climate extremes are likely to increase and more damage has to be expected. New means to counteract will be required.

i) Policy relevance

The high tech and scientifically supported farming as targeted by ICT - similar to organic agriculture - can alter the agricultural and food value chain. It is a political decision if this technology – currently too expensive to be employed by small farmers - will penetrate even small scale farm businesses.

7. Satisfaction

- Did your fellowship conform to your expectations? **YES**
- Will the OECD Co-operative Research Programme fellowship increase directly or indirectly your career opportunities? **NO**, or I do not know, program is too short.
- Did you encounter any practical problems? **NO**
- Please suggest any improvements in the Fellowship Programme. Allow more than one fellowship every 5 years.

8. Advertising the Co-operative Research Programme

- How did you learn about the Co-operative Research Programme? **Colleague** informed me!
- What would you suggest to make it more “visible”? Feature several fellowship holders whom you consider successful and tell their story - or let them tell their story!
- Are there any issues you would like to record? **NO**.