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ICT, integral models and new methods support farmer's and forester's integration into environmental caretaking and risk-management

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Abstract: Farmers and foresters – in total worldwide more than 2 billion people - manage large parts of most of the countries, in some 90% or more. Rich, risk-exposure countries with beautiful nature like Austria or Switzerland due to mountains did a lot of excellent environmental caretaking because of intensive tourism and reduced with the help of government existing risks, supported by legislation, avalanche-, torrent- or river- departments, land consolidation units, Chambers of Agriculture, Ministerial departments etc. and were supported by farmers with a general concept: Managing a farm or forest correctly, manages also the environment well. EC's GAP (Good Agricultural Practice) took this concept EC-wide. Changing risk patterns and also population increase needs taking care more of regional environment- and/or risk related questions – together with farmers. Many new strongly needed workplaces supporting all of us also can be created. New technologies (ICT and global ortho-images, GIS, GPS, GPRS, mobile equipment for outdoor use, precision farming/forestry technologies, sensors, etc.) and increased know how understanding interrelations of environment-related factors allow better planning of needs and to-dos avoiding future problems. Preventing is better than healing!

Keywords: *Holistic solution, GIS, maps, farm management systems, logistics, precision farming*

1. Introduction

Just if we take the new notification from the EC Commission to the EC Parliament (20.9.2011 KOM (2011) 571 final) about a future roadmap for a resource-protecting Europe, we read, within the 20th century use of fossil combustible material twelvefold, digging for mineral resources 34-fold, within EC use per head is yearly 16t raw materials, 6t of it become waste, 50% of the waste becomes landfill.

If we read further and focus only on, for agriculture and forestry relevant facts, we find:

- Vision 2050: With respect to the shortage of resources we learned integrative thinking and cover also a high standard of living, maintaining a lower ecological damage. All resources are managed sustainably – from raw-material till energy, water, air, land and soil. Protection of climate was reached, biodiversity and benefits of the ecosystem was renewed.
- We need an innovation wave: Water, productive and sustainable agriculture, raw-materials
- Lead-Indicator must be “resource–productivity” and add-on indicators for water, land, carbon.
- We must overcome barriers, investigate markets, prices, taxes, subsidies as far as they don't mirror correct costs of resource-use, we have to support sustainable and innovative thinking within politics, industry and finance and need to support research for closing know how gaps.
- A “green” model has to support ecosystems (natural assets), the economy (produced and financial assets) as well as human well-being (social and human assets)
- We must optimize products, consumer behaviour, efficient production, (ecological footprint and eco-design directive!) and make resources from waste: 2020: Manage waste as resource
- Inefficient subsidies have to be terminated and we have to show the “real” prices of resources like water, clean air, ecosystems, biodiversity
- Taxation has to change from factor “work” to factor “environment”
- In-between target ecosystems benefits have to be determined according their real value
- We need financing facilities for biodiversity-projects and payments for ecosystem-benefits
- Biodiversity, water, raw-materials, air, land, soil, sea-resources must be managed sustainable
- Key-factors to be maintained are: Food, better construction and efficient mobility.
- Governance and control is a must!
- We need more dialog, invest into the transfer, need to define indicators and targets and have to support resource efficiency international.

When we read these lines we will start to understand that agriculture and forestry is a significant element within this resource-supporting European target and have to understand that environmental caretaking is not only a burden. It has to be seen as a chance to deliver services to the whole population. Naturally, we know that within a transition period we will have the one or other problem as not all services will be acknowledged immediately, nevertheless we have to go in that direction as only sustainability also of the own farm or forest-enterprise will support the whole target. It is one of the urgent questions towards politics to buffer these inequities. We have not to stay with our back on the wall but have to accept the challenge working towards this target.

For the start of this process we have to think about “**what are the factors that give us the feedback if we work sustainable or not**”. Also if we know that the nature is a rather complex system we have to limit the number of factors that have to be taken into consideration or measured because otherwise the model runs out of scope. To verify, measure and control these key-factors will be THE question within any environmental decision support system. Worldwide such systems are NOT in place yet although know how and understanding is available already.

Before thinking towards this target and how to reach it we have to think about the **carrying capacity of every piece of land** first – what can we do on a piece of land under a sustainable target on one side and on the needs to get services from this piece of land for the involved private and public bodies on the other side. I personally support private landownership, nevertheless we have to take into consideration that a landowner has also an environmental and social responsibility. In many cases only a private landowner – also cooperatives can be private landowners - will be able to support and guarantee these long-term targets. But they only will be able to do this if compensation for the add-on services is worked out. To be able to do this we have to start understanding what is part of a “normal”, under good agriculture practice (GAP) sustainable managed agriculture and what is part under the umbrella of additional or other targets that should be reached and the defined targets show more or other factors that have to be supported by farmers or foresters. We also have to think who is able to define these “other”, e.g. special environmental targets like maintaining a landscape, to do risk-reduction etc.. The so called “commons” model, supported from many parties today will work if, only partly and for sure not always. The past has shown that a private managing farmer who wants to support his property sustainable and maintain it for the next generation will be THE driving factor for sustainable managing of land. This only if the burden of having to support targets that do not coincide with his sustainability targets and for supporting other targets he is not compensated – as often happens today and drives farmers out of business because of financial- or often psychological burdens - is taken off from him.

First let us start to understand which technologies and applications we need for managing the standard needs of farms taking into consideration that the farmer is not alone on the world but is also linked with chain partners like buyers, suppliers, banks, insurance companies, neighbours, cooperatives where he is member, governmental organisations etc.; if we want to design a software for the farmer alone without supporting and understanding these links and needs we would produce a crash landing. Also from the point of environment these links are of importance as some of them influence immediately and strongly the farmer and its behaviour. For the future we have to embed into these types of software such complex models like fertilizer balancing, carbon sequestering etc. to be able to show later the farmers influence on these factors.

2. The method

2.1. The map as a base fundament:

1. WinGIS is an easy to use and efficient GIS software with wide geographic application possibilities and facilities. The integration of the online map data of Microsoft Bing Maps as „embedded Module“ provides the access to worldwide available map data like satellite/aerial images, road/terrain maps and geocoding functionalities. Data exchange interfaces to/from other GIS/CAD systems and database support (WinGIS internal database or external databases) are already part of the delivered software package. (Details see www.progis.com)
2. Microsoft Bing Maps (www.bing.com/maps) in the form of ortho-images, embedded into all PROGIS technologies either online or downloaded allow to start up work for every single user or advisor immediately. Also other available maps in a country can be used and also crunched with Bing Maps or worked out with local experts like rural-OSM (Open Street Map).
3. Based on that GIS system there are about 20 applications supporting agriculture, forestry, environmental caretaking and risk management as well as affiliated chain-partners.

4. Open interfaces allow the linkage to existing other technologies: Samples are agro-sensor-stations, mobile equipment, RFID technology, GPRS or UMTS communication.



Abb. 1: 30cm orthoimage of a rural area

- **Specific features:**

4D-GIS with the 4 elements hybrid geography, a database, time- and activity management and a down sizeable expert information.

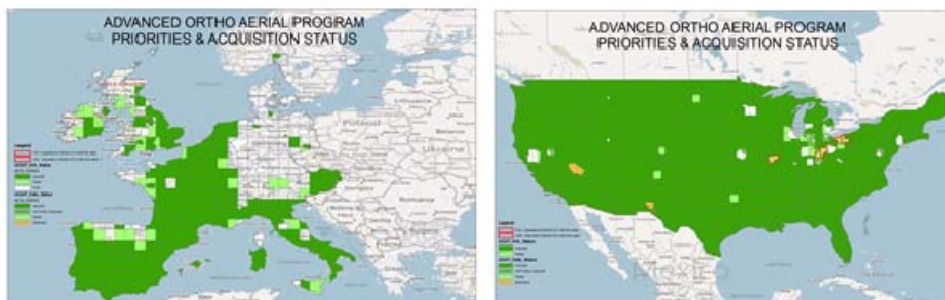


Abb.2: Available orthoimages 30cm resolution from flights Europe (2011) and US (2010/2011)

An integrated model has many beneficiaries. From the Minster who gets information directly from farmers who get better tools for managing their farms or get better support by advisors till to the advisors who are embedded into a powerful tool that is permanently upgraded with data from the science. Traders, the food producing- and processing companies are also beneficiaries like banks and insurance companies (why should not banks support to run an advisory concept? It would help them to use their rural area branch offices better) or also the producers of machinery or agro-chemicals. Foresters, land managers, utility managers or environment- and risk experts will also benefit from such an intelligent maintained system. Even telecom companies could support to be able to run their new services also in rural areas – they are needed there.

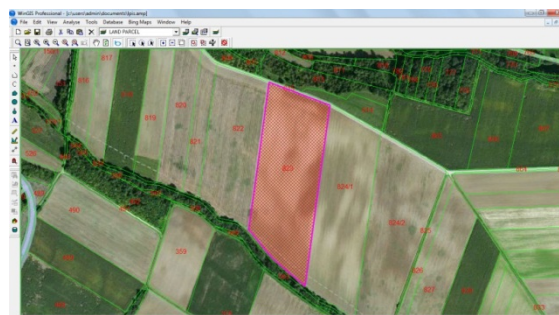


Abb. 3: Orthoimage 30cm, land parcel measured with WinGIS

2.2. Farm-, forest management as the next step:

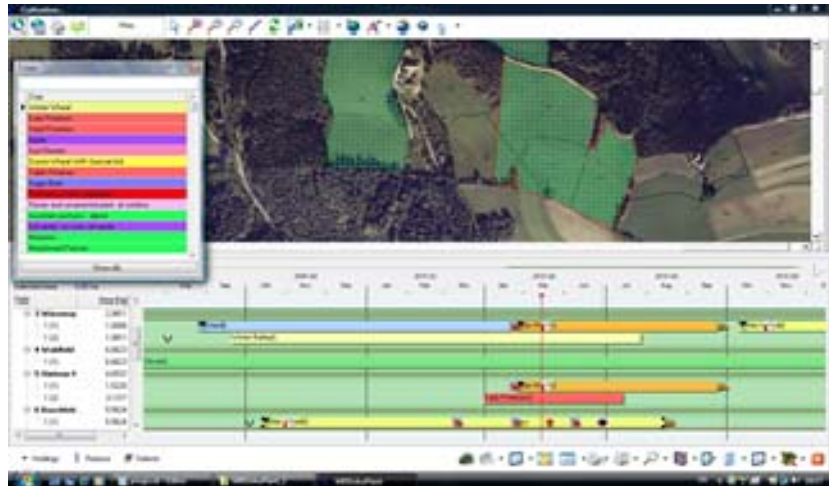
The next element is a farm management, forest management or farm advisory service management software:

The Farm management tool named "DokuPlant" is based on an expert system that can be developed and sustainably maintained by local agricultural experts and contains all machines and their costs and efforts per area (ha, acre etc.), all pesticides with their chemical active substances, all organic and inorganic fertilizers with their nutrient contents as well as all the crops and varieties. Further based on this content all the activities during a year or a crop season have to be foreseen in all details for all crops, e.g. to grow maize needs step no 1 a tractor and a plough, step no 2 a tractor with a fertilizer equipment linked and NPK fertilizer and so on. The average farmer or advisor can just use the expert information; the upgraded user can maintain expert data himself and modify them according to his know-how.

This allows planning all details with a click on a polygon on the map – representing the field and either to be drawn on the raster-map or with GPS points to be imported – and select a crop – with all the details of the expert information in background. The rest is just output. Besides planning during the year, all the done activities have to be recorded, either with manual input or with a link to mobile equipment.

On output, the following possibilities are foreseen for a field or for the complete farm: Calculation of costs, returns or contribution margins, calculation of nutrient balances (or also energy- or CO₂ balances), documentation of all activities and transfer of the data (or part of them) to chain partners or to a trust centre, sending a subsidy claim to a ministerial system or to any other host computer and further creating thematic maps.

A single farm can be managed on one PC, as well as many farmers with advisors. It allows also



comparing anonymously crop statistics of different farmers.

Naturally the advisors also know the use of fertilizers, pesticides or seeds etc. for their regions; several advisors can be bundled to a region and many regions to a country. A new ICT based advisory system can be set up – details see later.

2.3. Logistic-Unit and mobGIS link the many machines/farmers together:

Logistics in general is the – GIS based - know how of all the locations of different fields integrated into a control centre that guides manual workers, machines and/or trucks to a field with GPRS/UMTS communication via mobGIS. The local driver can answer with a push of a button that he got the order "Where to go and what to do" and later on when he finished his works he responds: e.g. how many sugar beets put for later pickup. The update frequency is software depending, in practical work usually in 30 seconds what is more or less online.

When the central station knows where e.g. the sugar beets (sugar beet is just a sample of the system, it is open to ALL crops) have



Abb. 5: Logistics display showing routes for the drivers

to be picked up, it sends another contract to a pickup machine and this machine invites based on the know how of how many tons to be loaded, two, three or four trucks that are linked with e.g. a TomTom routing tool. When the truck is loaded the mobGIS transfers the dataset to an RFID that is located on the truck and the truck drives to the factory that gets a just in time delivery e.g. number of trucks a day. In the same manner as a contract can be send from a control centre to a mobGIS, a farm management tool, DokuPlant, can send a contract to the control centre that manages the use of machines. Suddenly we see how farm-management tools, control centres and mobile equipment can work integrated together. In a small farm structured region, the control centre will be driven by a local service organisation, e.g. a chamber; a machine cooperative etc., large farms will run this centre themselves or even cooperate with smallholders as service providers.

2.4. The (meteo- and soil) agro-sensor network:

Collecting agro-sensor-data with agro-sensor-station in the relevant micro climatic areas of target region/farms is the basis for additional precision farming services, such as irrigation control, disease prediction, seeding and harvest timing, but also to apply for index based crop insurance. Therefore a network of agro-sensor-stations and, if more accurate irrigation control is desired, an integrated network of soil moisture stations needs to be established.

Today agro-sensor-stations are able to measure for one microclimate all important agro-sensor data incl. also soil moisture data and transfer them via GPRS (offline data-storage also available) into e.g. WinGIS for further processing. Based on expert models decisions about spraying can be done very precisely and farmers can be informed via SMS where to spray when and what. The focus is on reduction of sprays per crop season and so reduction of costs and environmental impact. Agro-sensor-station models can be set up countrywide together with advisory services and normally have a ROI of 1-2 years at the most.

The model allows to use for precise farming 1. old tractors and old e.g. fertilizer equipment and work with the help of a laptop to show the location and where to change the kg/ha "manually precise", 2. an old tractor with a new fertilizer equipment can be upgraded with PC that triggers the new equipment and 3. is the use of a new CAN-bus driven tractor.



Abb. 6: Meteo-sensors with solar panel, com-unit and location on a map with data

2.5. Integration of banks and insurance companies:

Was the logistic technology the showcase how to integrate the farmer with his suppliers and buyers supporting the question when and where someone has to deliver, is the integration of banks and insurance companies that are also in contact with the farmers and belong to his partners a next step to be integrated.

To plan for a farmer what he will do at his fields during the next three or five years and generate with some added data a business plan for banks as a base for financing. To know from the farm management system where how many hectares of which crop are growing, gives a data set that can easily be distributed to an insurance company as base for the policy insurance. Also the control of

fields in a catastrophe scenario can easily be maintained with a mobile PC, a GIS and the farmer's field data.

In countries without broad insurance but with the need to start better farming, excellent insurance models are a must for getting financing; and financing is necessary for getting started farming. The base of all is better information as also insurance cannot start without having better information. The integration of better information, (micro-)financing, insurance and sustainable farming methods are necessary to be able to start modern farming. Without this it will not be possible!

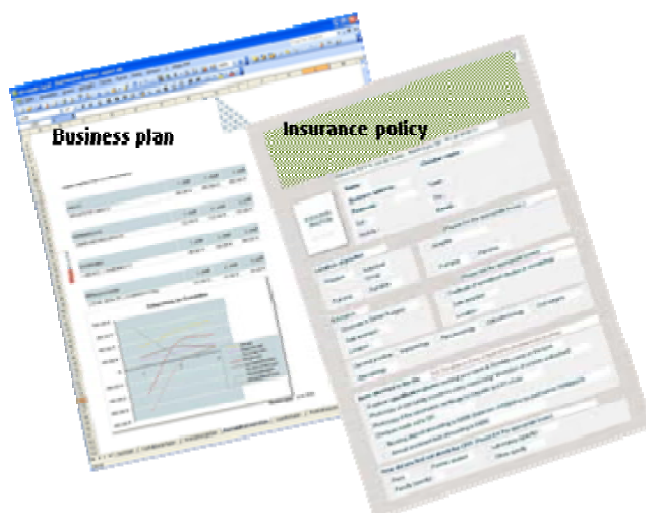


Abb. 7: Business plan for banks and insurance policy as result of integration

2.6. The highlights for experts - on top applications

They show that there are several next steps. Although it becomes rather sector oriented, the input of farmers and their activities is necessary

1	Natural resource-risk- and environmental-management	Consulting for natural resource-, environment- and risk management has to integrate methods how to measure the local carrying capacity of a piece of land, how to know what is needed and what could be delivered from a piece of land in products and or services and how to optimize this. These thoughts and linked methods were implemented into PROGIS technology that also can be modified by local experts.
2	REDD+	Understanding REDD+ (Reducing Emissions from Deforestation and Forest Degradation) and natural risk management models enable the setup of REDD+ programs within a country as well as to understand better methods how to prevent natural risks.
3	Remote sensing	Consulting for natural hazard and risk management based on the possibility that remote sensing gives. In all cases where we need simulation these technologies will help and input for simulations can come from e.g. farm- or forest management
4	Eco-management	Wildlife management, natural parks, hunting, fishing, agro-forestry, nature conservation, eco-tourism, rural development etc. are other sectors that can and must be linked to farming and forestry.
5	Logistics	Logistics is not only that what PROGIS is offering – see above – but starts much earlier – with the needs to make and manage infrastructures for rural areas .
6	Carbon modelling	Consultancy for carbon modeling , for nutrient and carbon management, for countrywide carbon models and also for Precision Farming is a next step for on top applications. A countrywide integration of carbon situation within agriculture and forestry can be measured, calculated, optimized and certificated with the target to enable with the support of the extension services the setup of a

		country wide carbon model to get carbon financing not only for a project but also for a country.
7	Livestock and nutrient use	Applications can support livestock management and nutrient use for animals and the impact on fields what gives for intensive livestock farms enormous new possibilities to save money and optimize in parallel the situation on the fields.
8	Cooperative management	Cooperative structures are a need in every country and must be part of a new and integrative agricultural structure. Consulting in transfer of this know how in setting up and managing such structures needs also the support of ICT technologies.
9	Forest inventory	Forest inventory methods and forest management are further applications for an integrated rural area management
10	Land consolidation	PROGIS has successfully implemented the land consolidation technology together with the government; it runs since more than 7 years. The model supports this Austrian model that is managed in Austria since more than a century, but now with technology.
11	Trust Center	With large ICT partners we support the PROGIS concept of trust centres that can be a mainframe or even a cloud based technology for all agricultural-forestry-environmental-natural-risk data and give precise a link from the farmer to the consumer = from farm to fork to enable traceability throughout the chain and to manage the data also for the government.
12	Influencing drought and rainfall	Technology is available to influence with models drought and rainfall and enable the setup of vulnerability maps.

2.7. Environmental management as a special case and technology

Besides a GIS (WinGIS®), integration of MS-BING®-maps, agriculture- and forestry applications also such for environment- or risk-management were developed, based on know-how and science-cooperation. New methods allow local experts to become part of solutions. New cooperation models are supported.



Abb.8: Agricultural and forestry services from a well-managed nature



Abb.9: Forestry failure ???

These models – in principle designed by a.o. Prof. Alfred Pitterle, Prof. of the University of Bodenkultur (Natural resources), in detail then designed by local experts, allow experts to define, what must be measured outdoor in a region to enable identifying the relevance of a piece of land to one or several environmental- or risk - management problems and store the data into WinGIS.



Abb.9: Forestry and Agricultural failure ???

As 2nd step models can be worked out increasing the capability of this piece of land to support identified environmental problems. Farmers as owners of a ground are engaged, balancing needed benefits and its beneficiaries. Based on social responsibilities of private owners of land and on new legal frameworks as well as bilateral agreements between farmers as supporters of the benefits as well as one or several structures (international, governments, regional and local administrations, private and NGO structures, ...) representing the beneficiaries, > 2 billion farmers worldwide can and must become part of environmental caretaking. Correct and objective methods and models between private motivation to support sustainable management of a piece of land in relation to its carrying capacities, the experts know how, the social responsibility and the identified needs of works to be done and their costs have to be integrated into the models to involve farmers and foresters in environmental caretaking for the benefit for all of us.

3. Conclusion

When we look at the international discussion about commons - also named "solidary economy" – and the renaissance of these old structures, I am sure that an excellent organized and government supported private agriculture, in vertical or horizontal sectors supported by cooperatives of farmers, will be in most of the cases the best way to organize an optimized private farm on one side and support in parallel better organized ethical, social and environmental targets that are based on excellent defined carrying capacities of a piece of land as well as based also on the needs of local, regional and global targets. In that moment when we have this and understand in detail the benefits that could be delivered sustainable from farmers as well as identify beneficiaries – a single one or a group of beneficiaries - the asked services can be delivered from single farms or from cooperatives and must be honoured also for all elements that are over a GAP bottom line, that means everything what is good agricultural practice (GAP) must be delivered in any case, everything what is beyond this line and there are local, regional or international targets defined must be honoured separately. I am myself chairman of two agricultural cooperatives, farmer as well as forester and understand that this is a huge possibility that is also needed urgently worldwide - to support all these services that agriculture and forestry could and should deliver. It would be good for the environment, good for farmers and foresters and would create lots of high end (advisors, experts) and low end (workers) workplaces. The time when all these services come automatically from an excellent managed agriculture or forestry has been passed as we will become in the next 40 years nearly 10 billion people on the world and should manage beside food and wood also bioenergy and environmental- and natural risk-management. A private farmer that is working sustainable because he wants to pass over the land to his children is the best guarantee that the sustainability targets are reached. We have learned that large financial investors into agriculture or also governments as owners do not have these sustainability thinking as a good educated, motivated and government supported farmer has.