**Communication**

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# Netherlands Public Private Partnerships Aimed at Co-Innovation in the Potato Value Chain in Emerging Markets

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**Abstract:** Since 2013 the Netherlands Ministries of Economic and Foreign Affairs has been involved in private companies in research and development (R&D) in developing countries. This in a policy going "from aid to trade". Especially in upcoming markets, R&D is carried out through Public Private Partnerships. Such partnerships not only include R&D organizations in the two countries but specifically also include businesses in both countries. This was to assure a logical flow of material and knowledge by all parties involved. Half of an R&D project is funded by the ministry and the rest is covered by a consortium of companies that contribute in kind and in cash. The policy is aimed at stimulating business development in developing countries and the Netherlands through cooperation and joint R&D. The paper explains how eleven consortia around potato business opportunities were formed, their R&D need was elicited and R&D projects formulated in the Asian countries China, India, Indonesia, Vietnam, Bangladesh and Myanmar, and Ethiopia and Kenya in Africa. In common are fact finding and descriptions of cropping systems, yield gap analysis and value chains in each country. Emphases differ with China looking for an integrated system of field operations, India for optimization of storage and processing, Indonesia to reduce pesticide and nutrient inputs, Vietnam for widening the varietal base, Bangladesh for combating late blight, Myanmar for cultural practices that lead to increased yield, Ethiopia where a potato processing unit is being established and Kenya importing seed potato from the Netherlands. Some content information is given as examples to illustrate the approach and some preliminary conclusion are discussed.

**Keywords:** Interdisciplinary research; industrial consortia; economic affairs

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## 1 The approach of public-private partnerships

Of the 40 largest global food companies, 12 have their base in The Netherlands (F&B 2014) and the country is leading in the production of propagation materials of flowers such as tulips, potatoes and vegetable seeds such as of tomatoes. Major food stuffs produced and exported are vegetables, meat, eggs and dairy products and processed frozen potato products. The Netherlands is the second largest exporter of agricultural products in monetary terms after the United States of America. Exports are made possible partly because of the import of feed from the Americas after the extraction of oil and starch there. Potato is the most important arable crop grown in the Netherlands on nearly 160,000 ha with a yield of 45 t/ha and total production of about 7 million tons per annum (FAOstat, 2016). The country also imports over 1 million tons for processing and as early table potatoes (http://www.nao.nl/nl/markt) in the off season (June and July) when old stocks have partly deteriorated. For processing

into chips and crisps 3.5 million tons of raw material is used, for starch production 2 million tons. The seed potato industry produces 1.2 million tons. About 80 % of all production is exported, so the potato industry is an important economic sector. Beside potato production and processing the industry has a significant supply activity such as the potato breeding companies and companies producing stores and storage equipment, processing equipment and chemical supplies. Therefore research and development focus largely on potatoes that receives funding for public private partnerships (PPPs). As a food security crop and as a contributor to diversification of the diet, potato already received considerable attention from the Netherlands before PPP's became a leading instrument in international cooperation.

In 2011 the Netherlands government identified ten so called 'Top Sectors' of The Netherlands' economy. They are the main drivers of the country's economy and because of their economic importance two sectors are closely linked to agricultural research: the Top Sectors 'Horticulture & Propagation Material' (Topsector Horticulture 2017), and 'Agriculture & Food' (OECD 2015). The objectives of the Top Sector policy are to carry out research that is most relevant for a globally competitive and profitable Netherlands industry. The objectives of the two Top Sectors related to agriculture are: to produce more food with less space, water, energy and minerals; to improve food security and food safety; to stimulate healthy food; environment and wellbeing; to increase value addition in the supply chains; and to foster international leadership and cooperation through trade. Increasingly, R&D projects carried out by Wageningen University and Research (WUR) are funded in agreement with this policy. For Netherlands companies to benefit from R&D carried out by research institutions they have to establish a pre-competitive value chain-wide consortium and include WUR. WUR takes part because the policy-makers have asked the universities and research institutions in The Netherlands to be part of the policy. The Dutch stakeholders involved in the policy were initially selected by the agricultural counsellors in the potato producing countries. They know both the potato of the country where they work and of the Netherlands. Once a small consortium is formed, additional partners are identified to ensure all expertise is mustered.

The R&D needs of the target recipient developing country are elicited through workshops and a work plan is developed that benefits both the local and Netherlands potato industry. The Netherlands government (ministries of Economic and of Foreign Affairs) funds half of the project costs and the consortium of companies the other half. The objectives of the PPPs are to combine expertise, partnerships between government, industry and non-governmental organisations (NGOs) or knowledge institutions to identify innovative solutions, create efficient and sustainable business models and contribute to inclusive growth of small entrepreneurs and producers. To achieve the objectives, the innovative capacity of the private sector of the public sector are combined. This paper illustrates the potato PPPs approach in some contrasting Asian and African setting and not to deliver a theoretical and conceptual framework. The countries were selected based on the importance the local political, business and R&D community give to potato. The crop in these countries already contributes considerably to food security, diversification of the diet and profitability of the agricultural sector. If this is not visible yet in national statistics, then it is at least at the regional level.

## 2 Potato in the current PPP target countries

Table 1 shows the importance of potato in the eleven target Asian, African and American countries where PPPs were carried out. In Vietnam and Indonesia the tuber is merely considered as a vegetable with less than 5 kg per person on average produced. Production in Ethiopia is higher with 7.5 kg per person and in Myanmar higher still at over 11 kg per person per year (200 g per week) but still only marginally contributing to food security and variety of diet and value. Yet regionally potato is of great importance and when compared to situations in neighbouring countries (respectively Kenya and Bangladesh) greatly under-utilized.

In India production is 35 kg per person, in China almost double at 68 kg, with Bangladesh in an intermediate position, comparable to Kenya where it is the second staple diet after maize. In all these countries and Algeria and Argentina potato production increased rapidly over the last decades and now substantially contributes to their food security.

Total production in these countries cannot be used for any type of consumption knowing that at least 10% of the crop is reserved as propagation material for next season and up to 10% storage losses may occur. Vietnam and Indonesia import approximately 40,000 tons of potato or raw potato equivalent in potato products. The Netherlands produce 415 kg per capita per year. In this potato hub a wide range of potato crops is grown as table potato, as certified seed for national use and for processing into starch, frozen products and snacks. Specialization in potatoes explains the interest of the Netherlands potato industry

and research in carrying out R&D and explore market opportunities in other countries. Table 1 also shows the per capita production of other commodities with rice being important in all Asian countries, sweat potato in China and wheat in China and India. Vietnam produces almost 470 kg of rice per person per year with potato a very minor crop. Food availability is lowest in Bangladesh followed by India; two countries with relatively low consumption of animal products. In China meat consumption is considerable and is made possible by the production of maize, most of which is consumed by animals. In Ethiopia another cereal, teff according to FAO statistics, is produced at a rate of 27.5 kg per inhabitant and thus considerably contributes to the national food security.

With some countries depending excessively on one single foodstuff, such as Vietnam and Indonesia on rice and Kenya on maize, potato serves as a needed variation of the diet. Table 2 shows that the carbohydrate, energy and protein content of the major staples are comparable. Potato, however, is richer in calcium, iron and vitamin B6 and exceptionally rich in potassium and vitamin C (e.g. Friedman 1996). Compared to rice, potato also contains substantial amounts of fibre and calcium. Therefore enhancing potato consumption is an option to supplement and enrich local diets contributing to the nutrition security.

In developing countries where varieties are often used that are not optimally adapted to the local environment

**Table 1:** Selected data from the PPP target and reference countries, data from FaoStat (2016), Worldometer (2016)

| Country | Potato | | | | Production kg/capita/year | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Area 1000 ha | Yield t/ha | Production million t/year | Population million | Potato | Sweet potato | Rice | Maize | Wheat |
| Algeria | 130 | 30 | 3.9 | 40.3 | 96.8 | | | | 69.4 |
| Argentina | 70 | 28.8 | 2.0 | 43.8 | 45.6 | 9.1 | 36.0 | 732 | 183 |
| Bangladesh | 451 | 18.9 | 8.5 | 162.9 | 52.3 | 1.63 | 31.7 | 11.3 | 6.1 |
| China | 5,770 | 15.4 | 89.4 | 1,382 | 68.1 | 55.3 | 145.1 | 150.8 | 83.1 |
| Ethiopia | 70 | 11.0 | 0.77 | 101.8 | 7.5 | 1.2 | 1.5 | 64.7 | 39.2 |
| India | 1,990 | 22.8 | 45.0 | 1,326 | 35 | 0.83 | 121.4 | 17.2 | 72.3 |
| Indonesia | 62 | 16.4 | 1.02 | 260.6 | 3.9 | 9.4 | 265.1 | 71.0 | 0 |
| Kenya | 145 | 18.9 | 2.7 | 47.3 | 57.1 | 18.2 | 2.5 | 76.1 | 9.6 |
| Myanmar | 40 | 15.9 | 0.60 | 53.4 | 11.2 | 0.94 | pm | 28.1 | 3.5 |
| former Sudan | 21 | 16.7 | 0.35 | 53.9 | 6.5 | 4.5 | | 0.8 | 5.6 |
| Vietnam | 40 | 11,0 | 0.44 | 94.4 | 4.7 | 15.0 | 468.8 | 53.8 | 0 |
| *Netherlands* | *156* | *45.2* | *7.05* | *17.0* | *415* | | | | *76.4* |

http://www.worldometers.info/world-population/population-by-country/

http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor

**Table 2:** Some components of the important staple foods

| Component (per 100g dry weight) | Maize | White rice | Wheat | Potato |
|---|---|---|---|---|
| Carbohydrate | 82.1 | 91.2 | 82.7 | 80.9 |
| Energy (kJ) | 1696 | 1696 | 1574 | 1533 |
| Protein (g) | 10 | 8.11 | 14.5 | 9.5 |
| Fibre (g) | 8.1 | 1.48 | 14 | 10.5 |
| Calcium (mg) | 7.8 | 31.9 | 33.4 | 57.1 |
| Iron (mg) | 3.01 | 0.91 | 3.66 | 3.71 |
| Potassium (mg) | 319 | 131 | 417 | 2004 |
| Vitamin C (mg) | 0 | 0 | 0 | 93.8 |
| Vitamin B6 (mg) | 0.69 | 0.18 | 0.35 | 1.43 |

*http://ndb.nal.usda.gov/ndb/search/list*

**Table 3:** Potential (Ypot) and actual (Yact) yields and their ratio (A/P) calculated with LINTUL-POTATO-DSS (Haverkort et al. 2012)

| Country | Production region/crop | Ypot t ha$^{-1}$ | Yact t ha$^{-1}$ | A/P |
|---|---|---|---|---|
| Algeria | Autumn crop | 35 | 25 | 0.71 |
| | Spring crop | 43 | 30 | 0.70 |
| Argentina | Summer crop | 66 | 43 | 0.66 |
| Bangladesh | Irrigated winter crop | 61 | 35 | 0.57 |
| China | Heilongjiang, summer crop | 64 | 32 | 0.50 |
| | Ningxia, summer crop | 66 | 25 | 0.38 |
| Ethiopia | Belge (early monsoon) | 75 | 13 | 0.17 |
| | Meher (late monsoon) | 60 | 10 | 0.17 |
| | Winter | 55 | 15 | 0.27 |
| Indonesia | Bandung, rain-fed crop | 32 | 17 | 0.53 |
| | Bandung, irrigated crop | 33 | 16 | 0.49 |
| India | Gujarat, winter crop | 63 | 41 | 0.65 |
| | Punjab, winter crop | 29 | 22 | 0.76 |
| Kenya | Highland rainfed crop | 60 | 18.9 | 0.32 |
| Myanmar | Rainy season, highland | 35 | 13 | 0.37 |
| | Irrigated | 45 | 15 | 0.33 |
| Vietnam | Winter crop Red River Delta | 28 | 11 | 0.39 |
| | Highland, Dalat | 52 | 20 | 0.38 |
| Netherlands | Summer crop, table | 96 | 63 | 0.66 |
| | Summer crop starch | 96 | 47 | 0.49 |

and not resistant to prevailing pests and diseases, or where degenerated seed tubers are planted and supply of water fertilizers and crop protectants is inadequate, yields lag behind what is physically and economically attainable (Pronk et al. 2015 and 2017; Kempenaar et al. 2017; Haverkort et al. 2012). With the LINTUL-POTATO-DSS crop growth model (Haverkort et al. 2015), with long term temperature and solar radiation as weather inputs and planting and harvest dates as crop inputs, potential yields were calculated and compared to actual yields. The results of some selected sites are shown Table 3. In countries and seasons where most of the problems related to potato have been overcome and yields are economically optimal the actual: potential ratio is about 0.65 (see also Vasco Silva et al. 2017). Farmers are able to achieve higher yields but then inputs (seed, water, fertilizers, pesticides) need to be given at uneconomically high rates. The highest relative yields are obtained in Bangladesh, India (Gujarat), Algeria, Argentina and in The Netherlands (table potatoes), the lowest in Ethiopia, Myanmar and Vietnam, indicating that in the latter countries, large yield gains can be made by reducing the yield diminishing factors. The highest potential yields were calculated for The Netherlands at close to 100 t ha$^{-1}$. This results from the long growing season (170 days) with a long photoperiod of up to 16 hours in the middle of the growing season. The lowest potential yields were calculated for the winter crops in Punjab in India and the Red River Delta in Vietnam where an 80-90 days winter crop is grown during short days and overcast skies.

# 3 Current Netherlands' PPPs

Since 2012 eleven PPPs on potato research projects have started and were concluded with industry consortia that cover the whole value chain from breeding and seed production firms, machinery makers, potato stores equipment, crop protection, advisory services to firms producing equipment for the production of crisps and frozen chips. Some consortia only address part of the value chain such as in Algeria where only new varieties and field equipment were tested, or in Ethiopia where the focus was on raw material for processing. The diversity of participating companies and activities is shown in Table 4. Typically a project lasted 4 years with a public and private

**Table 4:** Major activities in the Netherlands PPP potato projects 2012-2016

| Nr. | Country: project acronym | Major activities |
|---|---|---|
| 1 | Algeria: ELOUED, starting | Varieties, field equipment |
| 2 | Argentina: GITAH, completed | Processing, value chain, knowledge transfer |
| 3 | Bangladesh: GEOPOTATO | Late blight control, decision support system (DSS) |
| 4 | China: POTATOGAP | Mechanization, yield gap analysis, GAP, disease control, DSS |
| 5a | Ethiopia: POTATO-PPP | Processing, seed production |
| 5b | India: POTATO-PPP | Storage, varieties, seed, mechanization, market studies |
| 6 | Indonesia: VEGIMPACT | Varieties, seed potatoes, GAP, policy brief |
| 7 | Kenya: FAST TRACK | Variety selection, seed import and multiplication, training of phytosanitary agency (KEPHIS) |
| 8 | Myanmar: PM | Varieties, seed production, soil and plant diagnostics |
| 9 | Sudan: NSAL | Varieties, machinery, processing, training, demonstration |
| 10 | Vietnam: PROPOORPOTATO | Varieties, processing, policy brief value chain |

funding budget that varies between half and one million Euros total for a four year project.

The activities mentioned in Table 4 centred around themes. Variety introduction is a major one: testing varieties from The Netherlands aimed at selecting and registering varieties with enhanced yields. These should also require less pesticides and have better quality for end users. The supply chain management for raw material for the processing theme explores the future needs of pre-basic, basic and certified seeds that are needed to fulfil the raw material need. Sourcing from various regions and seasons and estimates of storage needs were part of this exercise. The seed production efforts support the establishment of a seed production system starting with clean (local in-vitro or from imports) material. This also required organisations to register varieties for their intellectual property and payments of breeders' rights. Assisting public and private partners in the writing of a Potato Policy Document involves an analysis of the current and potential future role of the potato crop to secure food, diversify the diet and create value. Such a document is written to assist public and private policy makers in priority setting for future investments. Decision support systems (DSS) on late blight consist of collection of real time weather and crop data used to schedule time and dose of fungicide applications. The weather data include rainfall, dew point, wind speed and crop data include ground cover, variety (lateness). This and the Potato Policy Document are in the interest of all links of the potato value chain as all benefit from a flawless chain. The theme of mechanization involves the study of the costs of current manual operations and of replacing it partly by machinery such as planters, ridging machines and harvesters. It also involves post-harvest handling and replacing bags by bulk storage with store loading and unloading equipment. The market explorations for potato products involve the study of the current range of potato products and trends in consumption. This is mainly done to satisfy the interest of companies producing processing equipment for the production of flakes, crisps and chips. Storage equipment producers are interested in research on the costs and benefits of stores and control of temperature, carbon dioxide and humidity. Soil and plant diagnostics research is aimed at soil fertility and soil and plant health: assessment of the presence and nature of soil and plant pests and diseases. Consultancy firms and extension services use this information to assist growers in making decisions on time and dose of chemical fertilisers, crop protectants and irrigation water.

# 4 Brief illustration of approaches in PPP's

The objectives, material and methods and results of all PPPs are written in scientific papers by researchers in the joint potato projects although some preliminary reports were produced (e.g. Kempenaar et al. 2017; Pronk et al. 2017). We describe hereafter major observations in the five largest PPP (with reference nrs. 3 - 7).

GEOPOTATO (3): The Late Blight DSS developed in this PPP provides location-specific advice for late blight control that is generally applicable for all potato farmers in a given production area. The DSS is delivered to the growers through text messages and supports farmers to control late blight disease in a better way than applying

fungicides based on fixed time intervals. Most farmers in Bangladesh have mobile phones and messages are provided in text or as voice mail to illiterate farmers. Fungicides are abundantly available for late blight control, approximately thirty different effective fungicide brands are on the market, and within short distances of farmers. The DSS is a first step towards a more personalized service and other types of information to increase yields and improve resource use efficiencies in potato production in Bangladesh. Refinement of the service is foreseen through providing personalized advice, for example, on the type of fungicide to be applied once farmers provide feedback through SMS or a call centre. It has to be evaluated in the first phase of the project if such a feedback mechanism is feasible in the short term within the context of Bangladesh. The DSS also provides good opportunities to provide additional services. Within the project and post project period examples of additional information are the risks of late blight outbreak, location specific timing, type and dose of fungicide to apply.

POTATO-GAP (4): Similarly good agricultural practices in northern China in Heilongjiang, Inner Mongolia and Hebei where potato production is a major economic activity, were targeted. Here national and international processing industries increasingly establish factories and source their raw material. Hence, quality of the tubers is becoming more and more important: high dry matter and consistency among lots are important for processing and to avoid irregular products due to varying contents of reducing sugars leading to discoloured products. There are three factors that strongly influence potato yield and quality in Heilongjiang and Hebei: propagation material, disease and pests control and regularity of operations (Kempenaar et al. 2015). For the last of these, using modern equipment was deployed that replaces handwork and old machines. Large scale demonstration fields were set up to test propagation material, decision support systems and machinery.

POTATO-PPP (5a, 5b): In India over 95% of potato production takes place in winter, of which the bulk of the tubers are stored for up to 10 months. This typically takes place in 5 storey high cold stores with 7,500 t capacity where potatoes are stored in netted bags of 50 kg each. The stores are owned by companies that operate them, but growers rent space and load and unload according to their sales planning. Traditionally cold stores have one cooling unit and a sensor somewhere in the middle of the building. Upgrading within the framework of the PPP project is done by placing more sensors, also in the middle of a bag in the middle of a pile rather than in the air. The stores were compartmentalised to improve aeration and remove excess carbon dioxide. Bulk stores, the first ones in the country owned by a processing company in Gujarat, were tested as well. Here not only the means of storage was altered, but also many handling operations such as mechanised harvesting that needed bags when done manually. For sampling and monitoring netted bags were placed inside stacks supplied with a wireless recording device. Samples consist of well cured tubers and tubers with skin damage due to immaturity at the moment of store loading. The type of observations carried out to assess the effect of the improvement of the stores included weight and quality losses and suitability for processing. In Punjab, to fully mechanize harvest and storage in bulk, the tubers need to be hardened in the soil before lifting. Tests were done to kill the foliage well before maturity. This stops tuber growth, to arrive at a higher proportion and yield of seed sized tubers, to reduce virus infection and to suppress the development of seed-borne survival structures of fungi (e.g., sclerotia of *Rhizoctonia solani*, i.e. black scurf) and to influence dormancy. Trials here included mechanical haulm killing by leaf cutting, flail mowing and pulling, compared to chemical haulm killing with a herbicide. Also a two phased harvest by lifting by windrower and subsequent covering with soil and lifting again after a few weeks as a method to harden the skin was tested.

VEGIMPACT (6): In Indonesia a survey was held among growers in West Java who produce the processing variety Atlantic or table potato Granola. A preliminary evaluation of the farm surveys indicates that farmers use extremely high amounts of pesticides and nutrients which strongly reduces their profits. The three main constraints identified were subject of field demonstration and training activities. These were an efficient late blight control, inefficient nutrient management, and low quality of the planting material. Demonstration plots were laid out comparing current farmers' practice and a strategy that potentially reduces costs and is more environmentally friendly.

FAST TRACK (7): Do potato yields in Kenya increase if at the short-to-medium term imports of high quality seed potato seeds takes place to assist the current shortage was part of "Fast Track Seed Potato Development Project in Kenya" (Janssens et al. 2013). The project was formulated by Kenyan and Netherlands seed potato sector stakeholders. It was foreseen to import seed potatoes from the Netherlands, and multiply them in Kenya by medium-to-large scale professional seed growers. The locally multiplied seed must be economically purchasable by small, medium and large-scale farmers and the resulting potatoes are destined to contribute to food security, and to

add value among others in the processing industry. Crucial to the project's approach was close Dutch-Kenyan public-private cooperation, by which seed potato expertise of the Netherlands was combined with the know-how of local Kenyan private sector players. Marketing & agribusiness and a phytosanitary strategy were formulated, focusing on how to improve the current seed potato situation in Kenya. Strategies and activities mainly centered around phytosanitary aspects with a role for KEPHIS (the Kenyan phytosanitary agency), market access and agribusiness support.

In Ethiopia and Vietnam, R&D activities were carried out to assist the potato processing industry in promoting potato and its products. The main elements were consumer and market studies for fresh washed, sorted, packed and branded potatoes for the supermarket and the production of crisps, flakes and chilled pre-fried chips. A survey of quality of current potato sources included the varieties grown, their market value, the growing seasons and regions and the prevailing management practices. The activities further include testing varieties for adaptation and market value for registration and admission to the national variety lists and the build-up of propagation material (in-vitro plantlets, minituber, basic seed, seed for marketed crop) with national companies and (small scale) out-growers. This is all aimed at assuring a future year-round consistent flow of raw material to the factories and consumers.

## 5 Concluding deliberations

The research, development and knowledge transfer projects carried out within the PPPs shown here address a number of relevant issues in the potato value chains in upcoming markets. The approach of PPPs in The Netherlands proved to be a suitable instrument to link governments and companies to potato research groups both in the upcoming markets and in The Netherlands. Consortia in The Netherlands and in the developing country steer research to obtain information and interdisciplinary potato research groups co-innovate with the potato industry in the new settings of emerging markets. In The Netherlands this approach has been coined "The Golden Triangle' and is especially successful in the country itself. Government aid to individual companies is forbidden within the European Union so there is always more than one company involved in PPPs and the results of governmental funded PPP's – tax payers money – have to be brought into the public domain. This conflicts with companies' interests who want to protect the scientific findings that are specific for a company and for the area where they work. Fort the time being, consortia are willing to invest on a 50-50 basis (government-companies) in co-innovation in developing countries and upcoming markets. In the future, however this approach proves to become more cumbersome as new policies in The Netherlands gradually increase the needed financial contribution of the industry. This while the rate of financial return for companies in such markets is uncertain. Where previously R&D projects were commissioned by civil servants of ministries (education and science, international cooperation of foreign affairs and economic affairs), now increasingly employers of companies are articulating the research questions and they monitor progress. That requires a thorough learning process for both researchers and business people. The former are required to find quick solutions for the industry and the latter giving attention to long term returns. The funding is public, at least in part, so the results must also appear in the public domain which is not in the interest of companies.

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