Sustainable Pineapple Costa Rica Market Study

CSR Netherlands (MVO Nederland / De Groene Zaak)
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## Abbreviations

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<th>Full Form</th>
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<tr>
<td>CANAPEP</td>
<td>Cámara Nacional de Productores y Exportadores de Piña (National Chamber of Producers and Exporters of Pineapples)</td>
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<tr>
<td>CeniBiot</td>
<td>Centro Nacional de Innovaciones Biotecnológicas (National Center for Biotechnological Innovations)</td>
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<td>CIA</td>
<td>Centro de Investigaciones Agronómicas (Center for Agronomic Research)</td>
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<td>CORBANA</td>
<td>Corporación Bananera Nacional (National Banana Corporation)</td>
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<td>CSR</td>
<td>Corporate Social Responsibility</td>
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<tr>
<td>ICE</td>
<td>Instituto Costarricense de Electricidad (Institute of Electricity of Costa Rica)</td>
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<tr>
<td>LANOTEC</td>
<td>Laboratorio Nacional de Nanotecnología (National Laboratory of Nanotechnology)</td>
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<tr>
<td>MAG</td>
<td>Ministerio de Agricultura y Ganadería (Ministry of Agriculture and Livestock)</td>
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<tr>
<td>PNUD (UNDP)</td>
<td>El Programa de las Naciones Unidas para el Desarrollo (The United Nations Development Program)</td>
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<tr>
<td>POLIUNA</td>
<td>Laboratorio de Investigación y desarrollo en polímeros de la Universidad Nacional de Costa Rica (Laboratory of investigation and development of polymers of the National University of Costa Rica)</td>
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<tr>
<td>PROCOMER</td>
<td>Promotora del Comercio Exterior de Costa Rica (Promoter of Foreign Trade of Costa Rica)</td>
</tr>
<tr>
<td>UTN</td>
<td>Universidad Técnica Nacional (National Technical University)</td>
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<tr>
<td>WUR</td>
<td>Wageningen University and Research</td>
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1. Summary
Project background and collaboration

- **Contribution of CSR Netherlands to the ELAN event** in San José, Costa Rica, in September 2016: dinner at the Embassy in San José with several Stakeholders and visits to pineapple producers, University of Costa Rica and CORBANA.

- End of 2016 CSR Netherlands started **exploring project development** on valorising pineapple plants in Costa Rica with companies and experts like Cool Fresh International, TNO, Wageningen Environmental Research, ICARO investments, LANOTE, Universidad de Costa Rica and the Embassy of the Kingdom of the Netherlands in Costa Rica.

- This market study is a collaboration between the Embassy of the Kingdom of the Netherlands in Costa Rica and CSR Netherlands to identify mainly **business opportunities in the pineapple sector** of Costa Rica for Dutch companies. It was **jointly executed** from January 2018 till May 2018. Information was obtained by desk research and conducting interviews in both countries.
Market study

Research questions

• What are the **opportunities** for Dutch companies and Dutch **Unique Selling Points** in the Costa Rican bioenergy and bioeconomy sector, in particular to the pineapple industry?

• Which **trade barriers and knowledge lacunes** can have an obstructive way?

Scope

• Creating a bioeconomy to achieve **sustainable pineapple production**.

• **Valorising** biomass of the pineapple plant after fruit harvesting (without degradation of soil fertility).

• Using **Dutch knowledge & technologies**.
The challenges and opportunities

- Pineapples are harvested twice: after 11 months and an additional 12 months. Then the farmers remove as quickly as possible the crop residue to replant and at the same time to comply with government regulations to prevent a plague of stable fly. This is currently mainly done in three ways: use of herbicides, multiple times ploughing or burying in holes, sometimes together microorganisms as accelerators of decomposition. **These techniques require strict and onerous environmental management to reduce the long-term risks of reducing soil fertility, environmental pollution and the health of workers and the community surrounding the fields.**

- At the same time pineapple crop residue, with an estimated **annual volume of 4.5 million tonnes per year** in Costa Rica, is a **potentially valuable resource** for several valorization options as long as the companies find a economically feasible way to take out the crop residues from the field, and build partnerships to develop new (industrial) applications.
Major opportunities

• Costa Rica has a **stable and safe business & investors climate**.

• There are **subsidies, funds and investors available** for Dutch companies which want to do business in the pineapple sector in Costa Rica.

• Pineapple production generates approximately **4.5 million tonnes crop residue each year** that can be used for multiple industrial applications, like paper, plastic, biogas and more.

• **Producers are willing to adopt sustainable practices**, as long as the extra effort makes good business sense. This is mainly due to some required certifications which prohibit use of highly hazardous pesticides and to media communication about some cases where unsustainable practices have taken place that has **affected the image**. Another reason is to **add more value to their business** by finding new business opportunities.

• **Much research has been done** by universities, organisations and pineapple producers on crop residue valorisation. It should be noted that most research is hard to access or not published. There is **willingness to cooperate and to jointly develop & share this knowledge** to realise valorisation options.
Crop residue valorisation options outlined
Two steps approach

Two steps approach:
1. Remove & collect crop residue from the land by machines.
2. Valorise crop residue (without soil fertility degradation).

Figure 11: Pineapple crop residue valorisation options
The interviewed Dutch companies could provide multiple solutions and have shown interest to further explore possibilities in Costa Rica.

- Some valorisation options only use a certain part of the crop residue, which means the leftover parts could be used for other purposes.

- After chemical extraction, the bulk of the material remains which could be used for energy generation. By-products of biogas production are fibres and liquids. These fibres might be used for production of paper and transport pallet. The figure below shows this order of valorisation options.

- The interviewed Dutch companies are included in the figure at processes where they might have solutions. They are willing to further explore possibilities and in collaboration with Costa Rican parties. Other Dutch companies which might be interested are included in section 11: Annex.

*Figure 12: Potential order of pineapple crop residue valorisation options*
Explored Dutch Unique Selling Points and possible solutions

- **Schouten** has a machine to **mow the plant** above the soil and **collect the crop residue**. **Bas Rijs** has a machine for **removing & collecting crop residue** and a machine to **lift the plants from the soil** (after which they should be collected manually).

- **Schutpapier** could **import cellulose** from Costa Rica and **produce paper** in the Netherlands. Alternatively, they can share knowledge with Costa Rican paper companies to **support local paper production**.

- **Yellow Pallet** could use pineapple fibre for **production of transport pallets**. Yellow Pallet could also use the **biogas** that can be derived from the pineapple fiber for the **drying process** of the fibers.

- **Colsen** developed a biogas installation which could produce **biogas, fertilizer and irrigation water** from pineapple crop residue.

- **Avantium** is specialized in renewable chemistry by focusing on converting biomass to chemicals, energy carriers among others. They are especially interested in high value molecules like **bromelain and nanocellulose**.
### Best valorisation options according WUR Ranking

<table>
<thead>
<tr>
<th>Valorisation product</th>
<th>TRL</th>
<th>Economic potential</th>
<th>Available market</th>
<th>Easiness to implement</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td>9 for many feedstocks 4 for pineapple residue</td>
<td>Medium</td>
<td>Yes</td>
<td>Easy</td>
<td>1</td>
</tr>
<tr>
<td>Pallets</td>
<td>9 for banana leaves Should be tested for pineapple residue</td>
<td>Medium</td>
<td>Yes</td>
<td>Easy</td>
<td>2</td>
</tr>
<tr>
<td>Biogas</td>
<td>9 for many feedstocks Should be tested for pineapple residue</td>
<td>Low, needs subsidy</td>
<td>Yes</td>
<td>Easy</td>
<td>3</td>
</tr>
<tr>
<td>Bromelain</td>
<td>9 for pineapple stems 3 for pineapple leaves</td>
<td>High</td>
<td>No</td>
<td>Medium</td>
<td>4</td>
</tr>
<tr>
<td>Nanocellulose</td>
<td>9 for wood pulp 4 for pineapple residue</td>
<td>High</td>
<td>No</td>
<td>Medium</td>
<td>5</td>
</tr>
</tbody>
</table>

*Table 3: Ranking of valorisation options of pineapple crop residue*

**Ranking further explained:**
- **Paper #1:** could be implemented locally, has an available market, will not have negative returns and can be quickly developed.
- **Pallets #2:** scoring indicators almost similar to paper, however no TRL tests have been done.
- **Biogas #3:** less economically viable.
- **Bromelain & nanocellulose #4/5:** have very small markets and need a complex technology.
Potentially interesting collaborations
To be further explored

• In selecting suitable machines for the removal of crop residue Bas Rijs and Schouten could get in touch with pineapple producers. This would lead to more specific information about the farms and machine requirements. The machines could also be tested on some farms. Giro Industrial with knowledge on machines could join forces.

• For paper production, LANOTEC and University of Costa Rica could provide detailed knowledge on the fibre to help Schutpapier to determine suitability. Smurfit Kappa could use their paper production facility in Costa Rica to further develop this valorisation option. The same applies for Yellow Pallet for the production of transport pallets in Costa Rica.

• Colsen could discuss a biogas installation with ICE and government bodies to find ways to make it economically feasible and how to collaborate. Colsen and Yellow Pallet could research the advantages of using biogas for drying the fibre for transport pallets.

• For the extraction of bromelain and nanocellulose, LANOTEC, UTN and CeniBiot could share their knowledge with Avantium. This would support Avantium in determining in which component they might invest. Avantium, PNUD and POLIUNA could collaborate to explore the production of bio-plastics from crop residue.

• Involve soil specialists to avoid degradation of soil fertility while extracting plant material from the fields and meanwhile improve product quality (for example via The Soil Initiative).

• Involve other local parties, such as the Ministry of Agriculture, Ministry of the Environment, Ministry of Health, CANAPEP, PROCOMER and CINDE.
Major barriers

- Besides general policies at macro level and the Action Plan for Strengthening Responsible Production and Trade of Pineapple in Costa Rica 2013-2017, there are few guidelines to stimulate sustainable practices at pineapple producers.

- The actors in the pineapple sector have a limited willingness and culture of working together. This makes development of integrated solutions between companies, knowledge institutions and government challenging.

- Few funds are available for technological innovation projects in the pineapple sector.

- By law, companies can produce biogas and electricity for self-consumption. They are not allowed to sell it to third parties. ICE is the exception and pays a low price according to several producers. Therefore it is an obstacle for these producers to get involved in biogas production. New biogas initiatives need to be developed on a small scale or should involve the participation of ICE (or another electric service cooperative).

- Pineapple farms show great variation in design, which makes them difficult to mechanize.

- Limited research has been conducted about the economic feasibility of pineapple crop residue valorisation options on farm scale. Transport is expected to be expensive, therefore it is important to manage logistics well to decrease costs.
Recommended next steps

• Share the **market study findings** with:
  • Participating companies (May / June 2018)
  • WUR (May 2018)
  • Seminar bio-economy Costa Rica (June 2018).

• Further **research by WUR** (Seed Money Project) on specific questions from participating companies (June 2018).

• **Investigate other valorisation options** with other Dutch companies (September 2018).

• **Fact finding mission** in Costa Rica and/or establish a Partners for International Business (PIB) cluster (September 2018). In advance, **potentially interesting ‘circular’ collaborations** between Dutch companies and local parties in Costa Rica could be **set-up** (valorisation biomass, soil management, etc.).

• Ongoing **one-on-one support** by the Embassy to interested companies.

• **Execute producer-company pilots** in Costa Rica (2019 onwards).
2. Introduction
Recent developments between Costa Rica and The Netherlands

- **A Memorandum of Understanding** between the Dutch and Costa Rican government to strengthen trade relations was signed in 2015.

- **Visit of the Costa Rican vice minister of Economic Affairs** to CSR Netherlands in April 2016.

- The **visit of Luis Felipe Araúz**, Costa Rican Minister of Agriculture, to WUR in November 2016 to show interest in exchange of experts and knowledge for future sustainability projects.

- The **Costa Rican presidential visit** to the Netherlands in 2017 showed willingness to closer partnerships.
Project background and collaboration

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## Organisations interviewed

**Table 1: Interviewed organisations by CSR Netherlands**

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<thead>
<tr>
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<th>Interviewee</th>
</tr>
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<tbody>
<tr>
<td>Avantium</td>
<td>Ed de Jong</td>
</tr>
<tr>
<td>Bas Rijs</td>
<td>Corné Bastiaansen</td>
</tr>
<tr>
<td>Colsen</td>
<td>Jurgen Brekelmans</td>
</tr>
<tr>
<td>Coolfresh</td>
<td>Hugo Vermeulen</td>
</tr>
<tr>
<td>Schutpapier</td>
<td>René Kort</td>
</tr>
<tr>
<td>Schouten</td>
<td>Rudolf Schouten</td>
</tr>
<tr>
<td>Yellow Pallet</td>
<td>Hein van Opstal</td>
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**Table 2: Interviewed organisations by the Embassy of the Kingdom of the Netherlands in Costa Rica**

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<thead>
<tr>
<th>Organisation</th>
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</thead>
<tbody>
<tr>
<td>CANAPEP</td>
<td>Abel Chavés</td>
</tr>
<tr>
<td>Earth University</td>
<td>Arturo Condo</td>
</tr>
<tr>
<td>Escoia</td>
<td>Esteban Bermúdez</td>
</tr>
<tr>
<td>Fyffes</td>
<td>Hugo Hays</td>
</tr>
<tr>
<td>Giro Industrial</td>
<td>Gilberth Rojas</td>
</tr>
<tr>
<td>Grupo Acón</td>
<td>Roberto and Jorge Acón</td>
</tr>
<tr>
<td>ICE</td>
<td>Carolina Hernández</td>
</tr>
<tr>
<td>LANOTEC</td>
<td>José Roberto Vega</td>
</tr>
<tr>
<td>Ministry of Agriculture</td>
<td>Ivannia Quesada Villalobos and Luis Felipe Araúz</td>
</tr>
<tr>
<td>PNUD</td>
<td>Juan Carlos Piñar</td>
</tr>
<tr>
<td>University of Costa Rica</td>
<td>Julio Madriz</td>
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Market study

Research questions

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Scope

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• **Valorising** biomass of the pineapple plant after fruit harvesting (without degradation of soil fertility).

• Using **Dutch knowledge & technologies**.
Market study objectives

• Overview of the pineapple sector in Costa Rica.

• Overview of the main policy objectives of the Costa Rican Government.

• Overview of the main stakeholders and (potential) partners in Costa Rica related to the different aspects of circular economy.

• Identify at least four Dutch industries that could potentially provide innovative solutions to make more effective and sustainable use of the leftover biomass in the pineapple sector.

• Provide sufficient information to plan an exploratory visit.

• Provide a roadmap for next possible steps.
3. Pineapple sector in Costa Rica
Photo impressions of a pineapple farm

Figure 1: Pineapple cultivation (Piñales del Caribe - Plantation of Grupo Acón, 2018)

Figure 2: Plastic cover is usually used on organic farms to avoid herbicides (Piñales del Caribe - Plantation of Grupo Acón)
Photo impressions of pineapple crop residue

Figure 3: Crop residue (Piñales del Caribe - Plantation of Grupo Acón)

Figure 4: Removal of crop residue by tractor (Piñales del Caribe - Plantation of Grupo Acón)

*Figure 5: Growth in crop production, 1995-2015 index (OECD, 2017)*
Costa Rica exports 55% of world’s fresh / dried pineapple (2015)
Equalling approximately 1.9 million tonnes (UN, 2016)

Figure 6: Costa Rica’s share in world exports of selected commodities, 1994-2015 (OECD, 2017)
Export value has shown a steady increase (2012-2016), except for 2015. USA & NL major markets, 6 countries represent 94% of export value (2016).
Pineapple farms show great variation in designs and practices. Plants are usually grown on beds, using drains and pesticides.

- Pineapples are **cultivated in three areas** in Costa Rica: North, South and Central. The most common soils of pineapple farms are clay, ultisol, sandy loam, clay loam and inceptisols. The farms are designed in many different ways.

- Seedlings are planted on an average distance of **28 cm between plants and 45 cm between rows**. They are often planted on **beds with an average height of 30 cm** and 1 m distance from centre to centre.

- **Drains are used to manage the water** on the farm. Distance and depth of the drains is dependant on topography and type of drainage (primary/secondary etc.). **Herbicides, insecticides and fungicides are often used to control weeds, pests and funghi.**

- Pineapples are **harvested twice**: after 11 months and an additional 12 months. Then the pineapple plant is not profitable anymore and will be removed. Due to planting in cycles, harvesting is done all year round. The pineapple **plant weighs 2.6 kg and is 1.2 m high** on average. The **roots weigh 300 g and are 27 cm long** on average.
In 2017, pineapple plantations in Costa Rica equalled 44,500 hectares (CANAPEP, 2017). Plantations produce on average 200 tonnes crop residue (i.e. the leaves and roots of the pineapple plants) per hectare after each harvest, which is every two years. This would be totalling 4.5 million tonnes pineapple crop residue annually in Costa Rica.

The crop residue is a substrate for the larvae of the blood-sucking stable fly (Stomoxys calcitrans). The stable flies affect nearby cattle farms affecting animal behaviour and causing decreased milk production.

It is not possible to plant new pineapple plants as long as there is crop residue on the land. The processing of crop residue therefore interferes with the pineapple production.

To avoid the stable fly and interference with production, quick removal of the crop residue is necessary. This can be done through current methods (see next page) or by collecting the residue for valorisation options (see section 8).
Applying herbicides on crop residue is the most common practice
Causing environmental and health issues

Each producer processes the crop residue in a different way. The three most common methods to process the crop residue are:

1. **Herbicides**, like paraquat, are applied to desiccate the crop residue. Sometimes it is burned with fire, where this cannot exceed the respective burn permit granted by the corresponding Agricultural Services Agency of the Ministry of Agriculture and Livestock (MAG), according to Executive Decree No. 35368 MAG-S-MINAET. Consequently, the crop residue leftovers is cut by a machine and processed into the soil.

This process takes approximately **two months** and is the **most common practice**. Estimated costs are $1,700 per ha. Required inputs are mainly desiccant herbicide and machinery, like tractors, harrows and crushers (usually of the brands John Deere, Same o New Holland, Seppi and Mobile). The application of herbicides involves risks to human health and pollution to the environment.
2. **Microorganisms** are used to accelerate decomposition of the crop residue when chemicals are not allowed due to certifications. It is then **cut** by a machine several times (sometimes up to 13x) due to the toughness of the plant and processed into the soil (by another type of machine). The multiple times cutting by heavy machines has a negative impact on the soil fertility. Therefore, a natural fertilizer is applied to restore the N/P balance, after which the soil needs to recover 3 months. This total process can take between 2 weeks and 4 months, depending on the weather, with an average of **6 weeks**. It is done mainly by organic and Rainforest Alliance certified producers. Estimated costs are **$2,600 per ha**. Required inputs are soil improvers, insecticide pest control and machinery, e.g. crusher, harrow and tractor of the brands FAE, Nobili, John Deere (tractor 135 hp) and Seppi (Midiforst 225 DP-shredder).

3. Crop residue is cut and afterwards **buried** in holes by different types of machines. Estimated costs are **$1,600 per ha**. This is a less common practice than the previous two. Most producers rent the machines. New machines cost approximately $80,000 for a tractor, $35,000 for a cutting machine and $14,000 for a harrow.
Organic pineapple production is 2.7% of production area
Plastic covers keep the soil healthy & reduce the amount of insects

- The organic pineapple sector consists of approximately 1,200 ha (2.7% of total production). The largest producers are Dole, Inversiones SOGO S.A. and Valle del Tarso, as shown in figure 9.

- Coopeproagro R. L. is a cooperative of 21 organic pineapple producers from Upala, Guatuso and San Carlos.

- Many organic producers are successfully applying plastic covers on their plantations reducing the amount of insects (up to 80%), protect their soil from erosion contamination & diseases and to manage the water. The plastic cover is removed after the harvest and is not being reused.

- North American and European consumers are getting more interested in organic and sustainable food, including pineapples, and they are willing to pay more for it (Kleeman, 2014).
Certified pineapples are required by some exporting companies. This usually ensures that producers comply to certain standards.

- Some exporters demand certified pineapples from producers to comply with safety, environmental and social standards.

- The main certifications are from:
  - **Global GAP** for good agricultural practices.
  - **Rainforest Alliance** for environmental and social improvement.
  - **British Retail Consortium** for packaging and food safety.
  - **Tesco Nurture** for sustainable agricultural practices.

- The Rainforest Alliance **prohibits use of highly hazardous pesticides**, like paraquat. Instead, integrated pest management is required to control the stable fly population. This involves fly glue traps, applying microorganisms to desiccate crop residue and repeated ploughing. **Workers are allowed to work a maximum of 8 hours per day** and have at least one day off per week. They need to wear protective clothing and should be paid at least the minimum wage. Workers can sometimes earn more, when they are payed based on their efficiency.
Producers in Costa Rica harvest pineapples with different characteristics, which determine their quality. Three types of pineapples can be identified:

1. **High quality pineapples**, which meet international standards of size, colour and taste. These pineapples are *exported*.

2. **Medium quality pineapples**, which do not meet international standards for fresh pineapples but are suitable for pineapple processing. These are sold to *processors of pineapple slices, pieces and dehydrated pineapples*.

3. **Low quality pineapples**, which are not suitable for export and processing of slices and pieces. These are used *for processing of juices and sold as fresh fruit on the local market*. 
Media report about unsustainable practices
CSR could improve the image of the sector

- Media report about unsustainable labour practices in the Costa Rican pineapple sector, like lack of protection for employees who work with pesticides, discrimination of women and migrant workers and low salaries (BananaLink, 2014).

- There was recently a scandal in the USA where a pineapple exporter in Costa Rica sold conventional pineapples as organic.

- The communication about unsustainable practices affects the image of the pineapple sector. Some producers work actively on CSR by focusing on worker conditions, communication with employees and environmental aspects of production.
4. Policy and legislation in Costa Rica
Costa Rica has ambitions to further improve sustainability. Policies are implemented:

- Costa Rica aims to be carbon neutral in 2021. Policies, like a domestic carbon market, carbon neutral certification, a National Energy Plan and REDD+ strategy are implemented to reach this (Climate Action Tracker).

- Implemented forest protection policies resulted in a decrease of mature forest loss from 2.2% to 1.2% per year. 20% of the country is defined as protected nature reserve (Fagan et al., 2013).

- The government defined a long-term agricultural and rural development strategy together with stakeholders. This “State Policy for Costa Rican Agri-food Sector and Rural Development 2010-2021” positions the agricultural sector as the basis of inclusive, modern, competitive and environmentally-responsible development (OECD, 2017).

- Import of the herbicide Bromacil, which was used to desiccate crop residue, is prohibited since June 2017 because it caused water pollution and health issues. It is allowed to use the national stock until it is exhausted.

- There is a zero tolerance policy for the stable fly at pineapple farms, to avoid spreading diseases to nearby cattle farms. Pineapple farms will be closed when there is a stable fly plague. Therefore crop residue must be removed from the land as soon as possible.
Action plan on pineapple production & trade
Aimed at improving social and environmental performance


1. Adopt the best practices in soil use and conservation
2. Consolidate PITTA-PIÑA (program on agricultural research and technology transfer)
3. Adopt the best practices in agrochemical use
4. Promote integrated pest management and eco-efficient input use
5. Ensure compliance with legal requirements
6. Promote dialogue spaces, transparency, and accountability on continued actions
7. Promote actions to adapt to climate change
8. Encourage the adoption of good agricultural practices (G.A.P.)
9. Build producers’ capacities to get internationally recognized G.A.P. certifications
10. Promote national dialogue on labor rights
11. Identify, offset, and remedy impacts of pineapple production
12. Encourage national production of organic pineapple
Further sustainable development is challenging
Mainly due to a lack of supporting policies and funds

• Besides general policies at macro level and the mentioned Action plan, there are few incentives, besides market demands, to stimulate sustainable practices at pineapple producers.

• Few funds are available for technological innovation projects in the pineapple sector. CORBANA (National Banana Corporation) finances technological innovations through funds generated by taxes on banana boxes. CANAPEP (National Chamber of Pineapple Exporters and Producers) could facilitate a similar initiative for the pineapple sector.

• Currently it is not economically feasible to produce biogas, mainly because it’s not allowed to store electricity that is not being used. It needs to be sold to the Institute of Electricity of Costa Rica (ICE) who pays a low price, according to several producers. The Ministry has plans to increase the electricity tariff generated by biomass. On the other hand, production of biogas also produces bio-fertilizers, which can replace the currently used chemicals.

• Producers mention it is difficult to get new pesticides approved, which are less polluting.
Available subsidies and funds for Dutch companies
Such as DTIF, SIB, PIB and Costa Rican funds

- **Dutch Trade and Investment Fund** (DTIF) is available for Dutch companies who want to invest in or export to foreign markets.

- **Starters International Business** (SIB) provides vouchers for a coaching or knowledge sessions about export or a voucher for a trade mission.

- **Partners for International Business** (PIB) is a multiple year program to help a group of Dutch companies to position themselves abroad.

- **Demonstration projects, feasibility studies and investment preparation studies (DHI)** scheme supports Dutch enterprises that want to invest in or execute a project in emerging markets and in developing countries.

- **Sistema de Banca para el Desarrollo** in Costa Rica has funds available for small enterprises.

- **The Ministry of Science and Technology** in Costa Rica has funds available for research.

- **The Ministry of Agriculture** in Costa Rica might have funds available for technology transfer and project investments.
5. Lobby and other guiding activities in Costa Rica
The organisation rate of the sector is limited
Lobbying against unsustainable practices is difficult

• Overall, **few environmental organisations** are present to lobby for sustainability issues in Costa Rica. Mostly **voluntary certifications**, like Rainforest Alliance, promote sustainable practices.

• There is a **low level of trade union organisation** in the pineapple sector (BananaLink, 2014).

• CANAPEP lobbies for **enhancing growth** for the pineapple producers.

• In several municipalities, inhabitants lobbied unsuccessfully for a **ban on new pineapple farms** due to presumed water contamination as a result of using herbicides on these farms. CANAPEP, representing the pineapple producers, lobbied against it. Consequently, the government did not allow the ban.
Producers face several challenges
Lobby can help to tackle these and support sustainable development

• Support is required to **change the regulations of the ICE**. By law, companies can **produce biogas and electricity for self-consumption**. They are not allowed to sell it to third parties. ICE is the exception and pays a low price according to several producers. Therefore it is an obstacle for these producers to get involved in biogas production.

• The government does not offer incentives and the banks are **not willing to grant credit for a high risk project**, which means that there are not many opportunities for innovation. Therefore, companies require lobby to get funds for innovation.

• The **domestic market is not willing to pay high prices** for products made from crop residues, and there is lack of knowledge of the opportunities abroad. Lobby could help to get **incentives (tax reduction) for the companies that produce green products** related with crop residue and find opportunities abroad.
6. Knowledge development and dissemination in Costa Rica
Many valorisation opportunities are possible
Local universities and organisations researched pineapple crop residue

- Researchers of the University of Costa Rica concluded that pineapple crop residue has some valuable characteristics. It can be used for paper, construction materials, aliments, energy, plastic and as substrate for cultivating oyster mushrooms. It might be used for around 40/50 different industry applications.

- Centro de Investigaciones Agronómicas (CIA) (Center for Agronomic Research) of the University of Costa Rica has worked in the production of oyster mushrooms by using pineapple crop residue and other harvest residues as substrate. Practices have been adopted by multiple farmers in the country.

- Universidad Técnica Nacional (UTN) (National Technical University) Regional Headquarters of San Carlos conducted projects related to the use of the crop residue of the pineapple sector for nanocellulose extraction, production of bromelain and as substrate of the oyster mushroom (*Pleurotus ostreatus*), promoting the collaboration and use of specialized services of the CIA, CeniBiot and LANOTEC.

- Laboratorio de Investigación y desarrollo en polímeros de la Universidad Nacional de Costa Rica (POLIUNA) (Laboratory of investigation and development of polymers of the National University of Costa Rica) is investigating bioplastics.

- EARTH University is interested in conducting research concerning the extraction and use of pineapple fibre for e.g. textile.
Other organisations and producers also conducted research on residue. A database is desired by stakeholders to combine all research.

- **Giro Industrial** is specialized in the production of agro-machinery and conducted research on a harvesting machine for crop residue. They have a prototype and knowledge about the environment and soils of several farms. The residue should be processed in a facility nearby to avoid high transport costs. Giro industrial is interested in working with Dutch companies.

- Many **pineapple producing companies** have done research on ways to get the crop residue from the field and on the use of crop residue. This research includes bio digestion, composting, biodiesel, bromelain, oyster mushroom and fibre production. It also involved nutritional value of produced compost and pineapple bio digestate, valuation of the volume of crop residue generated and usage of the fibre for spinning and textile production.

- Several organisations mentioned it would be beneficial to **collect all available information & researches** and to **set-up a database**.
Crop residue contains valuable products
LANOTEC has done much in-depth research

National Laboratory of Nanotechnology (LANOTEC) is a research laboratory specialized in the field of nanotechnology. They conducted research on substances of several parts of the pineapple plant:

1. Overall, it is possible to extract bromelain which has medical purposes. This has a high value, but this market is expected to be 600 tonnes (can be extracted from 10 million tonnes crop residue) in 2025, which is very small and thus easily oversaturated.
2. Nanocellulose can be extracted to produce plastic packaging. Hydrolysis of crop residue produces sugars.
3. Peel can be used for extraction of nanocellulose and vanillin. The peel can also be dissolved in a polyether to produce rigid foams.
4. Leaves can be used as substrate for mushrooms. This degrades the leaves into biopulp, which is suitable for paper production. Leaves also contain fibres that can be used for textile production.
5. Substance amounts are affected by changes in climate conditions. The exact amounts are unpredictable and vary greatly due to climate change.
Information about economic feasibility is still missing
Lack of cooperation and knowledge sharing

• **Limited research** has been conducted about the **economic feasibility** of valorisation options on farm scale. This is mainly due to **lack of funding**.

• **Transport is expected to be expensive**, therefore it is important to manage logistics well to limit the costs. According to various organisations, the crop residue processing facility should not be further than 10 km from the pineapple farm.

• There is a **lack of cooperation and knowledge sharing** between research institutes and companies.

• Between the pineapple producers there seems to be **no exchange of technological knowledge**. This could be explained by a high level of competition in the pineapple sector.

• **Cooperation between 7/8 producers** in the Northern area started end 2017. They are **willing to conduct pilots** in collaboration with companies to explore economic feasibility of valorisation options.
7. Business landscape in Costa Rica
Costa Rica has a reliable business climate
Economically and politically stable

- Costa Rica is the **safest country** in Latin America and has **one of the highest GDPs** per capita in Latin America. It has been a **democracy** for the past 120 years mostly characterized by economic and political stability (*PROCOMER, 2018*).

- The country’s moderately **strong economic growth rates** (4% in 2016) and **low inflation** (less than 1% in 2016) providing a stable investment climate. The labor force is relatively **well-educated** and often speaks English (*EB, 2017*).

- Costa Rica has a **central location** in the Americas with ports on the Pacific and Atlantic coasts. Free Trade Agreements provide preferential access to over 57 trade partners (*CINDE, 2018*).
The four largest companies have a 71% market share
Del Monte and Dole are the major players

- Costa Rica has around 250 pineapple producers. Four companies represent 71% of total production (and the other 246 companies represent 29%).

- There are 170 export companies. 32,000 people are employed in the pineapple sector.

- Pineapple products are packaged in 61 plants and exported to 48 countries.

- 56% of production is situated in the North area, 19% in the South area and 25% in the Central area.

![Figure 10: Pineapple production in Costa Rica per company (CANAPEP, 2017)](image_url)

Source: CANAPEP, 2017
Several stakeholders can help to realise valorisation options
There is willingness to explore cooperation with Dutch companies

- **CANAPEP** is the national chamber of **pineapple producers and exporters** and represents 90% of the sector. They aim to make Costa Rica the best pineapple supplier for the world market by providing outstanding quality and using modern production practices.

- **PROCOMER** is the promoter of **foreign trade**. They stimulate export of Costa Rican goods and services throughout the world. By simplifying and facilitating export procedures, generating export chains, registering export statistics of goods and conducting market studies.

- **UTN (Universidad Técnica Nacional - National Technical University)** has a strong focus on applied science and is willing to work with WUR. It is a university working together with the private sector and has a high amount of trust from employees in the pineapple sector.

- **Ministry of Agriculture** in Costa Rica could provide institutional support and funding.

- **CINDE** is an investment promotion agency and can provide services for foreign investors.
Potential investors could provide funding for valorisation options
As part of a program, by a private firm or by a co-investment

• **PNUD** is The United Nations Development Program which is investing in a program for the replacement of single-use plastics. Pineapple residue can be used to produce biobased and biodegradable plastics, which can contribute to the PNUD program.

• **Mesoamerica** is a private equity investment firm, which could be explored as a potential investor in valorisation options.

• A group of **pineapple producers** is willing to **co-invest** in pineapple residue valorisation options.
8. Business Solutions
Crop residue valorisation options outlined
Two steps approach

Two steps approach:
1. Remove & collect crop residue from the land by machines.
2. Valorise crop residue (without soil fertility degradation).

Figure 11: Pineapple crop residue valorisation options

1. Remove & collect by machines
2. Pineapple residue valorisation
   - Peels, crowns, core
     - Microcellulose, Nanocellulose
     - Plastic
     - Biogas
     - Digestate as fertilizer
   - Fermentation
     - Bromelain
     - Other proteins
   - Protein extraction
     - Mushrooms
   - Growing substrate
     - Composites
   - Fibres
     - Food & Feed
     - Paper and cardboard
     - Pallets
     - Textile
Soil quality important to be addressed
Risk management and business opportunity

- While **removing crop residue** from the fields an approach is needed to prevent (further) degradation of soil fertility. Good **soil quality** leads to greater crop yields, better quality and nutritional value of products and a greater security of delivery. As such it offers chances for sustainable business development.

- Soil quality can be improved by **crop rotations**. Other crops absorb different nutrients than the pineapple plant does. Alternating between the pineapple plant and other crops helps to restore the nutrient concentration. Also **green manuring**, where plants, like legumes, are grown and ploughed into the soil, can improve soil quality. This could be done in **combination with other crop varieties** from surrounding farms.

- Various Dutch companies and soil experts combined in **The Soil Initiative** work on innovative solutions in Food & Vegetables supply chains. Parties involved are amongst others Cool Fresh International, Wageningen Environmental Research, Soil & More Impacts and Plant Health Cure.

- These partners are able to provide the necessary expertise to **pilot a sustainable approach** on soil management at the farms in collaboration with the farmers in Costa Rica. In order to scale-up also other members of The Soil Initiative like Eosta and companies like Staay Food Group have shown their interest to be involved.
The interviewed Dutch companies could provide multiple solutions and have shown interest to further explore possibilities in Costa Rica.

- Some **valorisation options only use a certain part** of the crop residue, which means the leftover parts could be used for other purposes.

- After chemical extraction, the bulk of the material remains which could be used for energy generation. By-products of biogas production are fibres and liquids. These fibres might be used for production of paper and transport pallet. The figure below shows this **order of valorisation options**.

- The interviewed Dutch companies are included in the figure at processes where they might have solutions. They are willing to further explore possibilities and in collaboration with Costa Rican parties. Other Dutch companies which might be interested are included in section 11: Annex.

*Figure 12: Potential order of pineapple crop residue valorisation options*
Schouten and Bas Rijs could provide machines which are needed to remove & collect crop residue

• In order to valorise the crop residue, they first need to be removed & collected from the land by machines. The machines should be easy to use and relatively light & small. Pineapple farms have different designs which should be taken into account.

• Dutch company Schouten is specialized in agricultural, livestock and gardening machines. It has a machine to mow the plant above the soil and collect the crop residue in a container of 10 m3. This machine costs € 54,955 and can mow 0.5 to 1.5 hectares per hour.

• Dutch company Bas Rijs is specialized in planting and harvesting machines.
  • It has a machine for removing & collecting crop residue which cost between € 10,000-30,000 for a second hand and € 50,000 for a new machine. It moves 500-2000m per hour depending on the plant size and amount of soil allowed to be removed with the residue.
  • They also have a machine to lift the plants from the soil (after which they should be collected manually) which cost € 5,000.

• Other international companies are working on removal machines. An Italian company will test a machine in Costa Rica in May 2018. An Irish company is developing a machine for Fyffes.
Colsen could provide a biogas installation
Turning residue into biogas and fertilizers

- Dutch company **Colsen** is a company active in water, energy and environment. They develop technologies around fermentation, nitrogen and phosphate fixation and recover fertilizer from waste and wastewater. Colsen design & market these technologies and build installations with local people.

- Colsen developed a **biogas installation** which could produce **biogas, fertilizer and irrigation water** from pineapple crop residue. Fermentation takes approximately 20 to 25 days. An installation costs between € 3-4 million. The size of the installation depends on the throughput time and amount of input.

- According to ICE and CANAPEP pineapple crop residue are suitable for biogas and fertilizer production. They **tested at Agromonte and Group Acón** where biogas was sold to ICE and fertilizers were used at farms.

- Colsen has a **mobile pilot plant** (€ 100,000 -150,000) to determine exact yields, installation size and ROI. The pilot plant is approximately 3-4 m3 and should work for a few months.
Yellow pallet could provide transport pallets
Possibly to be produced from pineapple fibres

- Dutch company Yellow Pallet has developed 10 hectares of banana plantation in Costa Rica. They grow a species which is high in fibre and resistant to diseases. To produce transport pallets, the fibres of the banana stems are dried, cut and pressed in blocks, which are used in the production of pallets with wooden planks. The water, as removed during the drying process, is left on the plantation and evaporates. Pallets are sold locally and used to transport goods to Europe.

- Pineapple fibre could perhaps also be used for production of transport pallets. An estimated 1,200 hectares of pineapple plants are needed to produce 1.75 million pallets per year. It’s questionable whether this is a feasible solution since Yellow Pallet needs only 100 hectares of banana plants to produce the same amount of pallets. Yellow Pallet’s could also use the biogas that can be derived from the pineapple fiber for the drying process of the fibers as explained on the next page.
Yellow Pallet needs more information in exploring a biogas business case

- Pineapple crop residue could be used to produce biogas to dry banana fibre or as pineapple fibre for pallet production.

Figure 13: Potential business case with transport pallet factory and biogas factory

- Yellow Pallet could conduct an experiment with the fibre that remains after biogas production. They can use the current machines in the factory, but the types and capacities of the machines depend on the characteristics of the fibre. WUR could do this experiment on a small scale.
Avantium could extract valuable materials
Which could be used in food and plastics

• Dutch company Avantium is specialized in renewable chemistry by focusing on converting biomass to chemicals, energy carriers among others. They explore different possibilities like plastic and human food. Avantium works with exotic biomass and wood. Which type of biomass is used depends on location, availability and circumstances.

• Avantium is especially interested in high value molecules like bromelain and nanocellulose. These markets are small, e.g. 25,000 tonnes/year for nanocellulose, and the value is high, e.g. $10/kg cellulose.

• A pilot in their plant in the Netherlands would be required to identify which valuable materials and volumes are present. This costs around €60,000 per week and should run for at least two weeks.
Schutpapier could produce paper
Produced from agricultural residual streams

- Dutch company Schutpapier has a paper factory in the Netherlands and has experience in producing paper from agricultural residual streams. These streams could replace wood completely or are used as an additive depending on the fibre characteristics. Their factory in the Netherlands can be used for tests with new streams like pineapple residue.

- Schutpapier could import cellulose from Costa Rica and produce paper in the Netherlands. Alternatively, they can share knowledge with Costa Rican paper companies to support local paper production.

- Another option is cardboard production and could be used for packing pineapples in Costa Rica. Machines are relatively expensive. Dutch company Smurfit Kappa has a factory in Costa Rica, which could be used for cardboard production from crop residue.
Wageningen University & Research (WUR) valorisation options ranking
Several indicators determine the feasibility and profitability

WUR conducted a **ranking of the valorisation options** - as presented on the next page - based on the following indicators:

- The technology maturity or **Technological Readiness Level** (TRL) scaled from 1 to 9 (1=*basic principles known*, 2=*technology concept*, 3=*start of research*, 4=*lab scale*, 5=*farm scale*, 6=*prototype*, 7=*prototype on farm*, 8=*complete system*, 9=*actual system on farm*).

- The **economic potential** based on the value of the products minus the value of the crop residue (price times volume), scaled from high to low (**high**=*positive*, **medium**=*0*, **low**=*negative*).

- The **available world market** where the expected production volume matches the world market volume and buyers for the product are available (**yes**=*available*, **no**=*not available*).

- **Easiness to implement in Costa Rica** (**easy**, **medium** or **difficult**).
Best valorisation options according WUR Ranking

<table>
<thead>
<tr>
<th>Valorisation product</th>
<th>TRL</th>
<th>Economic potential</th>
<th>Available market</th>
<th>Easiness to implement</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td>9 for many feedstocks 4 for pineapple residue</td>
<td>Medium</td>
<td>Yes</td>
<td>Easy</td>
<td>1</td>
</tr>
<tr>
<td>Pallets</td>
<td>9 for banana leaves Should be tested for pineapple residue</td>
<td>Medium</td>
<td>Yes</td>
<td>Easy</td>
<td>2</td>
</tr>
<tr>
<td>Biogas</td>
<td>9 for many feedstocks Should be tested for pineapple residue</td>
<td>Low, needs subsidy</td>
<td>Yes</td>
<td>Easy</td>
<td>3</td>
</tr>
<tr>
<td>Bromelain</td>
<td>9 for pineapple stems 3 for pineapple leaves</td>
<td>High</td>
<td>No</td>
<td>Medium</td>
<td>4</td>
</tr>
<tr>
<td>Nanocellulose</td>
<td>9 for wood pulp 4 for pineapple residue</td>
<td>High</td>
<td>No</td>
<td>Medium</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 3: Ranking of valorisation options of pineapple crop residue

**Ranking further explained:**
- **Paper #1:** could be implemented locally, has an available market, will not have negative returns and can be quickly developed.
- **Pallets #2:** scoring indicators almost similar to paper, however no TRL tests have been done.
- **Biogas #3:** less economically viable.
- **Bromelain & nanocellulose # 4/5:** have very small markets and need a complex technology.
Potentially interesting collaborations
To be further explored

- In selecting suitable machines for the removal of crop residue Bas Rijs and Schouten could get in touch with pineapple producers. This would lead to more specific information about the farms and machine requirements. The machines could also be tested on some farms. Giro Industrial with knowledge on machines could join forces.

- For paper production, LANOTEC and University of Costa Rica could provide detailed knowledge on the fibre to help Schutpapier to determine suitability. Smurfit Kappa could use their paper production facility in Costa Rica to further develop this valorisation option. The same applies for Yellow Pallet for the production of transport pallets in Costa Rica.

- Colsen could discuss a biogas installation with ICE and government bodies to find ways to make it economically feasible and how to collaborate. Colsen and Yellow Pallet could research the advantages of using biogas for drying the fibre for transport pallets.

- For the extraction of bromelain and nanocellulose, LANOTEC, UTN and CeniBiot could share their knowledge with Avantium. This would support Avantium in determining in which component they might invest. Avantium, PNUD and POLIUNA could collaborate to explore the production of bio-plastics from crop residue.

- Involve soil specialists to avoid degradation of soil fertility while extracting plant material from the fields and meanwhile improve product quality (for example via The Soil Initiative).

- Involve other local parties, such as the Ministry of Agriculture, Ministry of the Environment, Ministry of Health, CANAPEP, PROCOMER and CINDE.
9. Roadmap
Recommended next steps

• Share the **market study findings** with:
  • Participating companies (May / June 2018)
  • WUR (May 2018)
  • Seminar bio-economy Costa Rica (June 2018).

• Further **research by WUR** (Seed Money Project) on specific questions from participating companies (June 2018).

• **Investigate other valorisation options** with other Dutch companies (September 2018).

• **Fact finding mission** in Costa Rica and/or establish a Partners for International Business (PIB) cluster (September 2018). In advance, **potentially interesting ‘circular’ collaborations** between Dutch companies and local parties in Costa Rica could be **set-up** (valorisation biomass, soil management, etc.).

• Ongoing **one-on-one support** by the Embassy to interested companies.

• **Execute producer-company pilots** in Costa Rica (2019 onwards).
List of challenges to be answered

Schouten:
- Is it possible to only mow the plant and not to remove the roots?

Bas Rijs:
- What is the experience of Costa Rican people with machines/tractors?
- Which companies in Costa Rica sell agricultural machines?

Colsen:
- Is there any legislation on how clean irrigation water must be?
- Is there any legislation on how you are allowed to use the biogas?
- What information is missing, that causes Costa Rican companies not to try valorisation options?

Avantium
- How are the logistics concerning the crop residue and what is the shelf life?
- What is the amount of water in the crop residue and the composition (amount of carbohydrates, composition of carbohydrates, amount of ash, amount of lignin)?
- What is the selling price of the crop residue and does it include logistics?
- Is there still herbicide/pesticide present in the crop residue?
List of challenges to be answered

Yellow Pallet:
• What quantity of biogas can be derived from 1200 ha of pineapple plantation per 2 years?
• How many litres of LPG can be saved in the drying process by using biogas?
• What are the prices of using biogas to dry fibre, compared to LPG, waste wood burning and solar energy for the pallet factory?
• Which machines are needed for treatment of pineapple fiber before it can be pressed in a mould?
• What are the costs involved (machines, processing, logistics, transport)?

Schutpapier and another Dutch paper company:
• What is the amount of cellulose and water in the residue?
• Is it possible to use standard technology to remove lignin from cellulose and make paper from it?
• What are specifications of the fibre: breaking length, availability through the year, modulus of fibre length, harvest costs, amount of alpha cellulose and beta cellulose?
• Is it possible to fractionate the fibres if it is a mix of long and short fibres?
• Do the pineapple fibres affect the paper quality?
• Is the crop residue considered as ‘waste’ (including its legal status)?
10. References
References

11. Annex
Other possible Dutch companies who might be interested

Several other companies in the Netherlands are working on valorisation of agricultural streams. They might be interested to be involved in the valorisation of pineapple crop residue.

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Contact</th>
<th>Valorisation option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenprotein</td>
<td>Paulus Kosters</td>
<td>Protein and fibre extraction</td>
</tr>
<tr>
<td>Grassa</td>
<td>Wim van Doorn</td>
<td>Protein and fibre extraction</td>
</tr>
<tr>
<td>Millvision</td>
<td>Leon Joore</td>
<td>Fibre extraction and use</td>
</tr>
<tr>
<td>Bioenergy Netherlands</td>
<td>Raoul Witteveen</td>
<td>Biogas</td>
</tr>
<tr>
<td>Nettenergy</td>
<td>Rob Vasbinder</td>
<td>Biogas</td>
</tr>
<tr>
<td>TNO Automotive</td>
<td>Rik Baert</td>
<td>Biofuel</td>
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<tr>
<td>NPSP</td>
<td>Wim Bottger</td>
<td>Biocomposites</td>
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<td>Paperwise</td>
<td>Niek op den Buijs</td>
<td>Paper</td>
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<td>Timo Buist</td>
<td>Machines</td>
</tr>
<tr>
<td>Rabobank</td>
<td>Taco Breukel</td>
<td>Machine financing</td>
</tr>
</tbody>
</table>

Table 4: Potentially interested other Dutch companies