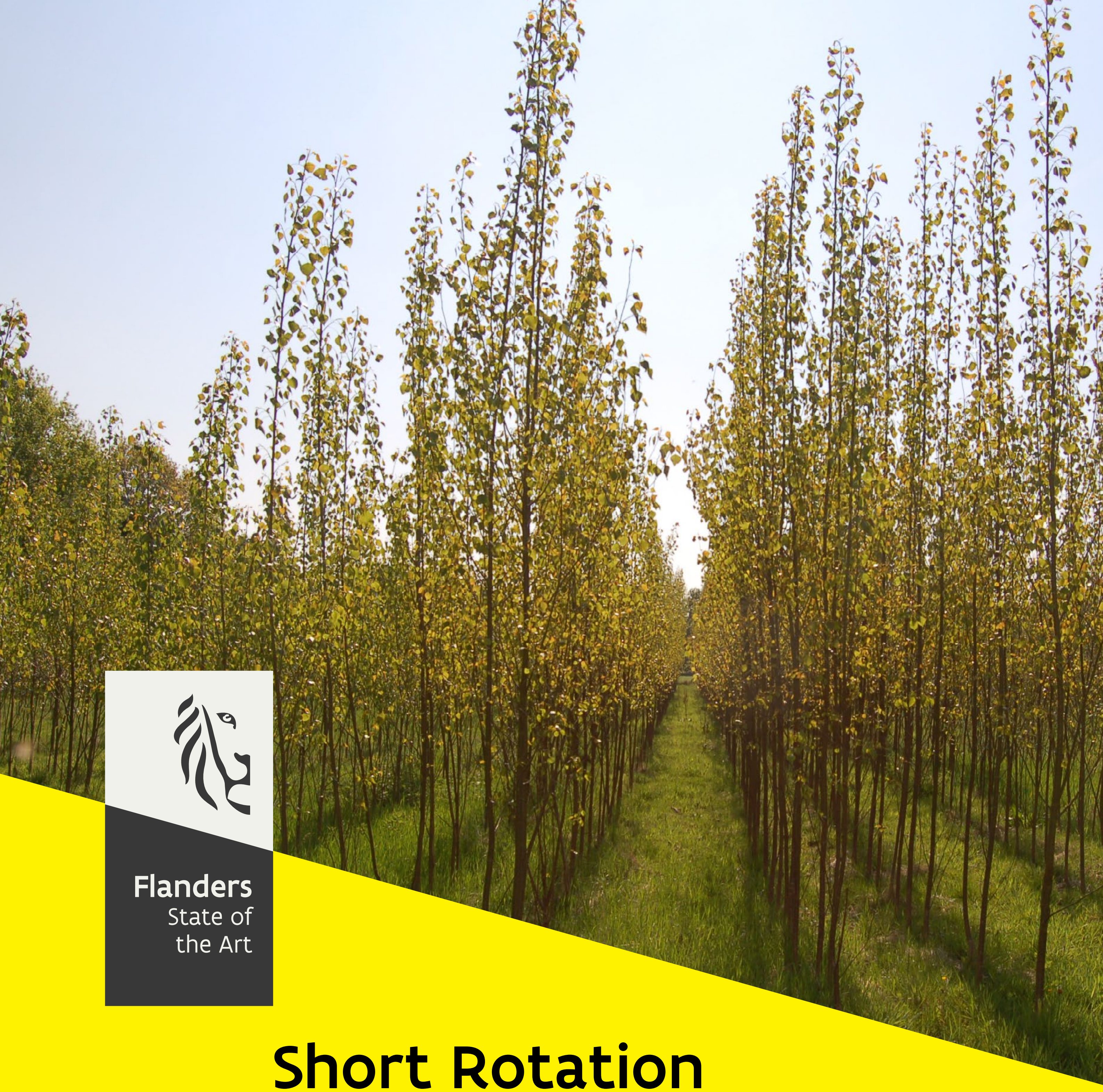

Flanders
State of the Art

Short Rotation Coppice in Belgium

Review on Opportunities, Barriers and Effects

Jomme Desair, Julie Callebaut, Marijke Steenackers, Francis Turkelboom, Lieven De Smet

INBO.be

Authors:
Jomme Desair, Julie Callebaut, Marijke Steenackers, Francis Turkelboom, Lieven De Smet
Research Institute for Nature and Forest (INBO)

Reviewers:
Wout Boerjan (Universiteit Gent), Reinhart Ceulemans (Universiteit Antwerpen), Simon De Pril (FOD Economie - SPF Economie), Linda Meiresonne (Instituut voor Natuur- en Bosonderzoek (gepensioneerd)), Wouter Mewis (Natuurpunt), Kristof Mouton (Groep Mouton), Olivier Poncin (Phitech), Gudrun Van Langenhove (Agentschap voor Natuur en Bos), Jan Van den Bulcke (Universiteit Gent - Woodlab), Nico Vanaken (OVAM), Stefan Vanbeveren (2Valorise)

The Research Institute for Nature and Forest (INBO) is an independent research institute of the Flemish government. Through applied scientific research, open data and knowledge, integration and disclosure, it underpins and evaluates biodiversity policy and management.

Location:
Herman Teirlinckgebouw
INBO Brussel
Havenlaan 88 bus 73, 1000 Brussels, Belgium
vlaanderen.be/inbo

e-mail:
jomme.desair@inbo.be

Way of quoting:
Desair, J., Callebaut, J., Steenackers, M., Turkelboom, F., De Smet, L. (2022). Short Rotation Coppice in Belgium, Review on Opportunities, Barriers and Effects. Reports of the Research Institute for Nature and Forest 2022 (28). Research Institute for Nature and Forest, Brussels.
DOI: doi.org/10.21436/inbor.85964562

D/2022/3241/292
Reports of the Research Institute for Nature and Forest 2022 (28)
ISSN: 1782-9054

Responsible publisher:
Maurice Hoffmann

Cover photograph:
Instituut voor Natuur- en Bosonderzoek

This research was carried out:
in the context of Ad-Libio, funded by the Energy Transition Fund of DG Energy (Belgium)

SHORT ROTATION COPPICE IN BELGIUM

Review on Opportunities, Barriers and Effects

Jomme Desair, Julie Callebaut, Marijke Steenackers, Francis Turkelboom en Lieven De Smet

doi.org/10.21436/inbor.85964562

Flanders
State of the Art

Reading Guide

This report was drafted as part of the project “ADvanced Liquid BIOfuels for advanced engine concepts enabled by advanced wood breeding and catalysis” – Ad-Libio. In light of the climate crises, biodiversity crises but also the current energy crisis, alternative resources might be considered to achieve bioenergy goals, with better environmental results than our current first-generation biofuels. The Ad-Libio project focuses on wood from short rotation coppice as a feedstock for biofuel production. This report will also focus on short rotation coppice but will not specify its end use.

It is intended for all people in Belgium who wish to explore the possibilities of using woody biomass of short rotation coppice. Be it as a farmer, innovator, local government or policy maker.

The report gives an introduction to short rotation coppice in Belgium (chapter 1), with possible applications and an estimation of the current amount and availability of land. The complexity and challenges concerning policy and legislation on short rotation coppice is discussed in chapter 2. A summary of policy recommendations to adjust existing legislation can be found after the extended abstract. Insight into the interactions between stakeholders is given in the stakeholder analysis (chapter 3). Direct effects of short rotation coppice can be consulted under chapter 4. Here the ecosystem services, economics and social dimensions of short rotation coppice are discussed. The report ends with a discussion on the indirect and spillover effects of large scale short rotation coppice (chapter 5).

 doi.org/10.21436/inbor.85964562

Acknowledgments

The Ad-Libio project is funded by FOD Economie, K.M.O., Middenstand en Energie.

An extended review of the report took place and we wish to thank the following people for their valuable contributions to the report:

- Wout Boerjan – Universiteit Gent
- Reinhart Ceulemans – Universiteit Antwerpen
- Simon De Pril – FOD Economie - SPF Economie
- Linda Meiresonne – Instituut voor Natuur- en Bosonderzoek (gepensioneerd)
- Wouter Mewis – Natuurpunt
- Kristof Mouton – Groep Mouton
- Olivier Poncin – Phitech
- Gudrun Van Langenhove – Agentschap voor Natuur en Bos
- Jan Van den Bulcke – Universiteit Gent - Woodlab
- Nico Vanaken – OVAM
- Stefan Vanbeveren – 2Valorise

We also wish to thank Carl De Schepper and Stefanie Brandt from ANB and Geoffrey Floymont from ValBiom for providing us necessary insights on relevant legislation in Flanders and Wallonia.

Popularised summary

Planting fast growing wood species very close to each other and cutting them every few years is a way of producing a large amount of wood in a short period of time. The next year the stumps will start to grow again and will be ready for the next harvest after a year or two. This way you can produce wood for up to 30 years. This is called short rotation coppice (SRC). The produced biomass can be used for a growing number of things thanks to new technologies. It is clear that biomass will play an important role in our green economy. However, we should make sure to use these plantations in the right spots to ensure these can be beneficial for our natural environment, the cultural landscape, agriculture and our local economies. SRC has multiple benefits. It sequesters carbon from the air, supports biodiversity and cleans water. But we should avoid to plant them everywhere as these benefits depend on the local situation. Sometimes SRC can even be harmful. In this report we look into the effects of SRC on the environment and the people living in it, as well as the effects on the producers. We also make an estimate of the possible availability of space. We conclude that SRC could be very useful to increase biodiversity and support a healthy natural living environment in agricultural and industrial landscapes. Nonetheless, there is a right place and management for SRC. Nature will benefit most if we let the trees grow longer and if we do not harvest everything at the same time. But using more environmentally friendly practices will be less profitable for the owner and therefore might need government or private support. This is not the only barrier. The legislation on how and where you are allowed to plant SRC is complex and unclear. Moreover, farmers who could benefit from SRC are not always interested and feel that it is their duty to produce food instead of wood. Still we believe that with the right incentives, changes in legislation and financial benefits, biomass from short rotation coppice could play a necessary role in our future green economy.

doi.org/10.21436/inbor.85964562

Vulgariserende samenvatting

Door snelgroeiende bomen zeer dicht bij elkaar te planten en elke paar jaar af te snijden kan je op korte tijd veel hout produceren. De stompen van de boompjes zullen het volgende jaar terug beginnen groeien en kunnen na een jaar of 2 opnieuw geoogst worden. Je kan op deze manier tot wel 30 jaar hout produceren. Dit systeem wordt korte-omloophout (KOH) of een houtakker genoemd. De geproduceerde biomassa kan voor steeds meer dingen gebruikt worden dankzij nieuwe technologieën. Biomassa zal dan ook een belangrijk element zijn voor onze groene economie. Het voordeel van KOH is dat het koolstof vastlegt in de bodem, biodiversiteit lokaal en in het landschap kan verhogen en water kan zuiveren. Toch moeten we oppassen om niet zomaar overal deze plantages aan te leggen. De voordelen komen niet overal tot uiting en in sommige gevallen kan KOH zelfs nadelig zijn. In dit rapport bekijken we welke effecten KOH kan hebben op de omgeving en de mensen die erin wonen en op de mensen die het zouden kunnen produceren. Daarnaast doen we ook een inschatting van hoeveel plaats er beschikbaar zou zijn voor KOH. Onze conclusie is dat KOH een interessant instrument kan zijn om de biodiversiteit te verhogen en bij te dragen aan gezonde natuurlijke leefomgeving in landbouw- en industrielandschappen. Toch moet er opgelet worden dat het op de juiste plaats en op de juiste manier gebeurt. Zo heeft de natuur er het meeste baat bij als de boompjes langer mogen groeien en dat niet alles in één keer geoogst wordt. Maar die manier van werken is vaak economisch niet rendabel. Er zal dus waarschijnlijk financiële hulp moeten komen vanuit de overheid of privé sector. Er zijn echter nog andere barrières, zoals de zeer complexe regelgeving rond KOH. Dit vergroot de stap voor veel landbouwers die zouden kunnen profiteren van de voordelen van KOH. Daarnaast is er ook weinig interesse vanuit de landbouwers om hout te kweken in plaats van voedsel. Toch geloven we dat met de juiste aansporingen, veranderingen in wetgeving en financiële compensaties, biomassa uit KOH een nodige rol zou kunnen spelen in de toekomstige groene economie.

Résumé vulgarisé

Planter des espèces de bois à croissance rapide très proches les unes des autres et les couper toutes les quelques années est un moyen de produire une grande quantité de bois en un court laps de temps. L'année suivante, les souches recommenceront à pousser et seront prêtes pour la prochaine récolte après un an ou deux. De cette façon, on peut produire du bois pour une période allant jusqu'à 30 ans. C'est ce qu'on appelle le taillis à courte rotation (TCR). Grâce aux nouvelles technologies, la biomasse produite peut être utilisée pour un nombre croissant de choses. Il est clair que la biomasse jouera un rôle important dans notre économie verte. Toutefois, nous devons veiller à utiliser ces plantations aux bons endroits afin qu'elles puissent être bénéfiques pour notre environnement naturel, le paysage culturel, l'agriculture et nos économies locales. Les avantages du TCR sont multiples. Il séquestre le carbone de l'air, soutient la biodiversité et nettoie l'eau. Mais nous devons éviter de développer ces plantations partout car ces avantages dépendent de la situation locale. Parfois, le TCR peut même être nuisible. Dans ce rapport, nous examinons les effets du TCR sur l'environnement et les personnes qui y vivent, ainsi que les effets sur les producteurs. Nous faisons également une estimation de la disponibilité éventuelle de l'espace. Nous concluons que le TCR pourrait être très utile pour accroître la biodiversité et favoriser un environnement naturel sain dans les paysages agricoles et industriels. Néanmoins, il existe un lieu et une gestion appropriés pour le TCR. La nature profitera davantage si nous laissons les arbres pousser plus longtemps et si nous ne récoltons pas tout en même temps. Mais l'utilisation de pratiques plus respectueuses de l'environnement sera moins rentable pour le propriétaire et pourrait donc nécessiter un soutien public ou privé. Ce n'est pas le seul obstacle. La législation sur la manière et l'endroit où il est autorisé de planter du TCR est complexe et peu claire. De plus, les agriculteurs qui pourraient bénéficier du TCR ne sont pas toujours intéressés et estiment qu'il est de leur devoir de produire de la nourriture plutôt que du bois. Nous sommes néanmoins convaincus qu'avec des incitations appropriées, des modifications de la législation et des avantages financiers, la biomasse issue de taillis à courte rotation pourrait jouer un rôle nécessaire dans notre future économie verte.

doi.org/10.21436/inbor.85964562

Extended Abstract

This report has been compiled in the context of the research project Ad-Libio, which aspires to produce new biofuel through inventive bio refining of locally produced wood, which is rich in cellulose through advanced breeding. In this report we solely look into the woody biomass production system of short rotation coppice (SRC) cultures in Belgium, without predetermining its application. The report addresses the following topics:

- The common cultivation practices of SRC in Belgium
- The current area of SRC in Belgium and the theoretically available area for extension
- Policy and legislation concerning SRC in Belgium
- The current knowledge on the impact of SRC on biodiversity and ecosystem services, the landscape and society more broadly
- The factors influencing the financial returns of this production system
- Effects of large-scale introduction of SRC

The information is mainly applied to Flanders and Wallonia but can, with certain caution, be extrapolated to Belgium and other regions with similar land-use patterns.

Short rotation coppice is a woody biomass production system that comes in many shapes and sizes. The common denominator is the dense planting of a single, selected fast-growing tree species that and quickly resprout after being cut back (coppiced) to about 5 cm above the mowing field. The main species in Belgium meeting these characteristics are from the genus willow (*Salix*) and poplar (*Populus*). Cuttings of these species are planted with a high density (5.000 to 30.000 per hectare) and such a plantation is traditionally harvested in cycles of 2 to 5 years, but this can also be as long as 8 to 10 years, depending on the growth conditions and management options. After coppicing, the stumps sprout back during the next growing season and the plantation starts to regrow. After a few rotations, the stumps are exhausted and production starts to decrease. This usually happens after 6 to 7 rotations or 20 to 25 years after planting. At this point the plantation can be renewed by removing the old stumps and planting new ones, or the land can be put to other use.

Yields of SRC are highly variable, depending on the soil and weather conditions, management practices and the varieties of the species used. Average yields from SRC in Belgium are estimated to be around 12 tons of dry matter per hectare per year, but can go up to 20 dry tons. Irrespective of the rotation length, the wood harvested from SRC plantations is usually processed into chips. Since these chips are made from thin stems, they have a rather high bark to stem ratio. Because of this characteristic, the chips are currently regarded as only suitable for energy production or composting. There is a high probability that in the near future wood from SRC could also be used for a wide range of other applications such as construction materials, bio-components and biofuels. It is also very likely that this type of woody biomass will play an increasingly important role in local energy supply. Because woody biomass can be produced by different sectors (agriculture, forestry, wood-processing industry) and used by different sectors (wood-processing industry, composting industry, energy industry, chemical industry,...) it is

difficult to estimate how the growth in supply and demand for woody biomass will evolve in Belgium, and what role SRC will play. This will also be influenced by the international woody biomass market, adding another layer of complexity.

Short rotation coppice has never been implemented on a large scale in Belgium, even though extensive research on the subject has already been conducted. In 2021 about 83 hectares SRC were planted on agricultural land, of which 31 ha in Wallonia and 52 ha in Flanders. When looking for additional land to expand SRC, there is only a limited agricultural area which could be immediately available for SRC without substituting land for food and feed production. There are around 1.000 hectares of fallow land in Flanders and around 3.000 in Wallonia, but it is currently difficult to estimate whether these parcels are kept under fallow long enough to make SRC a viable option. An option for SRC expansion could be the area that is presently used for first-generation biofuel crops or feed crops Shifting 75% of first generation to second generation biofuels would yield between 4.250 and 12.500 hectares of SRC in the long run. Also the mandatory ecological focus areas on agricultural land provide some opportunities for SRC expansion. These could cover between 400 and 4.000 hectares. Another promising area for immediate SRC expansion with no danger for substituting food production and which could be put under cultivation relatively fast are industrial sites that have not been developed yet. 5.000 hectares of such areas are theoretically available (not taking practical constraints into consideration). It can be concluded that theoretically in total about 5.000 hectares are in the short term available for SRC in Flanders from vacant industrial sites, which could (once more theoretically) increase in the future to a maximum of 21.000 hectares from agricultural land freed up from first generation biofuels and feed crops and from ecological focus areas**.** This area would yield about 252.000 tons of dry matter per year, not taking into account potential lower yields from marginal lands.

Introducing SRC into an agricultural landscape can have beneficial effects on biodiversity and the provisioning of ecosystem services. Especially in areas deprived of natural elements and in agricultural areas SRC can increase biodiversity, agricultural production and protect watercourses and protected areas from leaching nutrients. These benefits are maximised when the SRC is done on small scales on ecologically less valuable lands and when it connects natural elements. A number of other measures can be taken to increase the value of an SRC for biodiversity (cover crops, permanent structures, phased harvesting,…). Small-scale implementation has the lowest risk of negatively influencing the landscape and will probably be most accepted by the local community. However, the economic feasibility will be lower, making it an unattractive investment. Large-scale unregulated implementation of SRC, on the other hand, would be more economically feasible but would most probably have detrimental effects for the environment in Belgium, Europe and elsewhere. It could lead to a number of unwanted side effects such as competition with food production, biodiversity loss and increased emissions of greenhouse gases. With sound and enforced policies in place, the development of an economy on biomass from SRC could however have benefits for nature conservation, local economies and society.

In case policymakers would like to increase the production of woody biomass for achieving the bioenergy goals, SRC has the potential to rapidly respond to such a need due to its short rotations and high yields. Because this biomass is produced without having to harvest from

doi.org/10.21436/inbor.85964562

forests in Europe or elsewhere, it can also play a role in achieving the Land Use, land Use Change and Forestry goals. In the future, woody biomass from SRC could also support the further development of the biobased economy through other applications than energy. However, the slow development or even standstill of SRC in Belgium shows that multiple barriers have to be overcome to unlock this potential.

A major barrier in Flanders is the unclear and complex legislation concerning SRC. The current regulations also often stand in the way of ecologically beneficial SRC. Sites where nature conservation would benefit most from SRC (close to forests or in agricultural landscapes with high nature value) are the least probable to be converted to SRC due to the strict regulations of the Flemish Forest Decree (*Vlaams Bosdecreet*) the owner would have to adhere to. In case the conversion of these lands to SRC would take place, the most intensive form of SRC (namely very-short SRC) would probably be developed as it requires less permits, while these areas would benefit most from longer rotations. The Leasing Law (*Pachtwet*) potentially hampers the cultivation of SRC both on leased agricultural land and on land that has recently been taken out of lease. The Field Code (*Veldwetboek*) also has a potential influence on SRC via distance rules, depending on the interpretation. The European Common Agricultural Policy (CAP) supports the use of SRC and identifies it as suitable for ecological focus areas within agricultural lands. This could be an important incentive for farmers to adopt SRC. Nonetheless, the CAP also has its drawbacks as some restrictions within these focus areas, such as the restrictions on species or hybrids that can be used, could be less strict without compromising the ecological potential of SRC while increasing its economic feasibility.

Policy recommendations

If policy wants to increase SRC, it could achieve this by adjusting existing legislation and regulations:

- **Disentangling** the complexity of the different **legislations** affecting SRC
- Clearly **assigning the mandate** for SRC to one policy domain- we argue it would best fit within agriculture, or granting an own statute as is the case for agroforestry
- **Updating the regulations** of the Forest Decree and Nature Decree with the most recent scientific evidence on the potential environmental impacts of SRC to facilitate the synergies of SRC with nature conservation, namely not facilitating vSRC in forests or ecologically sensitive areas, but rather facilitating longer rotations
- **Clarifying the Field Code** regarding the distance rules for SRC plantations
- **Adjusting the Leasing Law** to remove the potential barriers of planting SRC on leased land and land that has recently been taken out of lease
- **Re-evaluating the restrictions in the CAP** post 2023 on the management practices of SRC to reconcile environmental and economic feasibility

Should policy want to go beyond just removing existing barriers, it could also:

- Put in place **incentives to stimulate the most environmentally friendly forms of SRC** (longer rotations, phased harvesting, mixing species and varieties), which would be less economically viable without government support
- **Organise information campaigns** on how to use SRC to become (more) energy independent as a farmer, company or local government
- Organise network events to **bring together all the potential actors** in the production chain like interested landowners, companies planting and managing SRC plantations, biomass processors, wood-processing companies and start-ups using biomass,...
- **Incentivize public investors** (like cities and municipalities) **to lead by example** as they can look beyond the purely financial gains and also are more likely to take into consideration the (non-monetary) public values SRC can create

Should demand for wood from SRC increase drastically, policy could adopt measures to ensure the expansion of SRC does not induce negative ecological, social or economic effects. For example by:

- **Enforcing the cascaded use of woody biomass** as technology evolves, to ensure the use of wood from SRC is not restricted to generating only energy when applications as material or bio-components emerge
- **Prohibiting the planting of SRC on carbon-rich land** (like historical permanent grasslands and forests)
- **Protecting productive agricultural land** from being converted to SRC should woody biomass prices exceed crop prices
- **Ensuring stakeholder consultation and participation** for landscape design when implementing large SRC plantations and accompanying infrastructure development projects
- **Matching development of industrial SRC-processing infrastructure with sustainably available supply of wood from SRC** in order to avoid the unsustainable use of other

doi.org/10.21436/inbor.85964562

biomass sources such as wood from increased harvesting in forests or biomass transported over long distances.

Table of contents

List of figures

List of tables

List of abbreviations

ANB	Agentschap Natuur en Bos = Flemish agency for nature and forest
CAP	Common agricultural policy
CoDT	Code de Développement Territorial = Spatial development code
EAG	Ecologisch aandachtsgebied = Ecological focus area
ES	Ecosystem Service
GHG	Greenhouse gases
GMO	Genetically modified organism
ILUC	Indirect land use change
LULUCF	Land use, land use change and forestry
OVAM	Openbare Afvalstoffenmaatschappij voor het Vlaams Gewest = Public Waste Agency of the Flemish Region
SPW	Service Public de Wallonie = Walloon public service
SRC	Short rotation coppice
SSA	Spatially sensitive areas
VEN	Vlaams ecologisch netwerk = Flemish ecological network
VLM	Vlaamse Landmaatschappij
vSRC	Very short rotation coppice

doi.org/10.21436/inbor.85964562

1 INTRODUCTION TO SHORT ROTATION COPPICE IN BELGIUM

1.1 SHORT ROTATION COPPICE PRODUCTION IN BELGIUM

Short Rotation Coppice (SRC) is a woody biomass production system that comes in many shapes and sizes. The common denominator is the dense planting of a few, selected and fast-growing tree species that quickly resprouts after being cut back to about 5 – 10 cm above the mowing field. The main species in Belgium meeting these characteristics are species from the genera willow (*Salix*) and poplar (*Populus*).

A plantation is made by planting un-rooted cuttings of these species with a length between 20 and 50 cm at a high density and often in twin rows to facilitate harvesting. This can be done with a specialised planting device which is towed by a tractor as illustrated in Figure 1.1. This device shoots the entire shoot in the ground, after which it is cut at the preferred length, leaving the cutting planted. A leek planter can also be used which plants pre-cut cuttings of 25 cm. Depending on the distance within and between the rows, a planting density of 5,000 up to even 30,000 cuttings per hectare can be achieved. Most commonly a density of 12.000 to 20.000 cuttings per hectare is used.

Figure 1.1:Planting of an SRC with the Energy Planter - Source: Egendal Maskinfabrik

Traditionally, this plantation is harvested in rotations of 2 to 5 years, but this can also be as long as 8 to 10 years, depending on the growth conditions and management practices. The next growing season, the stumps sprout back and the plantation starts to grow again. After a few rotations, the stumps are exhausted and production decreases. This usually happens after 6 to

7 rotations or 20 to 25 years after planting. After the last harvest, the stumps are removed or ploughed into the soil. After this, planting can take place again with new varieties or the land can be used (again) for other purposes, such as agriculture. An example of the different steps in SRC cultivation practices that are used in Belgium:

1) Ploughing and harrowing before the planting season
    a. Optional: Application of herbicide
2) Planting of the cuttings in early spring to early summer (March – June)
    a. Optional: sowing of cover crops
    b. Optional: application of fertiliser
3) Mechanical weeding during first (two) year(s)
    a. Optional: application of pesticides
    b. Optional: application of fertiliser
    c. Optional: cut back after first year for increased yield afterwards (only during the first rotation)
4) Optional: Clear fallen stems to increase harvest efficiency
5) Harvesting [return to step 3]

This is also visually represented in Figure 1.2 for the production of bioenergy. This overview was made in the context of the POPFULL project of University of Antwerp (2009 - 2014)[1].

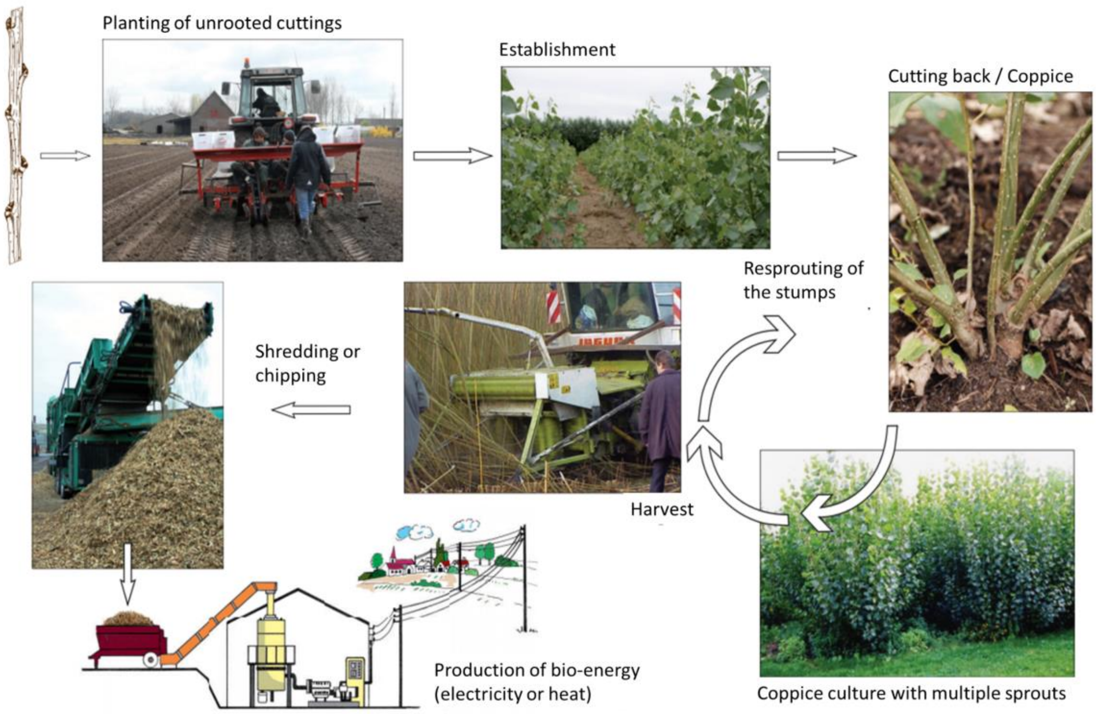

Figure 1.2: Schematic representation of the operations of an SRC plantation for the production of bioenergy - Source: POPFULL project University of Antwerp

Prior to planting, soil cultivation is necessary to facilitate the rooting of the cuttings. This means ploughing to a depth of 30 cm in autumn before planting and harrowing in spring. If necessary,

[1] https://webhosting.uantwerpen.be/popfull/

a herbicide is used before ploughing and/or harrowing. During the first two years of establishment or after each rotation, it is necessary to either mechanically or chemically control the undergrowth to limit its competition with the cuttings. Alternatively, cover crops can be used which can be sown in at the same time as the plantation as shown in Figure 1.3. They bring a number of benefits like increased biodiversity and pest control and possibly nitrogen fixation but require more know-how.

Figure 1.3: Young willow SRC with a clover cover crop. Photo credits: Olivier Poncin - Phitech

In case a monoculture is planted with one or very few clones, the plantation is sometimes susceptible to diseases and pests (De Somviele *et al.*, 2009). Treatment with fungicides and/or insecticides could in that case be considered, however this is often not cost-effective and a good genetic mixture of the plantation is a more efficient way to cope with pests. A common pest species are leaf beetles (Chysomelidae) which can be effectively managed by increasing nesting opportunities for birds predating them like tits (Paridae family) or starlings (*Sturnus vulgaris*). Also mammals pose a threat to the good development of the plantation, irrespective of the genus/species/clone mixture. Voles (e.g. *Arvicola scherman*) can be managed naturally by favouring conditions for foxes and mustelids (O. Poncin, personal communication, May 14, 2022) while the wild boar (*Sus scrofa*) is best avoided by small patches (ValBiom, personal communication, September 23, 2022). Fertiliser can be applied in between rotations. However, this is in most cases not necessary, in particular when planted on previous or abandoned agricultural land. The necessity is best determined by a soil sample analysis.

Several machines can be used for the harvest, influencing the price, possible end-product and resprouting capacity (Vanbeveren *et al.*, 2018). Which type can be used depends on the diameter of the stems, the species and the planting scheme. The diameter reached after a number of years depends on the growth conditions and the species. Poplar for example produces less but thicker stems than willow. For very short rotations (<3 years, diameter <6 cm) a converted corn harvester can be used. These harvesters will produce chips on-site. or a specialised SRC harvester. Both harvesters will produce chips. Medium-length rotations (2-5 years, diameter < 10 cm) require a specialised SRC machine. These machines are light and are hooked up to a tractor such as the Energy harvester[2] as demonstrated in Figure 1.4. They produce chips that are deposited directly into a trailer.

Figure 1.4: Energy harvester in action. Photo credits: Olivier Poncin - Phitech

For long rotations (>5 years, diameter > 10cm), forestry machines must be used. For these rotations the choice can be made to transport the trees in their entirety or to also chip them on the spot. Recently, a fourth type of harvesting machine was tested in Belgium, the Biobaler. It can handle stems of medium rotation and rolls the trees into bales that can afterwards be chipped or transported in its entirety.

Harvesting is out of economic considerations often done for the whole plantation at once in a clearcut. Yields of SRC are highly dependent on the soil and weather conditions, management practices and the species and varieties used. the first rotation in general has much lower yields, ranging between 5 and 6 t $ha^{-1}y^{-1}$ of dry matter. In the longest running SRC experiment in

[2] https://nyvraa.dk/en/machinery/

 doi.org/10.21436/inbor.85964562

Belgium, average dry biomass yields was 5,3 t $ha^{-1}y^{-1}$ after 4 rotation (16 years) with yields of different poplar clones ranging from 0 to 10,5 t $ha^{-1}y^{-1}$ (Dillen *et al.*, 2013). Nonetheless, yields of 12,5 t $ha^{-1}y^{-1}$ are generally accepted to be the average in Belgium (Laureysens *et al.*, 2004; Meiresonne, 2006; Verlinden *et al.*, 2015). Through selection and breeding, poplar clones with an average yield of 20 t $ha^{-1}y^{-1}$ were achieved at INBO (Meiresonne & Jansen, 2018).

The cultivation of Miscanthus is very similar to SRC. This system uses a dense plantation of the fast-growing lignocellulosic perennial grass species *Miscanthus* to rapidly produce biomass. This exotic species has the advantage that it produces less thick stems which can be handled with normal agricultural machinery, can be harvested every one or two years and does not require drying. This makes it an easier cultivation than SRC. Nonetheless Miscanthus plantations might not sustain as much biodiversity as SRC could (Williams *et al.*, 2019, 2022).

To summarise:
there are a few constant factors in SRC plantations:

- Short rotations (< 10 years)
- Use of specific species (poplar and willow) and often specific cultivars
- High planting density (5.000 – 30.000 cuttings per hectare)
- Wood chips as the end product

However, there are also a number of factors that are more flexible and that can have a significant influence on the overall sustainability of the system.

- Rotation length (2 to 10 years)
- Harvesting techniques (clear cuts to phased harvesting)
- Number of cultivars (monocultures to high diversity)
- Undergrowth management (initial ploughing and intensive management of undergrowth to no ploughing and cover crops)
- Fertilisation (application of fertiliser every rotation to no use of fertiliser)
- Pest management (use of herbicides, fungicides and insecticides to no use of pesticides)

1.2 POSSIBLE APPLICATIONS OF WOOD FROM SRC

Woody biomass in general can have multiple applications: material (furniture, boards, paper, building materials, etc.), electricity and/or heat generation, soil improvement, extraction of certain organic components (bio-oil, fungicides, salicin,...), animal feed, liquid biofuel etc. However, not every type of woody biomass can be used for every application, due to technological limitations. In addition, to increase the efficiency of the bio-economy and to stimulate circularity, it is not permitted to use every stream for every purpose (this will be further explained in chapter 2). In this report, we focus on wood from SRC plantations, for which thus some specific rules and possible applications apply. Irrespective of the rotation length, the end product of a SRC plantation is usually chips. Since these chips are made from thin stems, they have a rather high bark to wood ratio. Because of this characteristic, the chips are currently regarded as only suitable for energy production or composting. Nonetheless, it is very possible that in the near future wood from SRC will also be used for a wide range of other applications such as materials, bio-components and liquid fuels as these technologies are in full development.

The use of biomass as an energy source has long been on the rise (Camia *et al.*, 2021). In chapter 14 of the INBO NARA-T report: Ecosystem service production of energy crops (Van Kerckvoorde & Van Reeth, 2014), the rising demand is ascribed to a number of indirect drivers: (1) demographic growth, (2) higher energy use due to economic growth, (3) increased interest by policy at all levels in function of low-carbon solutions and energy independence (European, national, regional, local), (4) cultural drivers such as a growing awareness of the climate problem, (5) new technologies that can tap into more residual flows and do this more efficiently. Nevertheless, this increase is not unrestrained and there are a number of direct drivers that influence the supply and demand of woody biomass for energy production: (1) land conversion and land-use conversion, which changes the availability of wood, however, these changes are difficult to predict, making it difficult to estimate the final effect; (2) changes in pollutants and nutrients such as atmospheric nitrogen deposition, the effect of which is not yet certain; (3) overexploitation, which has a negative effect, (4) climate change, where more extreme weather conditions may offset higher productivity, (5) the introduction of exotic species, whereby higher biomass yields can be obtained through the use of non-native varieties, but which could also lead to the unwanted introduction of new pests and diseases and invasive species.

It is very likely that woody biomass will play an increasingly important role in energy supply in the near future (Wille, 2016). The new policy initiatives focusing on renewable energy already demonstrate this (see section 2.2). but due to the complexity and interdependence of the energy sector with other wood-processing sectors, agriculture, forestry and the international market in general, it is difficult to estimate how this growth will evolve in Belgium, and what part SRC will play.

1.3 CURRENT AMOUNT OF SRC IN BELGIUM

Short rotation coppice has never been implemented on a large scale in Belgium, even though an extensive amount of research on the subject has already been done (De Somviele *et al.*, 2009; Meiresonne, 2006; Verlinden *et al.*, 2015).

In 2021 there was a total of about 83 hectares SRC in Belgium planted on agricultural land, of which 31 ha in Wallonia and 52 ha in Flanders[3]. This might not cover all of the SRC plantations since SRC can also be planted on non-agricultural land under certain circumstances. However, there are no other available datasets to accurately quantify SRC on non-agricultural land. It was reported for Wallonia that there is certain amount of SRC planted by private owners on non-agricultural land, which therefore is not declared in the agricultural data. These plantations would however only amount up to some 50 hectares (ValBiom, personal communication, September 23, 2022). This proves that in Belgium there is little practical application of SRC. As far as Miscanthus concerns, there is a higher area planted in Belgium. In Flanders 77 ha were reported in 2021 whereas in Wallonia this even amounted up to 274 ha. This means there is a total of 351 ha of Miscanthus plantations in Belgium on agricultural parcels, about 4 times more than SRC.

[3] Calculated from the Parcellaire agricole anonyme, situation 2021 (Service public de Wallonie) and the Landbouwgebruikspercelen 2021 (Departement Landbouw en Visserij)

doi.org/10.21436/inbor.85964562

Figure 1.5 shows the evolution of the SRC area in Belgium from 2008 until 2021. After a peak in the year 2013 (100 ha) in Flanders, the area of SRC in Flanders has decreased and stabilised around 55 ha for most recent years. Also in Wallonia, the area of SRC has decreased over the years from 50 ha in 2015 to around 30 ha in 2021. Trends outside the agricultural areas are unknown for Flanders. In Wallonia, an increasing interest is reported outside agricultural areas for hunting reasons (ValBiom, personal communication, September 23, 2022).

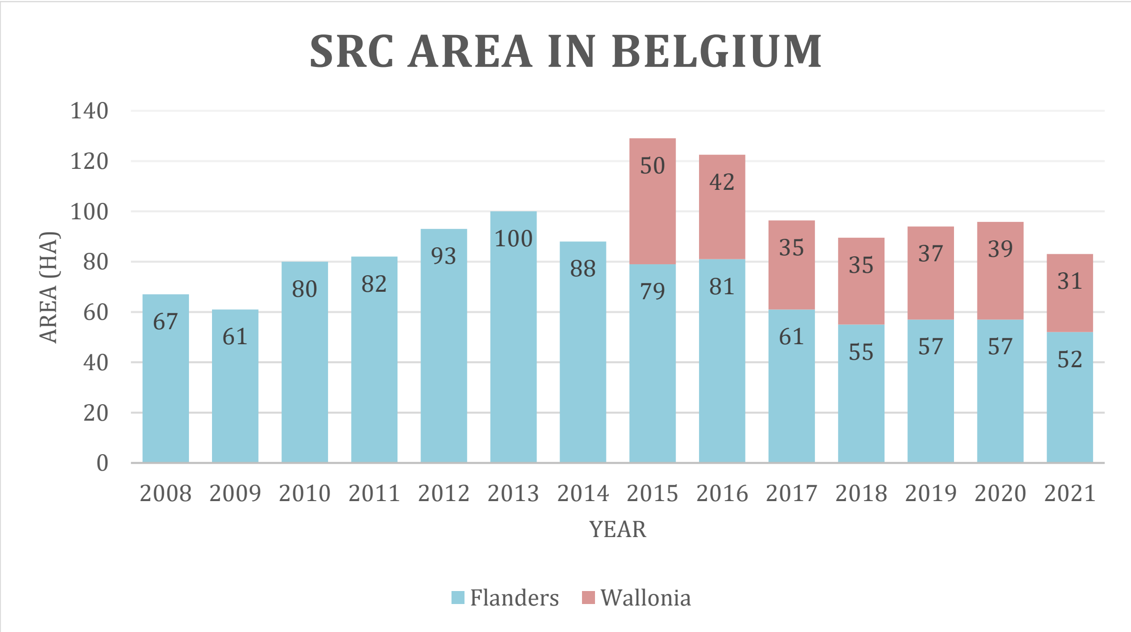

Figure 1.5: Evolution of SRC area in Belgium ('Landbouwgebruikspercelen' 2008-2021 and 'Parcellaire Agricole anonyme' 2015-2021; no data for the years 2008-2014)

In the year 2021, the total area of SRC in Flanders consists of 58 agricultural parcels, all below 10 ha in size (see Figure 1.6). In Wallonia we see a similar trend: the area of SRC consists of 36 agricultural parcels, all below 10 ha in size. The majority of SRC parcels in Belgium are below 1 ha in size, which might indicate that even small patches of SRC have a certain yieldability or return on investment. Due to the small size of these patches, these do not qualify as plantations, however these patches not only concern field borders, but also wider and more condensed areas.

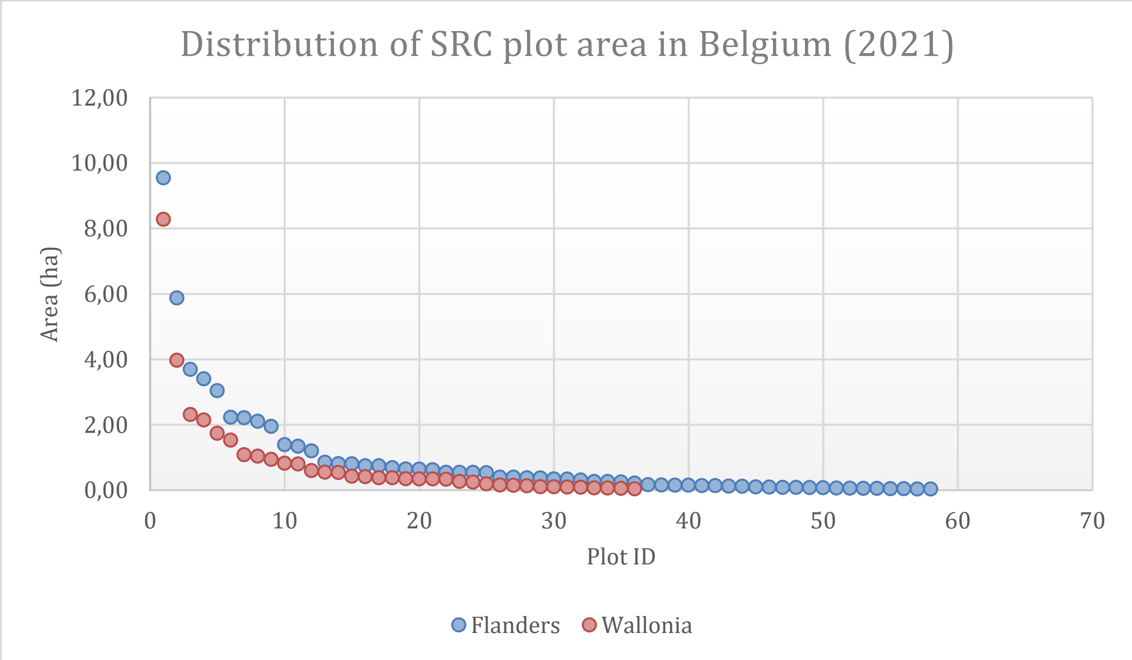

Figure 1.6: Distribution of SRC plot area

The parcels with SRC are scattered across Belgium (see Figure 1.7). In Flanders, most SRC parcels are located in the provinces of West-Flanders, East-Flanders and Antwerp. In Wallonia, SRC parcels are concentrated in the province of Walloon-Brabant and the west of Henegouwen. The parcel boundaries are presented with a thicker line, hence making the locations more visible on the map. In reality however, these parcels are smaller snippets.

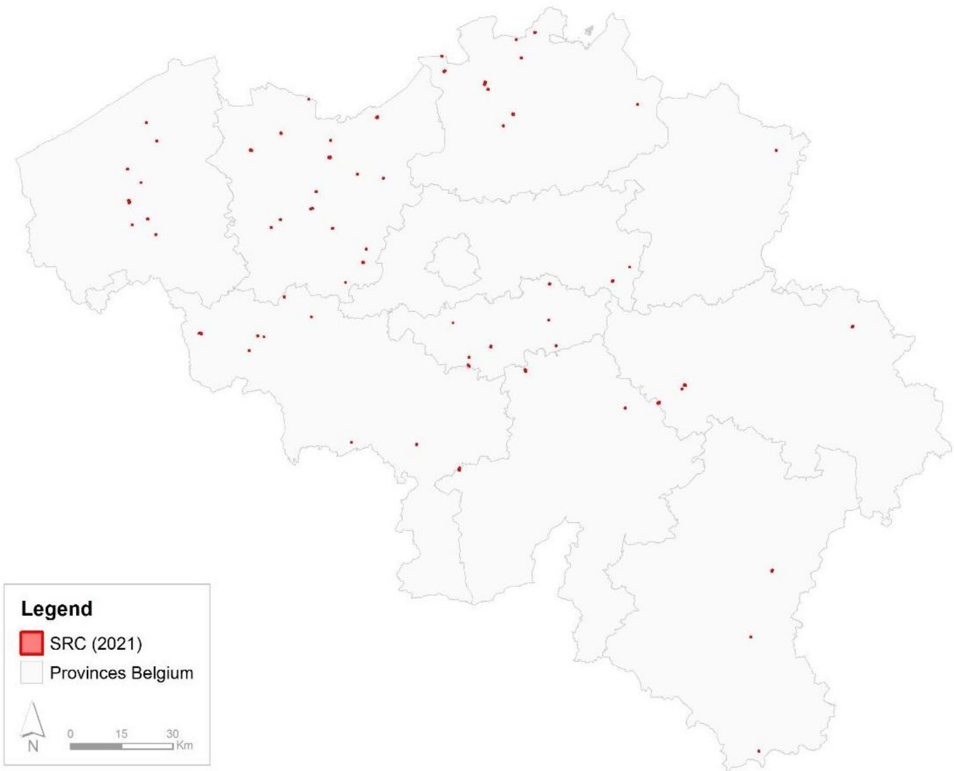

Figure 1.7: Location of SRC parcels in Belgium (Landbouwgebruikspercelen, Parcellaire Agricole anonyme, 2021). Thicker boundaries are used for better visibility on the map.

1.4 AVAILABILITY OF LAND FOR SRC IN FLANDERS

This section explores the availability of land for potential further expansion of SRC in Flanders. In a heavily populated and urbanised area like Belgium, and even more so in the region of Flanders, there is little or no 'vacant' land or agricultural land that has gone out of production. This however does not mean there are no opportunities for short-rotation coppice. There could be, among others, possibilities for cultivating short-rotation coppice on fallow land, marginal land, wetlands, industrial sites that have not been developed yet, as well as industrial brownfield sites that have not been redeveloped yet.

Agriculture and short rotation coppice do not exclude each other: short rotation coppice can be planted in conjunction with agriculture, having a series of positive effects. For example, a linear short rotation coppice planted in lines of 4m width through the crops can protected water streams from pollution, fight erosion, protect against wind, increases functional biodiversity,... (see Figure 1.8 and Figure 1.9). A short rotation coppice plantation can also be used as a grazing area for poultry (forest animals), see example in Figure 1.10. Wetland plots with low-productivity are also suitable for short rotation coppice plantations.

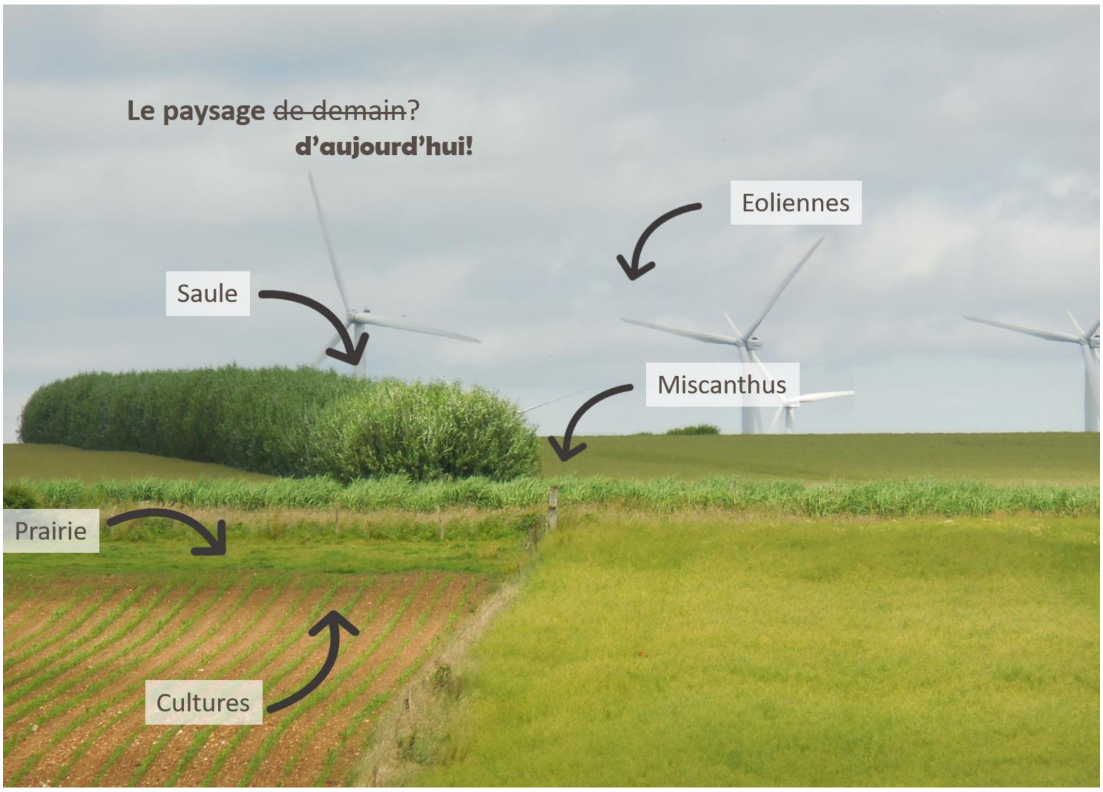

Figure 1.8: Example of linear short rotation coppice in an agricultural landscape. Photo credits: Olivier Poncin - Phitech

Figure 1.9: Example of linear short rotation coppice in between crops. Photo credits: Olivier Poncin - Phitech

Figure 1.10: Example of chicken breeding underneath short rotation coppice. Photo credits: Olivier Poncin - Phitech

We will estimate the potential area in Flanders for short rotation coppice in two stages. In the first stage we take into account certain land use types that could offer realistic opportunities to be developed or converted into SRC, such as fallow land or vacant industrial sites. By 'realistic' opportunities, we mean that we limit SRC potential to land that is not suitable for food production. Nor will nature reserves or forests with high biodiversity be counted as potential areas for SRC. Linear agroforestry elements like mentioned in the examples above, do not fall under this assumption. This first estimation exercise does not emphasise making assumptions of converting a certain percentage of existing land use types. In a second stage we do make assumptions on current land-uses of which a percentage could theoretically be converted to SRC in the near future. It should be noted however that these theoretical assumptions usually result in very high potential areas for SRC.

Table 1.1 gives an overview of the land use forms in Belgium that could be considered for immediate development of SRC (based on De Somviele et al., 2009). For each land use form, an indication of the potential area for SRC is given (in hectares).

Table 1.1: Land use forms in Belgium, with immediate potential for SRC

Land use category	**Land use forms** (with current area in ha)	**Potential area for SRC**	**Dataset**
Agricultural zones Flanders	Fallow land (undeveloped, vacant): ● Fallow land with minimal activity, *with* ecological area of interest (283 ha) ● Fallow land with minimal activity, *without* ecological area of interest (461 ha) ● Fallow land without minimal activity (251 ha)	995 ha (total of fallow land categories)	*Landbouwgebruikspercelen LV, 2021*
Agricultural zones Wallonia	● Fallow land (3010 ha) ● Fallow land planted for pollinators (32 ha) ● Non-herbaceous fallow land (180 ha) ● Non-agricultural use (log storage, ..) or wasteland (0 ha)	Around 3000 ha	*Parcellaire Agricole anonyme, 2021*
Industrial sites Flanders	Vacant land *(braakliggendeGrond)*, of which: ● Contaminated sites (171 ha) ● Sites with water issues (152 ha) ● Sites which are physically not feasible to be developed as industrial sites (135 ha)	5.919 ha	*Bedrijventerreinen_OSLO_20220210_Shapefile*
	Vacant land AND not offered (*Braakliggende grond EN niet Aangeboden)*	5.052 ha	
	Dredging sludge dumps on land: In the past, it was generally accepted that the dredged material released during the dredging of waterways was left on fields and lower areas without any protective measures or control. Dredged material was fertile and it was not considered that it might be contaminated by discharges into the watercourse.	/	*No data*
	Buffer strips along industrial sites. The total perimeter of all industrial sites in Flanders is around 6.341.132 m.	Theoretical estimation based on assumption of a buffer around all industrial sites in Flanders: 1m buffer ≅ 600 ha 2m buffer ≅ 1.200 ha 3m buffer ≅ 1.800 ha	*Bedrijventerreinen_OSLO_20220210_Shapefile*
Soils for water treatment	SRC can be used as a wastewater treatment plant for pre-treated domestic wastewater (Istenič *et al.*, 2021).	/	*No data*
Road or railway verges Flanders	The total area of roadside verges along the Flemish road network amounts to 20.000 to 25.000 ha. Of this, the Agency for Roads and Traffic manages about 9.000 ha along motorways and regional roads. Patches of these 9.000 ha are under coppice management.	The total area currently under coppice management, calculated from the shp file received from 'Agentschap Wegen en	*Hakhoutbeheer2021-2022_lijn* *Source:* https://w

doi.org/10.21436/inbor.85964562

	Source: https://www.vlaanderen.be/beheer-van-de-wegbermen-in-vlaanderen	Verkeer' is 55,5 ha. The potential area is likely higher.	egenenverkeer.be/natuur-en-milieu/ecologisch-bermbeheer/hakhoutbeheer

The total area of **fallow agricultural land** (undeveloped, vacant land) in Belgium is estimated around 4000 ha (the sum of different categories of fallow land mentioned in Table 1.1). Further analysis is needed to determine if these fallow lands stay vacant for several years, to allow for an SRC investment, or if this is a temporary phenomenon (the total area of fallow land is based on declarations for 1 year only, in this case the year 2021).

The total area of **vacant industrial sites** in Flanders is estimated around 6000 ha. A similar dataset was not found for Wallonia. If only vacant industrial sites are taken into account, which are not actively offered on the market to be developed, the total area sits around 5000 ha. The sub-categories however (contaminated sites, sites with water issues and sites with physical challenges for development), point to a lower indicative total of around 460 ha. Moreover, of these 5000 ha possibly only a fraction can be brought under SRC because of practical constraints (site quality, site access, size and shape,...). The perimeters of industrial sites could also be used for SRC. The SRC could act as a green buffer, hiding the industrial sites and buffering its sounds. The effect of soft soils and forest can mitigate noise, provided that the forest is sufficiently wide (100 to 300m) (Huisman, 1990). But also smaller hedges have a sound reducing effect, albeit a low one (Van Renterghem *et al.*, 2014). To avoid cutting down the entire buffer at once, harvesting SRC can follow a phased approach: harvesting a portion of SRC in one year, and harvesting the second part during the following year to maintain the larger willows. However, the mere presence of a visual buffer also decreases the nuisance experienced because of the sound (Liekens *et al.*, 2013). For this effect, the buffer does not need to be this wide.
A strip of 3 metre width would include 4 rows of SRC which is ideal for the SRC machinery. Buffers around industrial sites could theoretically add another 600 to 1.800 hectares of SRC, depending on the width of the buffer. This does, however, not take into account site suitability and will therefore probably be a high overestimation.

SRC could be used on **polluted sites** for phytoextraction and could serve as natural waste-water treatment (see sectionEcosystem services and biodiversity of SRC 4.1). Also **roadside and railway verges** provide an opportunity which is now already partially managed by coppice systems, albeit with longer rotations. For these land use forms, no spatial information is available at this point to do a proper estimation.

The EU-funded MAGIC project explores the cultivation of industrial crops on **marginal land** to avoid land-use competition with food production. Marginal Land Area maps (see Figure

1.11**Fout! Verwijzingsbron niet gevonden.**) are available for Europe (Magic Maps), and can give a rough indication of potential locations for SRC on marginal lands not suitable for agriculture. In Figure 1.11 the share of agricultural land which is classified as marginal because of natural constraints (climate, wetness, fertility, chemicals, rooting, terrain) is visualised.

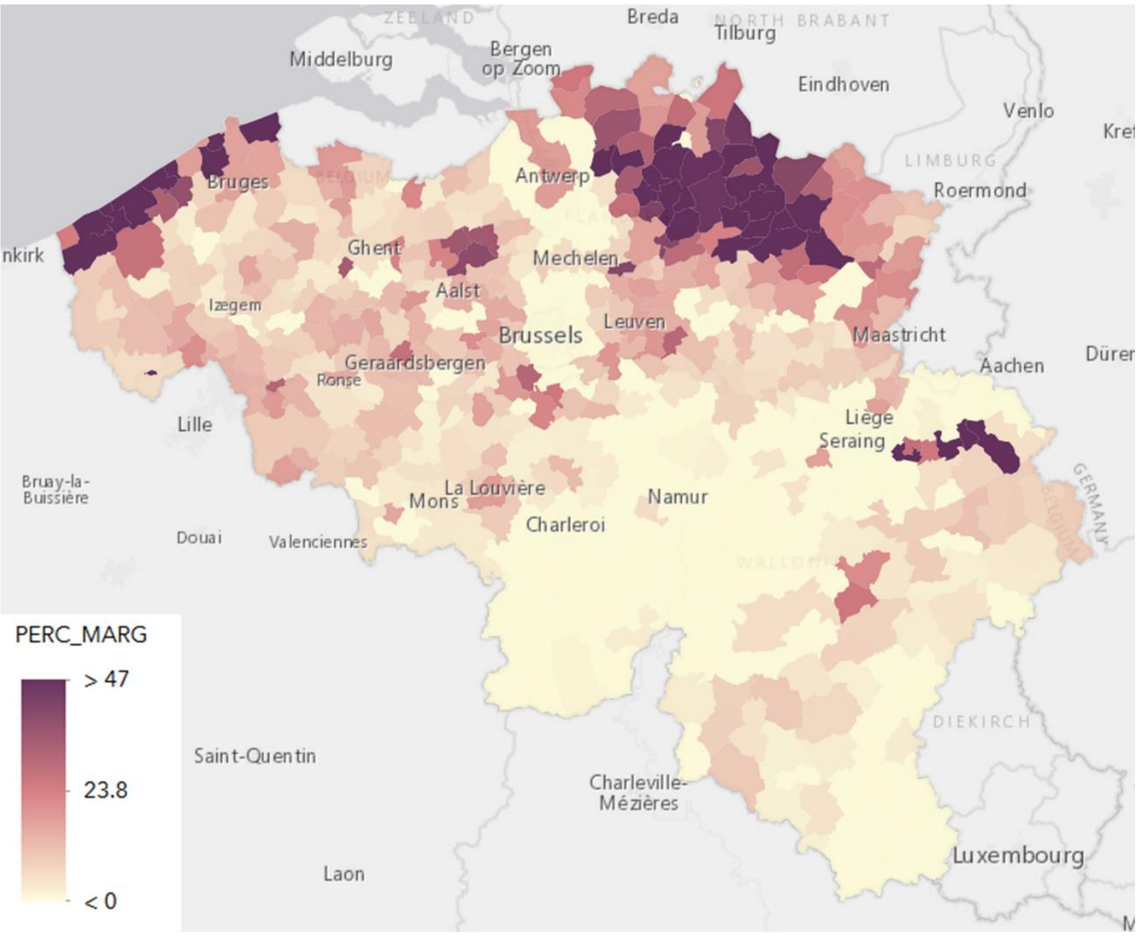

Figure 1.11: Marginal Land Area in Belgium as percentage of agricultural land (Magic Maps - Magic project)

In a second estimation exercise we look into hypothetical areas for SRC that would substitute other productive land uses.

Table 1.2 gives an overview of the land use forms in Belgium that could potentially be considered for SRC. For each land use form, an indication of the potential area for SRC is given (in hectares).

- The first land use forms are low-yield crops, now used for animal feed and biofuels. In a plausible scenario where first generation biofuels are phased out (see section 2.2 on emerging policy initiatives on this subject) this would free up land which could be used for second generation biofuels from SRC. Also the reduction of land used for animal feed is plausible as the European Farm to Fork strategy aims to shift diets more towards plant-based, and also the Flemish PAS[4] aims at reducing the amount of animals, freeing up agricultural land for other purposes, such as SRC.

[4] PAS (Programmatische Aanpak Stikstof or Programmatic Approach to Nitrogen) is a framework which sets out the emission rights for nitrogen. It includes reduction targets for the amount of pigs in Flanders. (Departement Omgeving, 2022)

- The second land use form consists of ecological focus areas (ecologisch aandachtsgebied - EAG) which every farmer with over 15 hectares of arable land is obliged to install to receive the basic payment of the CAP. This concerns 5% of the total arable land of the farmer and SRC is eligible to be produced within these focus areas (see section 2.4).

Table 1.2: Land use forms in Belgium, with hypothetical potential for SRC (based on Landbouwgebruikspercelen LV, 2021, Parcellaire agricole anonyme, 2021)

<table>
<tr><th>Land use forms
(with current area in ha)</th><th>Potential area for SRC
Assumptions based on % of conversion</th></tr>
<tr><td>
Low-yield crops (crops used for animal feed, agricultural crops partly used as biofuel such as wheat, maize, sugar beet or rape-seed)
<table>
<tr><th>Low-yield crops</th><th>Area Flanders (ha)</th><th>Area Wallonia (ha)</th><th>Total area Belgium</th></tr>
<tr><td>Animal fodder[5]</td><td>26.301</td><td>417.442</td><td>443.743</td></tr>
<tr><td>Wheat</td><td>64.249</td><td>128.690</td><td>192.939</td></tr>
<tr><td>Sugar beet</td><td>18.808</td><td>37.254</td><td>56.062</td></tr>
<tr><td>Rape-seed</td><td>597</td><td>7.821</td><td>8.418</td></tr>
<tr><td>Grain maize</td><td>42450</td><td>7166</td><td>49.616</td></tr>
<tr><td>Silo maize</td><td>128998</td><td>59301</td><td>188.299</td></tr>
<tr><td>Total</td><td>281.404</td><td>657.674</td><td>939.077</td></tr>
</table>

Two different methodologies are proposed in (Van Kerckvoorde & Van Reeth, 2014) for calculating the area used for first generation biofuels, based on different approaches and assumptions.

<u>Methodology 1:</u>
For wheat, sugar beet and grain maize, it is assumed that only 2% of the total area is eligible for energy purposes; the rest is mainly for food production (Van Kerckvoorde & Van Reeth, 2014). For Belgium this would mean a total area of around <u>6000 ha</u>.
<table>
<tr><th>Crop</th><th>Total area (ha)</th><th>2% (ha)</th></tr>
<tr><td>Wheat</td><td>192939</td><td>3859</td></tr>
<tr><td>Sugar beet</td><td>56062</td><td>1121</td></tr>
<tr><td>Grain maize</td><td>49616</td><td>992</td></tr>
<tr><td>Total</td><td>298617</td><td>5972</td></tr>
</table>

For rape-seed it is assumed that 30% is cultivated for energy purposes (Van Kerckvoorde & Van Reeth, 2014). For Belgium this would mean a total area of around <u>2500 ha</u> (30% of 8418 ha).

<u>Methodology 2:</u>
</td><td>
<u>Methodology 1:</u>
Theoretical assumptions based on % of conversion to SRC of the total area of energy crops (<u>8500 ha</u>)
<table>
<tr><th>%</th><th>Belgium (ha)</th></tr>
<tr><td>1%</td><td>≅ 85</td></tr>
<tr><td>5%</td><td>≅ 425</td></tr>
<tr><td>10%</td><td>≅ 850</td></tr>
<tr><td>20%</td><td>≅ 2.125</td></tr>
<tr><td>50%</td><td>≅ 4.250</td></tr>
<tr><td>75%</td><td>≅ 6.375</td></tr>
</table>

<u>Methodology 2:</u>
Theoretical assumptions based on % of conversion to SRC of the total area of energy crops (<u>25.000 ha</u>)
<table>
<tr><th>%</th><th>Belgium</th></tr>
<tr><td>1%</td><td>≅ 250</td></tr>
</table>
</td></tr>
</table>

[5] The crop group 'animal fodder' collects a whole range of crops, from fodder beets and fodder turnips, to fodder grasses such as lucerne, clover and mixtures of grasses and leguminous plants.

<table>
<tr>
<td>The study Van Kerckvoorde & Van Reeth, 2014 estimates a total of 3500 ha of silo maize for energy production in 2011, in Flanders alone. The same study mentions an estimated total of 21.500 ha for the energy crops wheat, sugar beets and rape-seed in Belgium in 2010. This would add up to a rough total of <u>25.000 ha.</u></td>
<td>
<table>
<tr><td>5%</td><td>≅ 1.250</td></tr>
<tr><td>10%</td><td>≅ 2.500</td></tr>
<tr><td>20%</td><td>≅ 5.000</td></tr>
<tr><td>50%</td><td>≅ 12.500</td></tr>
<tr><td>75%</td><td>≅ 18.750</td></tr>
</table>
</td>
</tr>
<tr>
<td>Ecological focus areas (‘ecologisch aandachtsgebied’ - EAG): farmers who declare 15 ha or more arable land, are required to have 5% of EAG.
<table>
<tr><th></th><th>Flanders (ha)</th><th>Wallonia (ha)</th><th>Total Belgium (ha)</th></tr>
<tr><td>Total area of arable land (minus infrastructure)</td><td>672.482</td><td>805.289</td><td>1.477.771</td></tr>
<tr><td>Obliged EAG (5% of total arable land)</td><td>17.582[6]</td><td>24.270[7]</td><td>41.852</td></tr>
</table>
</td>
<td>Theoretical assumptions based on % of conversion to SRC of the total area EAG in Belgium (41.852 ha):
<table>
<tr><th>%</th><th>Belgium</th></tr>
<tr><td>0.5%</td><td>≅ 210</td></tr>
<tr><td>1%</td><td>≅ 420</td></tr>
<tr><td>5%</td><td>≅ 2.100</td></tr>
<tr><td>10%</td><td>≅ 4.200</td></tr>
</table>
</td>
</tr>
</table>

When it comes to these potential conversions of low-yield crops and ecological focus areas, estimations were made based on assumptions, to get a rough idea of the size range. The total area of low-yield crops in Belgium is relatively high, especially using the second methodology. As these low-yield crops can have different purposes (food, fodder or energy purposes) only a percentage of the total area eligible for energy purposes is taken into account. Accurate data on the areas in Belgium where crops are cultivated for energy purposes are not available, therefore different methods are mentioned in the table, based on different available figures. The percentage of the first-generation biofuel crops that would be replaced could arguably range up to 100 in the future as there is a clear policy goal of phasing these out. We propose a more conservative 50% which would yield between 4.250 and 12.500 hectares in the longer run. For feed crops there are no clear targets on the reduction of animals (except for pigs in the PAS) and moreover, no clear numbers on the amount of domestically sourced feed. Therefore no estimation was done for land being freed up by shifting diets.

The total area available in Belgium as ecological focus area could theoretically amount up to around 41.852 hectares. However, this would certainly not be the most environmentally sustainable implementation. Assuming a more appropriate (but still optimistic) 10% of this area would be used for SRC, this would add another 4.200 hectares. A more conservative estimation of 5% would yield about 2.100 hectares. This area would yield about 252.000 tons of dry matter per year, not taking into account potential lower yields from marginal lands.

[6] Provided by Departement Landbouw & Visserij for the year 2021

[7] For the year 2019 (Wallonie agriculture SPW, 2021)

To summarise:
Agricultural areas are only scarcely available for direct use for SRC. Even though there are 4.000 hectares of fallow land in Belgium, it is currently difficult to estimate if these are kept under fallow long enough to make SRC a viable option. There could be a potential for SRC when replacing a percentage of first-generation biofuel crops or feed crops. If the phasing out of these fuels would lead to a reallocation of 75% of the land towards second generation, this would yield between 4.250 and 12.500 hectares in the longer run. The mandatory ecological focus areas also provide opportunities. This could theoretically range between 400 - 4.000 hectares of agricultural land. Industrial sites that have not been developed yet are also promising for immediate implementation of SRC with about 5.000 hectares theoretically available, not taking practical constraints into consideration. Buffers around industrial sites would yield only a minor increase in area. Other promising land uses are impossible to estimate with the current available data.

1.5 Summary and recommendations on current SRC systems in Belgium

The knowhow on SRC and the necessary machinery is already present in Belgium. Experience has moreover shown that yields in Belgium can reach 12 t of dry matter per ha per year, without intensive fertilisation on former agricultural land. Nonetheless current amounts of SRC show that there is only little interest in this production method. This could be a reflection of the scarce applications that are currently available for wood from SRC, namely use as solid biomass fuel or composting. With technological advances and increased policy interest in biomass for multiple applications, this could change in the near future. Should there be a higher interest in SRC, 5.000 ha of land could in theory directly be directed towards its cultivation. This could increase to 21.000 ha should land be freed up from phasing out of first-generation biofuels and shifting to more plant-based diets. This area would yield about 252.000 tons of dry matter per year, not taking into account potential lower yields from marginal lands.

It is clear that should policymakers want to increase the production of biomass, short rotation coppice has the potential to rapidly supply this. However, its slow or even absent development in Belgium shows that multiple barriers have to be overcome to unlock its potential in the future green economy.

2 POLICY AND LEGISLATION ON SHORT ROTATION COPPICE

Depending on the rotation length and the destination of the parcel it is planted on, SRC can be an agricultural crop on agricultural land or forestry on forest land and everything in between. Its product has multiple possible applications ranging from highly valuable bio-components to building materials to heat and/or electricity/liquid fuel generation. Because of this range of land use types and applications, it should not come as a surprise that there are multiple policy documents that regulate the planting and use of SRC (products). Moreover, as was made clear in section 1.2, policy has a significant influence on both the supply and demand for woody biomass. In this chapter, the most important European, national and regional policy documents and regional legislation will be reviewed. In Figure 2.1 the major policy initiatives and legislation that impact the planting and management of SRC plantations, as well as the use of its end product- biomass, are visualized according to their policy level and phase of the production chain it regulates. This chapter will first look into the policy initiatives and resulting legislation that situate SRC in our current and future bioeconomy, both as a source of material and of bioenergy. Afterwards we will discuss the prerequisites for the production of biomass rooted in the Land Use, Land Use Change and Forestry (LULUCF) as well as the agricultural policies. The chapter will end with addressing the specific legislation concerning where one is allowed to plant an SRC and under which conditions in Flanders and Wallonia.

<table>
<tr><th>Level</th><th>Land Use (where)</th><th>Production of (SRC) biomass (how)</th><th>Processing of biomass (end product)</th></tr>
<tr><td rowspan="6">EU</td><td>Regulation on LULUCF</td><td></td><td></td></tr>
<tr><td>Forest Strategy</td><td></td><td></td></tr>
<tr><td colspan="2">Common Agricultural Policy</td><td></td></tr>
<tr><td></td><td colspan="2">REPowerEU</td></tr>
<tr><td></td><td></td><td>Fuel Directive</td></tr>
<tr><td colspan="3">Renewable Energy Directive</td></tr>
<tr><td>National</td><td colspan="3">National plan on Energy and Climate</td></tr>
<tr><td rowspan="8">Flemish</td><td>Veldwetboek</td><td></td><td></td></tr>
<tr><td>Natuurdecreet</td><td></td><td></td></tr>
<tr><td>Pachtwet</td><td></td><td></td></tr>
<tr><td colspan="2">Bosdecreet</td><td></td></tr>
<tr><td colspan="2">Gemeenschappelijk Landbouw Beleid</td><td></td></tr>
<tr><td></td><td>Mestdecreet</td><td></td></tr>
<tr><td></td><td colspan="2">Energiedecreet</td></tr>
<tr><td></td><td colspan="2">Materialendecreet</td></tr>
<tr><td rowspan="3">Wallonian</td><td colspan="2">Code du Développement Territorial</td><td></td></tr>
<tr><td colspan="2">Politique Agricole Commune</td><td></td></tr>
<tr><td colspan="3">Arrêté du Gouvernement wallon du 24/02/2022, p. 16437 (Énergie)</td></tr>
</table>

Figure 2.1: Policy initiatives and legislation affecting the planting and management of SRC as well as its end products.

2.1 EFFICIENT USE OF MATERIALS

First of all, it is important to clarify which wood flows qualify for which applications. This is determined by the materials hierarchy and the cascaded use of woody biomass, which are strategies to use this raw material as (carbon) efficiently as possible.

At the European level, *the Renewable Energy Directive* (RED, 2018) is being revised to REDII. This will confirm once more the already adhered cascaded use of woody biomass as follows:

1) Wood products
2) Life extension
3) Reuse
4) Recycling
5) Bioenergy
6) Incineration without energy recuperation
7) Disposal.

In practice, this means that any type of wood, including freshly harvested SRC chips or logs, is preferentially used as a material. Only when this material is no longer (re)usable or transformable into another material, can it be used for energy purposes, including biofuels. For the time being, however, there is no demand from the industry for wood chips from SRC as a material (Dimitriou & Rutz, 2015). Nonetheless, this should be technically feasible for example for particle boards and innovations are making it possible to use the wood for a wide range of bio-components.

At the Flemish level, the legislation and efficient use of materials is translated into the "*Materialendecreet*" (henceforth Material Decree). The Materials Decree is operationalized in "*Actieplan Voedselverlies en Biomassa(rest)stromen Circulair 2021-2025 en het Besluit van de Vlaamse Regering tot vaststelling van het Vlaams reglement betreffende het duurzaam beheer van materiaalkringlopen en afvalstoffen (VLAREMA)*".

The Materials Decree underlines the materials hierarchy (cascading) for woody flows as follows:

1) Prevention of waste and a more efficient and less environmentally damaging use and consumption of materials through adapted production and consumption patterns;
2) Preparation of waste materials for reuse;
3) Recycling of waste materials and the use of materials in closed material cycles;
4) Other forms of recovery of waste materials, such as energy recovery and the use of materials as energy sources
5) the disposal of waste materials, with landfill as the last option.

This is in essence the same as the cascade mentioned in the European policy documents. However, it is possible to deviate from this when this is justified from a life cycle perspective and when it produces the best overall result for the environment and human health. The VLAREMA[8] explicitly states that organic waste from agriculture and forestry, wood waste and cork waste

[8] Besluit van de Vlaamse Regering tot vaststelling van het Vlaams reglement betreffende het duurzaam beheer van materiaalkringlopen en afvalstoffen

are exempt from the incineration ban, even though these materials are recyclable. This is to leave room for renewable energy production (Wille, 2016). Wood from SRC is not considered as waste and thus exempted from this incineration ban. In Wallonia, the same cascading principle is acknowledged by the "*Comité transversal de la Biomasse*" which is a committee that is finalizing the Walloon biomass strategy "*Bois-Energie*". However, also in Wallonia deviations from this cascade are allowed when justified.

2.2 BIOENERGY POLICIES

The European policy on renewable energy is mainly captured in the *Renewable Energy Directive* (RED). The first Directive was published in 2009 (European Parliament & Council of the European Union, 2009a). This was revised in 2018 (European Parliament & Council of the European Union, 2018a) (RED II) and is now in the process of a second revision (RED III). This new revision was proposed by the European Commission in 2021 and is expected to be adopted by the Council and Parliament in 2022 (European Commission DG for Energy, 2021). More recently, in May 2022 the Commission proposed its REPowerEU plan, as a reaction to the energy crises.

In RED III, the European Commission has proposed a new goal for reducing greenhouse gas (GHG) emissions by 55% by 2050 compared to the 1990 baseline. To do this, it relies on increasing the share of renewable energy to 40%[9]. In the REPowerEU plan, 45% renewable energy is proposed. The EU is also counting on woody biomass to meet these renewable energy targets. In this new plan there is also a heavy focus on renewable gas in the form of methane, sourced from sustainable (local) biomass feedstocks (European Commission, 2022).

The transport sector must also reduce emissions, and the 2009 *Fuel Quality Directive* (European Parliament & Council of the European Union, 2009b) stipulated that the GHG intensity of transport fuels had to be reduced by 6% by 2020. To this end, biofuels were considered as a part of the solution. More recently and also specifically for the transport sector, it was set in the 2018 RED II that the minimum share of renewable energy in final consumption must be at least 14% by 2030, RED III proposes a 2.2% share of advanced biofuels and biogas in the transport sector by 2030.

Nevertheless, it has been acknowledged since the 2009 RED that the use of biofuels (and using the same reasoning biomass for energy purposes as a whole) does not always lead to GHG emission reductions and can also have undesirable effects such as the loss of biodiversity. This is mainly the case for biofuels made from food and feed crops. Article 26 of the RED II therefore establishes the phasing out of biofuels from food and feed crops that have a high risk of indirect land use change with a significant expansion of the production area into high carbon stock land. In addition, there are several sustainability criteria coupled to the use of biofuel from agricultural biomass. It may not be produced from raw materials obtained from land with high biodiversity

[9] As a reference, in the RED II these figures were set at 40% emission reduction and 32% renewable energy (European Union, 2018).

doi.org/10.21436/inbor.85964562

value or high carbon stocks, or from protected areas or peatlands. As SRC is formally classified as agriculture, it must also adhere to these rules.

In addition to sustainability criteria at the source level, the entire production chain also needs to adhere to certain GHG emission standards. For example, the GHG emission reduction factor resulting from the use of biofuel must also be increased significantly in the coming years. The GHG emissions reduction factor is the amount of greenhouse gases that is not emitted because of the use of biofuels instead of fossil fuels. This factor can increase either by reducing the emissions of the cultivation practices (e.g. through less land use change or more efficient/reduced fertiliser use) or by reducing emissions from the conversion of feedstock into biofuel (e.g. making the conversion process more efficient). Whereas this reduction factor was still 50% for production plants built before 2015, it will have to be 65% for plants in operation after 2021. This has implications for how energy-intensive the cultivation of biomass is, and how far the transport of the biomass can be.

At the Flemish level, the legislation on renewable energy is translated into the "*Energiedecreet*" (henceforth the Energy Decree), which is operationalized in the "*Energiebesluit*".

The latter states that renewable energy from woody biomass will only receive support in the form of green electricity certificates if it is not an industrial raw material. Thereby the Energy Decree supports the (circular) bio-economy. It also specifies which materials can be used to generate electricity:

a. short-rotation wood;
b. wood flows that are not used as industrial raw material, at least the following:
    1. bark
    2. dust (sanding dust, filter dust, milling dust) with a particle size less than 0,2 mm;
    3. fine pruning no more than 4 cm in diameter
    4. twigs from tree crowns with a diameter of less than 4 cm
    5. stumps up to a maximum of 30 cm above ground level;

In the national energy and climate plan, the support through green electricity certificates for burning of biomass will be halted and the focus will be on supporting heat from biomass (ENOVER *et al.*, 2021).

At the Walloon level, the legislation on renewable energy is translated into the Arrêté du Gouvernement Wallon du 24/02/2022, p. 16437. This decree will come into force in 2023 and includes a wide range of sustainability criteria for biomass from agriculture or forestry that are used for bioenergy. This includes exemption of sourcing biomass from places with high biodiversity, protected nature sites, soils with high carbon stocks and countries without strict forestry regulations, who are not part of the Paris Agreement or who did not commit to limit greenhouse gas emissions at the UN Convention on Climate Change. They also adhere to the GHG emission reduction factors as proposed in the REDII.

2.3 LAND USE, LAND USE CHANGE AND FORESTRY POLICIES

Relevant policy documents on Land Use, Land Use Change and Forestry (LULUCF) include *Regulation 2018 on LULUCF* (European Parliament & Council of the European Union, 2018b), the *Forest Strategy* and the provisions of the Energy Decree already mentioned in the previous paragraph. In Regulation 2018 on LULUCF each EU Member State commits to ensuring that greenhouse gas emissions do not exceed removals, during the periods from 2021 to 2025 and 2026 to 2030, from land use, land use change and forestry. In 2021 the European Commission proposed a revision of this regulation in line with the Fit fir 55 package (European Commission, 2021a). It proposed to set out an overall Union target of net GHG removals in the LULUCF sector of 310 million t of CO_{2e} in the period of 2026 to 2030. Combined with the goal to decrease the overall greenhouse gas emissions, it is calculated that the European forests should take up 90 million t of CO_2 by 2050 (Grassi *et al.*, 2021). In this respect, it is important to increase the net annual increment of the current forests, which can most easily be done by simply harvesting less. Moreover, the *Forest Strategy* aims to improve the quantity and quality of EU forests. The EU also pledges to plant 3 billion new trees by 2030.

2.4 AGRICULTURAL POLICIES

The Common Agricultural Policy (CAP) is one of the biggest European funding schemes. In short it aims to support farmers and ensure a stable supply of affordable food. The CAP was expected to be reformed in 2021 but this was delayed until 2023 because of the launch of the *European Green Deal*. However, in December 2021 an agreement on the reform of the CAP was formally adopted, meaning the budgets have been assigned and divided. Each member state has submitted their proposal for their national CAP strategic plan on 31 December 2021. A transitional regulation extends most of the existing CAP rules until 2023 and has some additional elements for the transition towards the new CAP.

Within the *European Green Deal* there is a renewed interest in connecting forests and nature with agriculture. This is expressed, among other things, in the mentioning of agro-ecological farming practices, payment for ecosystem services, agroforestry and carbon farming in both the *Forest Strategy* and the *Farm to Fork Strategy*. The CAP was aligned with this strategic document and within the budget of the 2023 - 2027 CAP 25% of direct payments, also known as the first pillar, is earmarked for the support of eco-schemes (European Commission, 2021b). Within the current Flemish and Walloon CAP, greening in agriculture is also supported (Departement Landbouw & Visserij, 2021a). It is even mandatory for farmers to apply greening practices if they receive the basic payment (direct payment under the first pillar). These greening practices include the establishment of ecological focus areas. This must be at least 5% of the arable land area if the farmer has more than 15 ha of arable land. Ecological focus areas also include planting of woody elements, agroforestry, SRC and wooded farmland. To qualify for being part of the ecological focus area, the rotation length of the SRC, in line with the legislation of the Flemish Forest Decree (see further), may not exceed 8 years. Additional restrictions are the choice of species. Only the following species are allowed (Departement Landbouw & Visserij, 2021a):

- Black alder (*Alnus glutinosa*)

 doi.org/10.21436/inbor.85964562

- Willow (*Salix caprea*, *Salix alba* or *Salix viminalis*)
- Elm (*Ulmus laevis* or *Ulmus minor*)
- Common hazel (*Corylus avellana*)
- Black poplar (*Populus nigra*)
- Sycamore maple (*Acer pseudoplatanus*)
- European ash (*Fraxinus excelsior*)

Interesting to note is that most poplar species used for SRC or conventional poplar plantations in Belgium are hybrids between *Populus nigra, Populus deltoides, Populus trichocarpa or Populus maximowiczii* (the so-called *hybrid poplars*). All of these will therefore not be allowed in the ecological focus areas. There is also a ban on mineral fertilisation of the SRC plantation. However, it is not yet certain whether these measures will be maintained or extended in the next CAP post 2023. The weight of the SRC in the final determination of the area EAG a farmer has is 0,5. Meaning that only half of the area of SRC is accounted for.

In the current proposal for the CAP post 2023, a yearly support is foreseen for farmers who have SRC (Departement Landbouw & Visserij, 2021b). The amount would be €600 per ha, which is based on a percentage of the production costs. The farmer needs to commit five years to the cultivation. Apart from that there are some other prerequisites as well:

- No use of fertiliser
- The land was allocated as farmland or perennial crop in the previous two years
- The plantation must make use of certain species (to be announced)
- The plantation and cultivation must adhere to a ruleset (to be announced)

There Is also a support of 482 euro/ha for using a minimal of 40 ton/ha per 5 years of woodchips coming from the own farm. The chips are expected to come from woodsides and hedges. It is unclear if SRC would also be a viable source.

In Wallonia SRC can also be used for the ecological focus areas (surface d'intérêt écologique) with a larger list of accepted species (Ministère de l'Agriculture et de l'Alimentation, 2021):

Aulne glutineux (*Alnus glutinosa*)
Bouleau verruqueux (*Betula pendula*)
Charme (*Carpinus betulus*)
Erable champêtre (*Acer campestre*)
Erable plane (*Acer platanoïdes*)
Erable sycomore (*Acer pseudoplatanus*)
Merisier (*Prunus avium*)
Noisetier (*Corylus avellana*)
Peupliers (*Populus spp*)
Saules (*Salix spp*)
Sorbiers (*Sorbus spp*)
Tilleul à grandes feuilles (*Tilia platyphyllos*)
Tilleul à petites feuilles (*Tilia cordata*)
Chêne rouge (*Quercus rubra*)

In the new Walloon CAP (2023 – 2027) a specific ruleset on phytosanitary products and fertilization is also proposed, in line with the Flemish: "*Surfaces with the species detailed in the Walloon list of species, on which it is forbidden the use of mineral fertilisers and the spreading of* *phytosanitary products, with the exception of herbicides in the first year of planting, except in the 6 m along watercourses*." (Wallonie agriculture SPW, 2021).

2.5 FLEMISH LEGISLATION CONCERNING SRC

In the European regulations, short rotation coppice is an agricultural perennial crop. In Flanders an Wallonia, however, this is not so unequivocal and it can fall under the jurisdiction of different decrees, depending on the situation. A schematic overview of the regulations concerning the planting and managing of SRC in Flanders is included in the appendix (in Dutch). In the following section, decrees are printed in italic while permits are underlined.

The "*Bosdecreet*" (henceforth Forest Decree) and the "*Decreet betreffende het natuurbehoud en het natuurlijk milieu*" (henceforth Nature Decree) are the two most important decrees that can impose legal restrictions on the use of a plot of land for planting and managing an SRC plantation. Their application depends partly on the zonation[10] of the land, which can be consulted on Geopunt. However, it is always advisable to check this zonation with the spatial planning department of the municipality as well.

According to article 3 §1, the provisions of the Forest Decree cover:

- *Forests, which are land areas where trees and woody shrubbery predominate, which have their own fauna and flora and which serve one or more functions.*

Depending on the interpretation, SRC could fall under this definition. However, article 4 provision 14bis1 includes a definition of SRC as follows:

- *Cultivation of fast-growing woody plants where the above-ground biomass is harvested periodically up to 8 years after planting or after the previous harvest.*

Article 3, §2.4 stipulates that plantations that conform to this definition are **not** subject to the Forest Decree if they were planted on land with a zoning destination that is not "Ruimtelijk Kwetsbare Gebieden", which translates to Spatially Sensitive Areas (SSA). Moreover, article 3, §3.8 stipulates that an SRC cultivation of which the above-ground biomass is harvested periodically, maximum three years after planting or last harvest[11], is never considered as a forest, regardless of the zoning destination. This type of SRC is also called very short rotation coppice (vSRC).

In case the SRC is however planted on SSA and the rotation length is longer than three years, it is legally considered a forest which means you need a municipal afforestation permit (gemeentelijke bebossingsvergunning). One also needs to have a Forest Management Plan and the final harvest would be seen as deforestation, meaning that one needs a permit for deforestation (omgevingsvergunning voor ontbossing) and to provide forest compensation measures. Moreover, it is prohibited to use fertilisers or phytosanitary products (Forest Decree

[10] Ruimtelijke bestemming

[11] Three years should be interpreted as three growing seasons and is therefore not bounded by calendar dates (personal communication with ANB)

article 21). Should the rotation length of the SRC be more than 8 years, it becomes a regular coppice forest which is legally a forest, regardless of the zoning destination it is planted in.

But what are these Spatially Sensitive Areas? The "*Vlaamse Codex Ruimtelijke Ordening*" (Flemish Codex on Spatial Planning) states in Article 1.1.2, 10°, that the SSA's are the following areas, designated on development plans[12]:

1) agricultural areas with ecological importance
2) agricultural areas with ecological value
3) forest areas
4) spring areas
5) green areas
6) natural areas
7) nature reserves with scientific value
8) nature development areas
9) nature reserves
10) flood plains
11) park areas
12) valley areas

As well as areas designated on spatial implementation plans and sorted under one of the following categories or subcategories of area designation:

13) forest
14) park area
15) reserve and nature
16) the Flemish Ecological Network (VEN), consisting of the area categories Large Nature Units and Large Nature Units under development, mentioned in the Decree of 21 October 1997 on nature conservation and the natural environment
17) the protected dune areas and the agricultural areas important for the dune area, designated pursuant to Article 52, § 1, of the Law of 12 July 1973 on nature conservation

Some of these vulnerable areas are also subject to the "*Mestdecreet*" (Manure Decree) and if an SRC is planted in these areas, it may not be fertilised except by direct excretion through grazing. This concerns agricultural land situated in areas designated on regional spatial implementation plans (gewestelijke ruimtelijke uitvoeringsplannen) under the category of

1) forest
2) reserve and nature

as well as land as indicated on plans adopted by the "*Decreet betreffende de ruimtelijke ordening*" (Decree on spatial planning)

1) non-intensive grassland in forest areas
2) agricultural land in nature reserves

[12] These are the "*ruimtelijke uitvoeringplannen van gewest, provincie of gemeente*" as well as "*bijzondere plannen van aanleg*"

3) agricultural land in nature development areas
4) agricultural land in nature reserves

The *Nature Decree* applies for nature, regardless of the zoning destination and it regulates the protection of nature and natural elements, as we can read in article 9 §1 second paragraph:

The measures referred to in the first paragraph aim at the conservation of nature and may include the protection of existing nature and natural elements, such as habitats, hollow way, wood sides, pools, wetlands, heaths and historical permanent grassland, regardless of where nature and natural elements are located.

In Article 2, 7° we find the definition of nature as follows:

living organisms, their habitats, the ecosystems of which they are a part and the ecological processes linked to them, whether or not they occur as a result of human activity, with the exclusion of cultivated plants, farm animals and domestic animals.

Because SRC is a cultivation it is exempted from the regulations of the Nature Decree if planted in an agricultural zoning destination and if it substitutes another cultivation (Internal ANB guidelines 2006/01). Should you, however, want to plant an SRC, the Nature Decree can still pose restrictions in case you convert previously non-cultivated areas into SRC, even if the destination of this land is also agricultural. This requires a <u>permit for the altering of vegetation</u> (omgevingsvergunning voor het wijziging van de vegetatie) in case of the following destinations:

~~1) Green areas~~
~~2) Park areas~~
3) Buffer areas
~~4) Forest areas~~
~~5) Nature development areas~~
~~6) Valley areas~~
~~7) Spring areas~~
~~8) Agricultural areas of ecological importance or value~~
9) Agricultural areas with special value
10) All areas with a similar use to all the previous listed areas

And also in the following destinations, the land use conversion could mean that small landscape elements or their vegetation are altered or destroyed, which requires the <u>permit for altering small landscape elements</u> (omgevingsvergunnin voor het wijziging van kleine landschapselementen):

1) Agricultural areas with landscape value
2) Agricultural areas
3) All areas with a similar use to all the previous listed areas

Crossed out destinations are SSA and would therefore already require a permit under the regulations of the Forest Decree. The *Uitvoeringsbesluit bij het Natuurdecreet* stipulates in article 9, 3° that a permit under the Nature Decree is not necessary when one has already been granted under the Forest Decree. This means that in these crossed out destinations there is no need for extra permits under the Nature Decree, unless the SRC has a rotation less than 3 years, which would exempt it from the Forest decree regulations.

Another hurdle for managing SRC specifically on leased agricultural land is the "*Pachtwet*" (Leasing Law). This law limits the possibilities of planting and managing woody elements on leased lands and on lands that have been taken out of lease recently. Article 28 states:

- *The tenant may not carry out any new planting of trees unless with the written consent of the lessor. Nevertheless, planting necessary for the preservation of the property and, except in the case of valid termination, planting to replace dead or felled trees and those of low trunked fruit trees is allowed without the consent of the lessor.*

Moreover, even with the consent of the lessor, compensations can be demanded at the end of the coppice rotations because of changes in value of the agricultural land:

- *Where a planting authorised in writing by the lessor or carried out regularly in accordance with the foregoing provisions has resulted in an increase in the value of the leased property and the lease terminates on the initiative of the lessor before the planting reaches the age of eighteen years, the lessee shall be entitled to a payment equal to that increase in value; if the lease ends on the initiative of the lessee, that compensation shall not exceed the total rental paid by the lessee during the last five years for the total of the goods leased by him from the same owner.*
- *Where such planting has led to a reduction in the value of the leased property, the lessor shall be entitled to receive from the lessee compensation equal to that reduction in the value.*

The possibility of this clause to be relevant is real since the SRC cultivation practices often result in higher soil quality because of better porosity, higher amount of soil carbon, higher soil biodiversity and less erosion (see section 4.1.1 Soil).

Article 10 of the leasing law also stipulates that a lessor may withdraw the lease of the land, after the expiry of the lease period, provided that he exploits the land himself for the following 9 years. However, this may not be with deciduous trees, conifers or shrubs. Therefore, if an SRC is considered as forestry rather than agriculture, this may pose a problem.

The "*Veldwetboek*" (Field Code) also contains provisions related to the planting of woody vegetation. For example, Article 35 states for neighbouring parcels:

"*High-stemmed trees may only be planted at a distance determined by established and recognised custom; in the absence of such custom, high-stemmed trees may only be planted at two metres, other trees and living hedges only at half a metre from the dividing line between two yards*"

In article 35bis §5 we read a specification of these rules for agricultural zones:

"*In the parts of the territory reserved for agriculture, the planting of trees is forbidden at a distance of less than six metres from the dividing line between two properties; in addition, a permit from the Municipal Executive is required*."

And it is clarified that the same provisions apply on the area designated for forestry, along the area designated for agriculture. In Flanders, however, there is an additional provision that says:

"*The provisions of the first paragraph (Article 35a) do not apply to land use systems where the cultivation of trees is combined with agriculture on the same land, applied to a plot of agricultural land*"

This implies that for agroforestry[13], no distance rules apply. It is unclear, however, if SRC also falls under this exemption as it is no combination of agriculture but a crop itself.

If the planting of SRC is in SSA then it is officially a forest falling under the Forest Decree and must therefore have the afforestation permit and respect the distance rules. This is not the case for vSRC. If the (v)SRC falls outside the SSA, however, it is considered agricultural and no afforestation permit needs to be applied for, nor do the distance rules need to be respected (probably).

Independent of the Forest or Nature Decree or the Field Code, an SRC can still be subject to additional rules when the landscape is classified as immovable heritage. The *Heritage Decree* states in article 4.1.10 that when there is a felling of immovable property, included in the established inventory of woody plantations with heritage value, this must first be approved by the Heritage Agency. The very intensive and automated SRC has not become established in the Flemish landscape and the chance that a new plantation will therefore be located in a protected landscape and have heritage value is small. Nevertheless, it is always best to check whether the plot to be planted is not protected under this decree.

2.6 WALLOON LEGISLATION CONCERNING SRC

In Wallonia, two definitions of SRC can be found in legislative documents. The first in the Code du Développement territorial (CoDT) which talks about an Intensive cultivation of forest species in Art. R.II-36-4. These are permitted in the zones destined for agriculture on the following conditions:

1° it aims at the production of biomass or energy wood, and consists in covering with trees for a period of less than 12 years, by planting or by letting the vegetation develop for a period of less than 12 years, by planting or by allowing vegetation to develop, a property or part of a property not previously covered by trees;

2° the project is located on land adjacent to an existing woodland, grove or forest, or to a forest area included in the sector plan, unless the area to be afforested is greater than three hectares in one piece;

3° the project is not located within the perimeter of an outstanding viewpoint referred to in article D.II.21,§ 2, 1°, or of landscape interest referred to in Article D.II.21, § 2, 3°;

4° the project does not involve any modification of the ground relief or drainage

5° when the intensive cultivation of forest species is stopped, the site is returned to its agricultural use.

---

[13] Defined in the Forest Decree as "land use systems in which trees are grown in combination with agriculture on the same land, applied to an agricultural parcel"

doi.org/10.21436/inbor.85964562

In Art. D.II.37 the CoDT specifies in §6 that in exceptional cases a deforestation can take place in favour for agricultural purposes (thus including SRC), "*provided that it is contiguous with the agricultural zone. Such deforestation may not result in the removal of isolated woods and groves in an agricultural plain*." This does require a permit for deforestation.

The same CoDT states that an urbanism permit (Permis d'Urbanisme) is needed for cutting or planting forests or hedgerows. Only agroforestry systems are exempted from this. Agroforestry is defined as "*agricultural exploitation method that combines woody plantations with crops or grazing land*". It is thus uncertain how a linear SRC would interpreted, as a hedgerow and thus needing a permit or as an intensive cultivation of forest species and thus not requiring a permit.

The second definition can be found in the "*Arrêté du Gouvernement wallon modifiant l'arrêté du Gouvernement wallon du 12 février 2015 exécutant le régime des paiements directs en faveur des agriculteurs et l'arrêté du Gouvernement wallon du 27 août 2015 fixant les règles relatives à la conditionnalité en matière agricole, abrogeant l'arrêté du Gouvernement wallon du 13 juin 2014 fixant les exigences et les normes de conditionnalité en matière agricole et modifiant l'arrêté du Gouvernement wallon du 12 février 2015 exécutant le régime des paiements directs en faveur des agriculteurs*". SRC is described as "*an area planted with stump-removing forest species with a maximum harvest cycle of eight years*"[14]. This decree specifies that SRC can indeed be regarded as a perennial crop which can benefit from the CAP direct payments.

Interesting enough SRC is not regarded in the Walloon Forest decree (Décret relatif au Code forestier) or the Agricultural Decree (Décret relatif au Code Wallon de l'Agriculture). There are also no additional rules in the Leasing Law regarding planting tree species on leased land or land recently taken out of lease, which do apply for Flanders. Nonetheless, the provision stating the need for a compensation to be paid when the quality of the land increased or decreased because of the cultivation, do apply and cause uncertainty.

2.7 SUMMARY AND RECOMMENDATIONS ON POLICY AND LEGISLATION REGARDING SRC

Biomass from SRC could play a role in simultaneously achieving the bioenergy and LULUCF goals. SRC can rapidly supply biomass with potentially less of the sustainability concerns than agricultural energy crops and without having to harvest more from forests in Europe or elsewhere. Nonetheless, as technology evolves, it should be carefully monitored that its use is not restricted to generating energy as it will probably also have some applications as material or bio-component. This could in the future (this is not applicable yet) be done by retracting the exemption from the incineration ban.

The CAP supports the use of SRC and identifies it as suitable for ecological focus areas. This could be an important incentive for farmers to adopt SRC. Indeed, introducing well-managed SRCs can enrich biodiversity in an agriculture-dominated landscape (see section 4.1). Nonetheless, some restrictions on the management of SRC by the CAP, will significantly hamper its uptake and

[14] taillis à courte rotation »: une surface plantée d'essences forestières rejetant de souche, pour lesquelles le cycle de récolte est au maximum de huit ans;

therefore forfeits an ecological potential. The most significant restriction is the cultivar choice. There are no cultivars of native species available, such as *Populus nigra* and *Populus x tremula*, that can be used for SRC with satisfying yields compared to hybrid cultivars (personal expertise). This implies that having this restriction will result in greatly reduced yields. Moreover, there is, to our best knowledge, no scientific evidence for the belief that SRC plantations with hybrid poplars or introduced species, have a smaller positive effect on the native fauna than native poplar species (Koskela *et al.*, 2004). Nonetheless, to acknowledge the importance of promoting the use of native species, a larger EAG conversion factor could be used for SRC with native species. The revision of the CAP post 2023 in Flanders and Wallonia creates an opportunity to re-evaluate these criteria in order to reconcile environmental and economic feasibility. This also includes the stimulation of using own wood chips from SRC on the farm.

Concerning legislation in Flanders, much ambiguity exists. The complexity of the different regulations should be disentangled and the texts updated with current scientific insights. In the current version, the sites where SRC can contribute most to supporting biodiversity and protecting the environment (in high nature value agricultural landscapes as buffers and temporary habitat for species or close to forests as connecting elements in the landscape) are the least probable to be converted to SRC because of the strict regulations of the Forest decree. Should these sites still be converted, probably the most intensive form of SRC (namely vSRC) would be used while these areas would benefit most from longer rotations. The Leasing Law could potentially hamper the cultivation of SRC both on leased land and land that has recently been taken out of lease. We argue that SRC should be regarded as agriculture rather than forestry, as it is more an agricultural crop than an actual planting of trees. This would absolve the ambiguity of SRC needing to adhere to the distance rules of the Field Code and the planting restrictions of the Leasing Law. To incentivize the most extensive forms of SRC in the most ecologically sensitive areas, it would be best to adjust the Forest Code so that SRC plantations with longer rotations are not regarded as forest and don't need a permit, while SRC plantations with short rotations would need a permit. The same was already proposed by Meiresonne in 2006.

SRC can help in the green transition by supplying biomass with a low environmental impact or even benefits (see chapter 4). It is already supported in many policy documents but outdated and unclear legislation is hampering the actual implementation. Nonetheless, the changes needed to clarify the ambiguity are not extensive and could therefore be 'easily' solved.

3 STAKEHOLDER ANALYSIS OF BIOMASS FROM SHORT ROTATION COPPICE

As indicated in the previous chapters, the interest in woody biomass is on the rise and there will be more demand in the future for its use both as a raw material for goods and products and for renewable energy. The Belgian (policy) landscape is also changing, and depending on various policy choices, different sources of woody biomass will become more or less available. Which choices will be made depends on many factors, but especially on the actions and positions of many actors. It is therefore important to gain insight into the interactions between stakeholders.

3.1 IDENTIFICATION OF STAKEHOLDERS

For the identification of the stakeholders involved in woody biomass, a preliminary list was first drawn up that emerged from literature and through knowledge on the SRC sector. Representatives of these stakeholders were then invited for an interview in which their vision on, and their relation with woody biomass was discussed. At the end of each interview, the interviewee was asked to suggest other stakeholders with whom it would be interesting to have the same interview (snowball sampling). In total nine interviews were conducted and two field visits. The list of organisations interviewed and the interview questions can be found in annex 2.

3.2 TYPES OF STAKEHOLDERS

The interviews yielded a list of stakeholders that can be divided according to how they relate to the woody biomass processing stream (as can be appreciated Figure 3.1) namely:

a) stakeholders involved in the production and processing (central part in Figure 3.1)
b) stakeholders affected by this production and processing (lower part in Figure 3.1)
c) stakeholders influencing the production and processing or context setters (upper part in Figure 3.1).

Both the affected and the influencing stakeholders can be subdivided in two groups: one group who is present in the physical landscape where the biomass is being produced and a second group of stakeholders who is not physically present in the landscape.

A) Stakeholders involved in the production and processing of SRC

The central group of stakeholders are the producers and processors of woody biomass from SRC who make up the SRC production and supply chain. The production cycle starts with the owners or leasers of the land from which the woody biomass originates. For SRC, it is often farmers or biomass companies who are the owners. When the wood is derived from linear elements such as hedgerows or lanes, the owners can be farmers, cities and municipalities. The SRC plantation is often exploited by a specialised company, an agricultural service provider[15]. This company will do the harvesting and may or may not execute the transport to the processing company or hire a transport company themselves. The processing of SRC wood currently mainly encompasses the use as solid fuel or for composting. However, with evolving and emerging technologies, the wood could also be used as material and other, yet to be determined uses/sectors. This will put them in competition with the bioenergy and composting industry. The finished wood products, compost and also the energy generated from woody biomass enter the market through traders.

The entire production chain naturally influences each other through the market rules of supply and demand. This is partly determined by the consumer and influenced by the international market and policy choices, as mentioned in section 1.2. The international market in itself is also influenced by policy on a European and national level as there is a demand for carbon-neutral technology. At the same time new technologies also emerge, creating new opportunities for the international market which will translate in different supplies (increased supply because of new selection and breeding technology) and demands (new technology making wood from SRC a viable feedstock for various applications).

B) Stakeholders affected by the production and processing of SRC

The whole production and supply chain has an effect on people that live within the landscape where the chain operates. The choices of the landowner and the service provider determine how the landscape is impacted. The appearance and structure of the landscape affects inhabitants of this landscape, farmers who operate in the landscape, recreationalists as well as hunters. The management operations of the plantation (e.g. harvesting) and the transport influence the perception and quality of the immediate living environment. Heavy transport is for example often a concern of the local inhabitants (Mohr & Raman, 2015).The industries themselves also have a direct impact on the neighbouring communities. Construction and operation of industrial-sized plants and factories are often opposed by local communities (Dandy, 2010). It should also be noted that these industries, as well as the transport and service provider can provide jobs for the local inhabitants. Ultimately, the whole idea behind the production chain is that the goods and services reach society, which is also a form of influence but is not limited to people living within the landscape. Rather, this influences society as a whole.

C) Stakeholders influencing the production and processing

Policy sets the context within which the production chain can operate. As referred to in chapter 2, there are multiple policies that regulate the production and use of SRC. The policy makers that are not present in the landscape (European, national, regional, and sometimes also cities and municipalities) put into place regulations on the use of materials, bioenergy, land use, agriculture and forestry. They set the context within which SRC can be planted, managed, funded and for what its wood can be used.

The policy context is operationalized by context setters within the landscape who set specific rules and check the compliance. The Agency for Nature and Forest (ANB/DNF), the department of agriculture and the local/municipal government are the main executive stakeholders who

[15] The choice was made to use the term agricultural rather than forestry service provider as SRC is more often exploited with agricultural machinery than with forestry machinery in Belgium.

 doi.org/10.21436/inbor.85964562

check compliance with regulation for SRC. ANB grants permits of the Forest Decree, Nature Decree, the department of agriculture and the *Vlaamse Landmaatschappij* (VLM) determine and check compliance with agricultural policy such as ecological focus areas, the Leasing Law and the Manure Decree. The urbanism permits necessary in Wallonia are granted by the SPW Aménagement du territoire et urbanisme. Nonetheless, also other organisations are involved such as the Forest groups (Bosgroepen) and cities and municipalities for certain permits and procedures. The Regional landscapes in Flanders acts as an intermediary between policy, civil society, municipalities, government institutions and the production chain. While this role is taken up by different organisations Wallonia such as ValBiom (Valorisation de la biomasse), AWAF (Association pour l'agroforesterie en Wallonie et à Bruxelles), CTA de Strée (Centre des Technologies Agronomiques de Strée), CDAF (centre de Développement Agroforestier de Chimay), NatAgriWal.

The affected people within the landscape can indirectly influence the production chain. They can do this in three ways. First they can influence policy directly through their voting behaviour. Different parties have different priorities and visions for the landscape and the economy and will therefore potentially put other policy measures in place. Secondly they can get directly involved in the production chain by communicating with and expressing concerns, or in more drastic ways such as opposing permits. Thirdly they can organise themselves in civil society organisations. These organisations have more leverage to directly influence policy and can even take measures into their own hands and perform research, buy land and talk to stakeholders within the production chain.

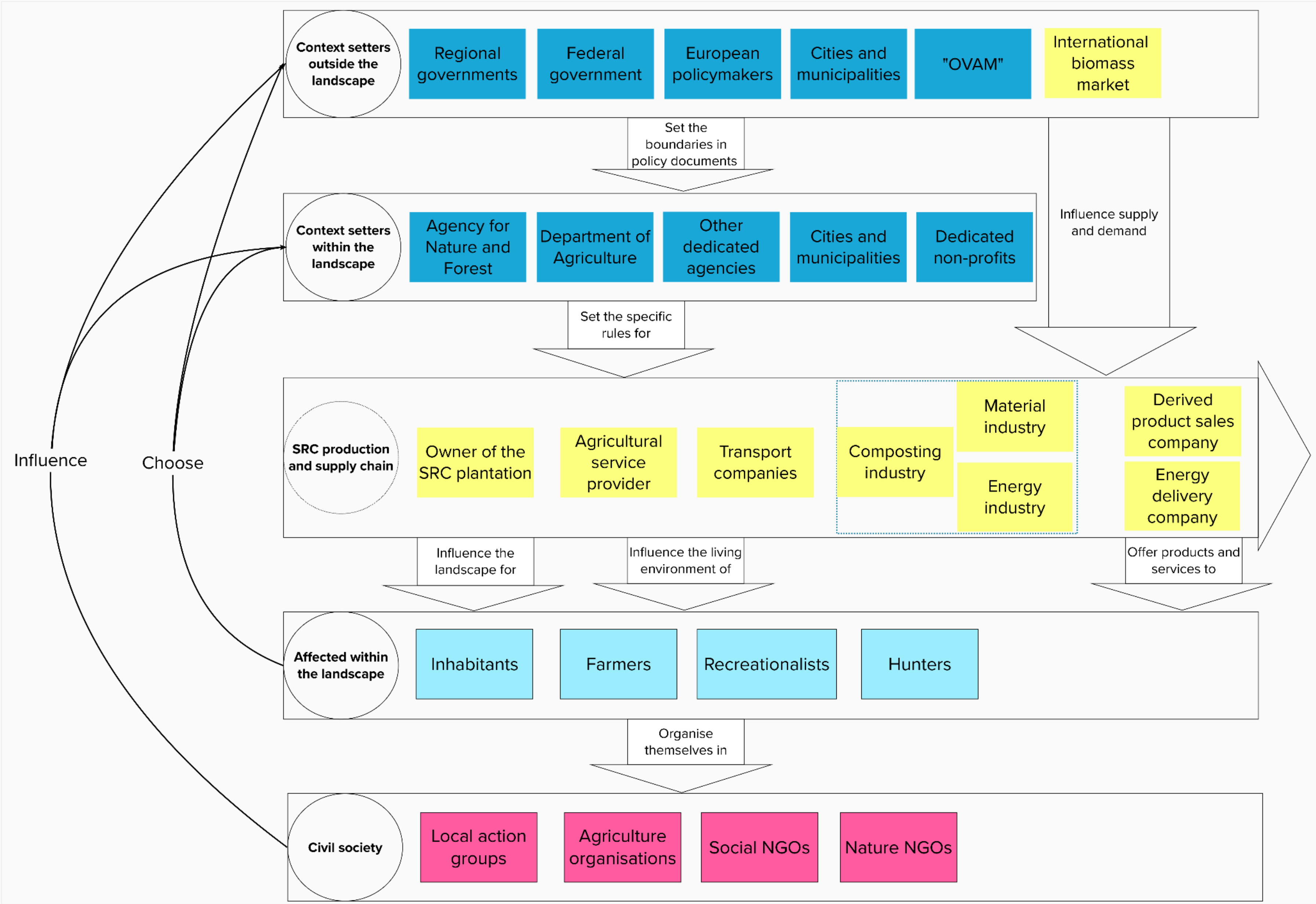

Figure 3.1: Stakeholder analysis of the SRC biomass production chain

doi.org/10.21436/inbor.85964562

4 DIRECT EFFECTS OF SHORT ROTATION COPPICE

Introducing a new land use in an existing landscape impacts the local natural and social system that was already present and often also has indirect effects on natural and social systems outside the local landscape through telecoupling effects. For SRC this is no different. On a local scale it will impact the amount of biodiversity that is already present and which could potentially be present in the future. It also affects the local biotic and abiotic determinants and thereby the functioning of the ecosystem.

People benefit from certain services of nature to society through the functioning of the ecosystem. Altering the ecosystem will possibly alter the functions and therefore possibly also the services to society. The difference in supply and possibly also in demand of these services will impact the local society and the local economy. Through displacement effects or other interactions, the change in local land use can also have effects on the functioning of ecosystems and the society and economy around it, elsewhere. This is mainly the case when the new land use is introduced on a large scale. For SRC this is an unlikely scenario and the focus of this report is on the direct effects that will mainly have a localised (regional, national) impact. Nonetheless we will briefly explore possible effects of the large-scale use of SRC in Belgium in chapter 5. In this section we will first analyse the delivery of ecosystem services and the possibility of SRC to support biodiversity. Secondly we will analyse the impact on the local economy, to end with the impact on the local social system. Nonetheless, it should be noted that these three are inextricably linked and many of the impacts will be highlighted in different ways throughout this chapter.

It is important to note that we are scoping the existence of possible impacts without discussing the probability or order of magnitude of the impact as this will mostly depend on the scale and form of implementation.

4.1 ECOSYSTEM SERVICES AND BIODIVERSITY OF SRC

On virtually every level, SRC has a smaller ecological impact than agriculture, but a larger impact than a forest. This means that when arable land is converted to an SRC plantation, or SRC is integrated into the arable land, this is associated with ecological gain, whereas when a forest has to make way for SRC this is associated with ecological loss. This is because SRC is a less intensive system than conventional agriculture. There is less or no fertilisation, less or no pesticides are used, there is less (soil) disturbance and a longer soil cover, it can therefore be regarded as more environmentally sustainable than conventional agriculture. Integration of SRC into arable land will have a part of the ecological benefits while simultaneously avoiding substantial losses in agricultural output. This can prove to be the most environmentally sustainable production method under certain circumstances. The environmental impact is often viewed from an anthropocentric angle and expressed in terms of changes in the delivery of ecosystem services (ES). Table 4.1 gives an overview of the relevant possible contributions of SRC systems to the delivery of ecosystem (dis)services with corresponding colour code for contributions to services (green) and disservices (red). There are also services that can be experienced as positive or negative, depending on the context or the stakeholder. These are indicated in orange. It should be noted that the colours do not reflect actual gains or losses in ES as this will depend on the land use the SRC will substitute. Cultural ES are discussed in section 4.3.

Table 4.1 Ecosystem services, disservices and mixed services to which SRC potentially contributes

Legend
Possible contributions of SRC to the ecosystem disservice
Possible contribution of SRC to the ecosystem (dis)service, depending on context or stakeholder
Possible contributions of SRC to the ecosystem service

Category	Service or disservice provided by SRC	Source
Soil quality	Erosion control	(De Somviele *et al.*, 2009)
	Support good soil structure	(De Somviele *et al.*, 2009; Schrama *et al.*, 2016)
	Manage nutrient leaching	(Don *et al.*, 2012; Whitaker *et al.*, 2018)
	Support high soil organic content	(Berhongaray *et al.*, 2019; Don *et al.*, 2012; Schrama *et al.*, 2016)
	Support soil biodiversity	(Schrama *et al.*, 2016; Vanbeveren & Ceulemans, 2019; Volk *et al.*, 2004)
	Phytoremediation of polluted soils	(Dimitriou *et al.*, 2011; Fehér *et al.*, 2020; Laureysens *et al.*, 2004; Meiresonne, 2016)
	Soil compaction during harvesting	(Kahle & Janssen, 2020; Souch *et al.*, 2004; Vanbeveren *et al.*, 2015; Virano Riquelme *et al.*, 2021)
	Damage to soils during uprooting	(Kahle *et al.*, 2013; Wachendorf *et al.*, 2017)
Above-ground biodiversity	Support insect diversity	(Dimitriou *et al.*, 2011; Vanbeveren & Ceulemans, 2019; Verheyen *et al.*, 2014)
	Support vertebrate animal diversity	(Dochy, 2011; Giordano & Meriggi, 2009; Vanbeveren &

 doi.org/10.21436/inbor.85964562

		Ceulemans, 2019; Zitzmann *et al.*, 2021)
	Support plant diversity	(Baum *et al.*, 2012; Dochy, 2011; Fehér *et al.*, 2020; Vanbeveren & Ceulemans, 2019; Verheyen *et al.*, 2014)
	Conservation of native genetic material	(Fehér *et al.*, 2020)
	Indirect biodiversity loss because of indirect land use change	(Fehér *et al.*, 2020; Njakou Djomo *et al.*, 2015b)
Water cycle	Water purification	(De Somviele *et al.*, 2009)
	Increased water use	(Bloemen *et al.*, 2017; Meiresonne, 2006)
Agriculture	Pasture and animal feed	(Fehér *et al.*, 2020)
	Foster natural pest control	(Verheyen *et al.*, 2014)
	Edible and medicinal plants	(Fehér *et al.*, 2020)
	Wind protection	(Englund *et al.*, 2021)
	Shadow creation	(Dimitriou & Rutz, 2015)
	Shelter for game	(Cornelis, 2015)
	(In)direct competition with food production	(Njakou Djomo *et al.*, 2015b)
	Competition of herb-layer with neighbouring agricultural crops	(Fehér *et al.*, 2020)
	Accommodating pests of agricultural crops	(Fehér *et al.*, 2020)
	Accommodating toxic, invasive or allergenic plants	(Fehér *et al.*, 2020)
Living environment	Heat mitigation	(Sperandio *et al.*, 2021)
	Greenhouse gas sequestration	(Don *et al.*, 2012; Horemans *et al.*, 2019; Li *et al.*, 2018; Njakou Djomo *et al.*, 2015a, 2015b)
	Air purification	(Beltman *et al.*, 2013)
	Emissions of Isoprene	(Beltman *et al.*, 2013)

4.1.1 Soil

SRC supports a soil with a good structure and soil food web. An SRC system has multi-year rotations, little or no fertilisation or phytosanitary products are used, and soil cultivation is only carried out at the start and after the final harvest of the plantation. Therefore planting SRC on a former agricultural field generally has a positive effect on soil quality. Compared to arable farming, an SRC can improve the soil structure (De Somviele *et al.*, 2009; Schrama *et al.*, 2016), increase the organic matter content (Berhongaray *et al.*, 2019; Don *et al.*, 2012; Ferré *et al.*, 2021; Schrama *et al.*, 2016) and increase the soil biodiversity (Schrama *et al.*, 2016; Vanbeveren & Ceulemans, 2019; Volk *et al.*, 2004). Nonetheless, practice has shown that establishment of the plantation can sometimes prove difficult on conventional agricultural land, indicating a lacking soil food web to support the cuttings in the early stages (O. Poncin, personal communication, May 14, 2022). Leaf fall and decomposition enrich the topsoil layer and the deep and fine rooting ensures good nutrient recycling and reduced leaching (Don *et al.*, 2012; Whitaker *et al.*, 2018). Due to the extensive root system, absence of soil tillage, constant soil cover and high interception rate, there is also less erosion (De Somviele *et al.*, 2009). In the study by Schrama et al. (2016) an agricultural crop grown on former SRC soil was found to grow faster and be more resistant to disease than agricultural crops grown on fields that had never been taken out of conventional production.

Willows and poplars are known for their resistance to high levels of metal pollution in the soil and their ability to absorb and fix these metals in their biomass (Dimitriou & Aronsson, 2011; Fehér *et al.*, 2020). Therefore, SRC with willow and poplar is often looked at as a possibility to remediate polluted soils. However, this is only possible for moderately contaminated soils where the contamination is located in the top 50 cm of the soil. This makes them eligible for remediation of agricultural soils historically contaminated with Cadmium (Dimitriou *et al.*, 2011; Meiresonne, 2016). Nonetheless, this should be approached with caution as the time horizon of the clean-up, even in the most optimistic estimates, may be several decades to several hundred years (Ruttens *et al.*, 2011). SRC does have the advantage that it can withstand the contamination, so the contaminated soil can still be put to good use, albeit not with a view to direct reuse as agricultural land. It is also possible to select and breed willow and poplar clones that have a higher uptake of contaminants. In addition, management practices such as removing the leaves and root systems can also speed up the process, but this will often increase the price significantly (Ruttens *et al.*, 2011). Another possibility is to use SRC to remediate sewage sludge or wastewater that can be used as fertiliser (Dimitriou *et al.*, 2011; Dimitriou & Aronsson, 2011; Dimitriou & Rosenqvist, 2011).

However, an SRC system also has some possible drawbacks for soil quality. This is because the SRC plantation harvest is generally mechanised, with heavy agricultural machinery or modified corn harvesters. If this happens when the ground is firmly frozen or dry, this does not pose a problem, but this is often not the case. As a result, soil compaction can occur (Kahle & Janssen, 2020; Souch *et al.*, 2004; Virano Riquelme *et al.*, 2021). This does however, not always seem to be the case (Vanbeveren *et al.*, 2015). In addition, after the last rotation (12 – 20 years), the choice can be made to harvest the root system along with the trees or to mill it into the soil. This is an intervention that greatly disturbs the soil and has a negative effect on soil carbon and erosion susceptibility (Kahle *et al.*, 2013; Wachendorf *et al.*, 2017). Nonetheless, a certain amount of the sequestrated carbon will stay for a longer period in the soil which can positively influence agricultural crop production (Kahle *et al.*, 2013).

4.1.2 Biodiversity

SRC can increase biodiversity in an agricultural landscape. The fauna and flora diversity in an SRC is generally higher than for land under intensive arable farming but generally lower than in forests or natural grasslands (Dauber *et al.*, 2011; Dimitriou *et al.*, 2011; Fehér *et al.*, 2020; Vanbeveren & Ceulemans, 2019; Verheyen *et al.*, 2014; Zitzmann *et al.*, 2021). Because SRC evolves from a bare plain to a young forest during each rotation, it can provide (partially and temporarily) a good habitat for many different species over time and space (Vanbeveren & Ceulemans, 2019). The strategic installation of SRC in an agricultural landscape is thus an effective way to increase plant and animal biodiversity and improve ecosystem functions (Haughton *et al.*, 2016). Introducing SRC in landscapes where there are between 2 and 20% semi-natural habitats has the greatest added value for biodiversity (Verheyen *et al.*, 2014). Nonetheless, care should be taken to not fragment important habitat for agrarian species, requiring open landscapes (Dochy, 2011). It should be noted that in some agricultural landscapes the biodiversity value is already so low that it cannot be resolved using SRC (Pedroli *et al.*, 2013).

For large and medium mammals and birds, an SRC system is not sufficient as a habitat but it can be an important landscape element (Dochy, 2011; Vanbeveren & Ceulemans, 2019; Volk *et al.*, 2004). For these animals, SRC is a habitat comparable to a young reforestation (Zitzmann *et al.*, 2021) and can play a role as an ecological corridor between fractured pieces of nature. Smaller animals do find a habitat in an SRC that meets all their requirements (Vanbeveren & Ceulemans, 2019). In Western Flanders Dochy found in 2011 that mainly common birds could be found in SRC.

The biodiversity of plants (Baum *et al.*, 2012; Dochy, 2011; Fehér *et al.*, 2020; Vanbeveren & Ceulemans, 2019), insects (Dimitriou *et al.*, 2011; Vanbeveren & Ceulemans, 2019; Verheyen *et al.*, 2014) and soil organisms is also higher under SRC than under annual agriculture (Schrama *et al.*, 2016; Vanbeveren & Ceulemans, 2019; Verheyen *et al.*, 2014; Volk *et al.*, 2004). Yet it is often mainly generalists that do well in an SRC, and they contribute little to the conservation of endangered or rare species (Dochy, 2011; Vanbeveren & Ceulemans, 2019). Nonetheless, in some cases they are also shown to be vital for endangered species like some species of ground beetles, where SRC provides a short-term habitat, especially during the planting phase, but also at the edges (Müller-Kroehling *et al.*, 2020; Piotrowska *et al.*, 2020).

The biodiversity value can be increased by management measures, such as creating heterogeneity in time and space, using different varieties and planting flower borders or cover crops (Baum *et al.*, 2012; Vanbeveren & Ceulemans, 2019; Volk *et al.*, 2004; Zitzmann *et al.*, 2021). Through these measures, fauna and flora always have a habitat, independent of the moment in the rotation. Planting or maintaining (thorny) bushes on the sides of the SRC can also provide important nesting and foraging opportunities for birds while small (fishless) ponds can provide habitat for amphibious animals, both of which will protect the plantation from pests (Dochy, 2011).

Nevertheless, the overall effect of SRC introduction can also have a negative impact on biodiversity (Fehér *et al.*, 2020; Njakou Djomo *et al.*, 2015b; Pedroli *et al.*, 2013; Whitaker *et al.*, 2018). For example, an SRC plantation could occupy a field that was being used for food production, thus causing another piece of land, possibly with a high biodiversity value to be taken into production elsewhere for growing food (indirect land use change or ILUC). Also, an increased demand for biomass could cause forests to be replaced by SRC, which would lead to a loss of biodiversity[16]. These aspects are covered more in-depth in chapter 5. Dochy concluded in 2011 that introducing SRC in an open agrarian landscape in Flanders where specialized agrarian meadow and field birds find their habitat, would be detrimental for their populations. Therefore SRC should be restricted to already fragmented landscapes which have little value for these bird species that are under pressure in Belgium.

In conclusion, biodiversity is mainly higher in extensive, small-scale and heterogeneous SRC plantations that are cleverly built into an agricultural landscape to connect the fragmented nature. Care should be taken that it is only planted on marginal land without nature value or that it replaces intensive arable farmland. However, these rules of thumb are not indisputable and it is therefore advisable to evaluate each case individually. It should of course be noted that an increased attention for nature conservation might result in a decreased direct economic gain. This will be discussed more in-depth in section 4.2.

4.1.3 Water

SRC influences the local water quality and quantity. Due to its extensive root network and strong nitrogen and phosphorus absorption, SRC is excellently suited to purify wastewater (De Somviele *et al.*, 2009). It can also serve as a buffer next to a field to catch the runoff and leaching of fertilisers to prevent it ending up in the watercourses (Meiresonne, 2006). This can be especially interesting in the Belgian context where eutrophication of watercourses is a major issue.

However, SRC has a high water consumption. The total water consumption is highly dependent on local factors such as soil type, precipitation, age, species and genotype (Bloemen *et al.*, 2017; Busch, 2009; Dimitriou *et al.*, 2011). In some cases, evapotranspiration is as high as for conventional agricultural crops (Bloemen *et al.*, 2017; Fischer *et al.*, 2018), in some cases it is higher (Dimitriou *et al.*, 2011). Meiresonne (2006) calculated the total water consumption of a poplar SRC to be 600 mm per year at an annual average precipitation of 700 mm, which is higher than for grassland, arable land and deciduous forests. This high water consumption continues even during dry periods, which can disrupt the local water cycle and cause problems for neighbouring crops. On top of this, SRC can cause lower groundwater recharge compared to agricultural land. This is due to its dense network of roots and higher water retention (Lupp *et al.*, 2015). On the other hand, SRC from willow (and to a lesser extent poplar) can be very interesting in wet areas where agriculture is not possible. These species tolerate a high water table and even temporary flooding (Meiresonne, 2006). A wet area can thus also be drained by an SRC and limit flooding or mosquito nuisance. Although there are advantages and

[16] In Belgium this is theoretically impossible because of legislation protecting forests and high biodiversity land.

 doi.org/10.21436/inbor.85964562

disadvantages of SRC water use on a local scale, in wetter areas (>550 mm per year; for comparison, Belgium has around 800 mm per year) there is unlikely to be a significant effect on river basin hydrology (Bloemen *et al.*, 2017; Busch, 2009; Dimitriou *et al.*, 2011).

4.1.4 Agriculture

SRC can support agriculture but can also compete with it. Bordering fields, SRC offers a breeding ground for natural enemies of pests that can affect agriculture (Verheyen *et al.*, 2014). In addition, it is also an effective windbreak which can protect fields or livestock from strong or cold winds. The shade provided by the trees during the later stages of the cycle can be important for cattle in summer. On the other hand, there is of course a loss of crop production due to that same shade. Also, in addition to pest controlling species, the SRC may harbour pest or invasive species that affect nearby agricultural areas or allergenic and toxic species that can harm animals and humans (Fehér *et al.*, 2020).

The herb layer of SRC may contain crops that can serve as food or medicine for humans and animals (Fehér *et al.*, 2020). This can be an unintentional, but welcome side effect or it can be intentionally exploited in the form of agroforestry. This has already been shown to have mutual benefits for SRC in combination with poultry (Vervisch & Verdonckt, 2015). On the other hand, the SRC also offers a potential habitat for game (Cornelis, 2015). This game can cause damage to agricultural crops, but is also an important cultural and economic service for hunting. Damage by wild animals can partially be avoided by planting linear plantations instead of whole parcels as this will create less shelter for the animals (ValBiom, personal communication, September 23, 2022). It is also clear that SRC can often compete directly or indirectly with other agricultural production in terms of land use (Njakou Djomo *et al.*, 2015b), this is especially important in Belgium where space is limited and agricultural land is already under constant pressure. Nonetheless this can also be to a large extent mitigated by integrating SRC in the agricultural parcels as field borders or alleys, on marginal land or on land that was formerly used for phased out crops such as first generation biofuel crops and feed crops.

4.1.5 Environment

SRC offers advantages and disadvantages for a healthy living environment. Like any plant, the trees in SRC plantations absorb fine dust and other pollutants and thus purify the air. Because of its higher roughness and larger leaf area, an SRC will do this to a greater extent than conventional agricultural plants. In addition, they also cool the environment, which is also directly related to the leaf area. On the other hand, willow and poplar have high isoprene emissions (Beltman *et al.*, 2013). This isoprene contributes to the formation of tropospheric ozone. For example, a conversion of 5% of grassland in Europe to poplar plantations for biomass could result in an increase in ozone indicators of health damage and vegetation damage by 25% and 40% respectively.

4.1.6 Carbon cycle

SRC plantations are net carbon sinks (Don *et al.*, 2012; Horemans *et al.*, 2019; Li *et al.*, 2018; Njakou Djomo *et al.*, 2015a, 2015b). As any plant, the trees in an SRC capture carbon dioxide from the air and store it in their tissue. This is also transferred to and stored in the soil. Underground carbon storage is calculated at 0.44 t soil C ha^{-1} $year^{-1}$ (Don *et al.*, 2012). It remains in the soil as long as it is not disturbed, thus contributing to the reduction of greenhouse gases in the atmosphere and to the improvement of soil quality. Due to a reduced use of fertiliser in comparison with conventional agriculture, there is very little N_2O production. Methane production is mainly influenced by the groundwater table, with waterlogged events meaning a production peak of methane. Since the water table can be lower at SRC than in agriculture due to increased water use, the methane production could be expected to be lower in some circumstances (Horemans *et al.*, 2019). However, other studies indicate that there is no real difference (Drewer *et al.*, 2012). Nonetheless, SRC is generally a net absorber of greenhouse gases, in contrast to conventional agricultural land. The aboveground biomass will be harvested and captured carbon eventually be released back into the atmosphere through conversion to energy. Nevertheless, energy from burning wood from SRC instead of fossil fuels is an environmental benefit as it emits 8 to 114% less greenhouse gases than energy from fossil fuels (Njakou Djomo *et al.*, 2015b). In terms of energy, a poplar SRC plantation was calculated to produce 7.9 times more energy than it consumed from cradle to plant gate in Belgium (Dillen *et al.*, 2013).

To summarise:
SRC has a significant potential to increase the diversity within an agriculture-dominated landscape. Moreover the neighbouring agricultural plots can benefit from its natural protection. SRC is capable of restoring degraded agricultural soils. If planted on degraded soils, there will be a net sequestration of GHG within the soil. The biomass can generate energy (much) more greenhouse gas efficiently than fossil fuels. SRC can also be used to remedy waterlogged sites or as phytoremediation for contaminated soils.
Nonetheless, care should be taken when planting SRC. It should not replace forests, which can support more biodiversity and store more carbon both above- and belowground. Highly biodiverse environments or soils with a high carbon content like permanent grasslands should also be avoided. Wide open agrarian zones that serve as habitat for endangered field- and meadow birds are best kept open and therefore free of SRC. In general SRC should not be planted on too large scale as this might affect the local water availability, could contribute to higher ozone concentrations and the benefit of landscape heterogeneity would be lost. The impact of the SRC on neighbouring agricultural plots should be monitored as game damage or pests and diseases could pose problems.
To maximise the environmental benefits of SRC, it should be planted as small and heterogeneous patches, as field borders or as alleys which are well placed within the landscape connecting other natural elements, protecting agriculture and watercourses. It should be planted with care for biodiversity and soil carbon and managed heterogeneously in time and space as to always provide habitat for species. Including cover crops, permanent bushes or trees, ponds and other natural elements will lead to higher biodiversity gains. Reducing inputs such as fertilizers and phytosanitary products will result in higher environmental gains.

4.2 THE ECONOMICS OF SRC

As there is only a very limited number of SRC plantations in Belgium, only a few economic feasibility studies have been performed (El Kasmioui & Ceulemans, 2012, 2013; Meiresonne, 2006). Apart from these studies, we also performed a series of 9 interviews with experts on SRC or woody biomass in general. The interviews focussed on the feasibility and effects of SRC in Flanders, where the economic aspects were also reflected upon. Previous studies and the interviews showed that with the current information, it is hard to generalise the financial feasibility of SRC. Therefore we will, in this section, elaborate on the factors that influence the feasibility, rather than making a fictive calculation.

We will approach the economics of SRC in three different parts. First by looking into the basic production costs of wood from SRC and the price one gets for selling it. Second by looking at the benefits and costs of a private actor. And lastly by looking into the costs and benefits of a public investor. A private actor or investor is expected to mainly try to maximise monetary profits, whereas a public actor or investor also needs to take into account other goods and services or trade-offs that arise from SRC production. Therefore these two investors are analysed separately.

4.2.1 The financial balance of SRC production

The main factors determining the production cost of SRC are:

1. **The price of the (agricultural) land:**
   In Flanders the pressure on agricultural land is high and increasing. Encroachment, speculation and investment in agricultural land further drives up the prices (Departement Landbouw & Visserij, 2021c). A Belgian farmer paid on average €310/ha lease in 2021. In Flanders this was as high as €391/ha with large regional differences, West-Flanders being the most expensive with €471/ha.
2. **The establishment of the plantation:**
   This includes soil preparation, application of pre- and/or post emergent herbicides and planting. This has been calculated to be 16% of the total costs over a time span of 21 years (7 rotations) (El Kasmioui & Ceulemans, 2013). Planting was the biggest single cost, with estimates of the planting material being €1.200/ha for a planting density of 15.000/ha (Meiresonne, 2006) and the planting operations ranging from 450 to €1000/ha (El Kasmioui & Ceulemans, 2013; Meiresonne, 2006). More recently the price for planting was reported by a Belgian company to be minimum €3500/ha (O. Poncin, personal communication, May 14, 2022).
3. **The maintenance of the plantation:**
   This includes weeding, possible fertilisation and emergency phytosanitary measures. For a plantation where only weeding was performed, these costs were only 2% of the total costs (El Kasmioui & Ceulemans, 2013). When sanitary measures need to be taken, this can add up to around €130/ha per year, not including the labour cost (De Somviele *et al.*, 2009).
4. **Harvesting and possibly chipping:**

This is the highest cost of the cultivation, amounting to 45% of the total costs during the lifespan of the plantation (El Kasmioui & Ceulemans, 2013). However, it heavily depends on the type of harvester used, from where the machine has to come and how efficiently it operates. Berhongaray et al. (2013) reported prices ranging from 388 € ha^{-1} to 541 € ha^{-1} when comparing three different harvester and harvesting types in Belgium. A price of €275/ha was reported by a Belgian company (O. Poncin, personal communication, May 14, 2022).

5. **Transport of the biomass:**
   This was calculated to be around €15 per oven-dry tonnes of chips for a distance of 50km (El Kasmioui & Ceulemans, 2013). Which is about 15% of the price one would get for oven-dry chips (De Somviele *et al.*, 2009).
6. **Drying of the chips:**
   As chips are harvested with a moisture content of at least 50%, they need drying before they can be efficiently converted into energy. When harvested as stems, they can be left on the field to dry. When directly chipped the drying requires either a place to stock the chips under an open roof on a concrete floor where convection will dry the heap to less than 30% moisture content (De Somviele *et al.*, 2009) or alternatively forced drying can be applied, which needs energy.
7. **Removal of the stumps:**
   At the end of the final rotation of the coppice plantation, the stumps need to be removed, either to make place for a new plantation or to convert to another land use or crop. This is calculated to be between 550 and €1.700/ha (El Kasmioui & Ceulemans, 2013).

The total production cost for fresh chips sold at the farm gate (so without transport and drying) was calculated to be around €40/ton (El Kasmioui & Ceulemans, 2013).

The cultivation of SRC is, moreover, not without a risk. Because of the perennial nature, it is more likely to have some disturbance within its lifetime. When only a limited amount of genetic diversity is introduced in the plantation, it is more prone to diseases and pests. Both these factors can rapidly and dramatically increase the costs of the plantation and render the investment unprofitable. Moreover, when the choice is made to cultivate the whole area with the same schedule, the revenues of the cultivation are not coming in every year. This can hamper the normal functioning of an agricultural enterprise, especially if the land is leased and needs to be paid yearly or if loans are to be paid at a monthly basis.

In contrast to these high costs and relatively high risks, the price of biomass is low. Fresh chips can go as low as 20 to €30/ton (El Kasmioui & Ceulemans, 2013), whereas high quality oven-dry chips can be sold at around 100 - €120/ton[17]. However this is a very dynamic market and the chips could be valorised more in other sectors.

Another source of income from SRC could come from financial governmental support. However, in Flanders there is no special support for SRC yet. This would change with the new GLB (2023 - 2027) where the support would be €600 per hectare per year (Departement Landbouw &

[17] Price obtained from personal communication with biomass companies before '22 energy crises.

Visserij, 2021b). This would close the gap between the production cost and the price at the farm gate for the fresh chips. Also the support for using own chips for increasing the soil carbon would contribute to the economic feasibility. This would amount up to 482 euro/ha per year if a minimum of 40 tons is applied over the course of 5 years. In Wallonia SRC can benefit from subsidies for planting linear coppices (taillis linéaire) under the Yes We Plant scheme (Yes We Plant, s.d.). This is a planting support and not a yearly support for maintenance. The support is €4 per meter length for a three-row plantation which is no more than 10m broad. There are a number of strict conditions for the form of the coppice:

- The minimum number of species in the coppice is 3 and no single species represents more than 50% of the number of plants;
- The minimum length of the plantation is 100 metres in one or more sections of at least 50 metres;
- The maximum distance between two plants in the row is 2 metres;
- The maximum distance between rows is 3 metres;
- The coppice occupies a maximum of 20% of the plot on which it is planted;
- The subsidy is limited to 2000 metres per year and per beneficiary.

And conditions to be met for the maintenance:

- The beneficiary must install, if necessary, protection against livestock, game or wildlife;
- The beneficiary does not mulch with non-biodegradable material;
- the rotation between 2 cuts of the coppice is greater than 5 years;
- for each linear coppice, at least 20% of the planted coppice is cut back and the part maintained is harvested at the earliest one year after the initial coppicing;
- maintenance is carried out outside the period from 1 April to 31 July.
- There is a ban on the application of mineral fertiliser and plant protection products within one metre of the plantation
- the plantation must be maintained for 30 years
- There are restrictions on the species that can be used, see annex of YES WE PLANT

The subsidy is limited to 2000 metres per year and per beneficiary. A square parcel of 1ha, surrounded by SRC on two sides would therefore have 1.900 m^2 of SRC (0,19 ha) and receive €760 support

Yet another possibility is payment for ecosystem services (PES). This is a system where land owners, making the choice to have more sustainable but less profitable cultivation (practices), are renumerated for the public benefits they generate. This however requires four things (1) the ecosystem service needs to be quantified, (2) the ecosystem service quantity needs to be translated into a monetary amount, (3) the delivery of the ecosystem service needs to be measurable and monitored during a period of time, (4) a payment scheme must be in place. Ecosystem services of SRC that could potentially be used for these schemes include (Fuertes *et al.*, 2021):

- Carbon sequestration in the soil
- Erosion prevention
- Prevention of nitrate leaching

- Flood prevention

In essence all the other ecosystem services, including the cultural services that will be discussed in section 4.3, should be taken into account, but most still lack the framework to quantify and monetize or are simply not monetizable (Fürtner *et al.*, 2022). Unfortunately the saying "we treasure what we measure" also applies to the environmental and social benefits, meaning that the benefits that are not readily translated into monetary values, are often overlooked. Nonetheless, already identifying them is a first important step towards acknowledging them in decision making at all levels.

4.2.2 The benefits and costs for a private investor

When looking at a private investment, mostly the financial gains are the determining factor. Other gains, such as increased biodiversity or delivery of ecosystem services or supporting a carbon-neutral economy might (or should) also be important criteria for private investors but here we will make the abstraction of the private investor to be solely interested in getting the best return on investment from a plot of land. Within this abstraction we can still subdivide the private investor in two categories. The first category is the farmer who can use his/her own farmland, machinery, labour, infrastructure and possibly even woodchips for private use. The farmer will only switch to SRC if this is more profitable than other land uses. The second category is the private enterprise that seeks to valorise its own undeveloped land but who cannot count on its own machinery, infrastructure nor can it use its own woodchips. Moreover, it will have to outsource all of its labour. The opportunity cost of the private enterprise, however, is mainly related to developing the area or leaving it under minimal management.

Benefits and costs for farmers

For a farmer it can be profitable to cultivate SRC, especially when the chips can be used on-farm. (El Kasmioui & Ceulemans, 2013) performed a financial analysis of an SRC plantation by a farmer in Belgium and concluded that the investment would be profitable after 21 years, meaning 7 rotations of 3 years. The profit was nonetheless rather limited with only 16,3 € ha^{-1} $year^{-1}$. Studies from Germany argue that the key lies in proper land allocation (Busch & Thiele, 2015). The study calculated what percentage of arable land would be more profitable with SRC compared to a conventional cultivation (barley – barley – sugar beet rotation). This resulted in 35% of the agricultural land proving more profitable under SRC. Similarly, in the Sachsen region SRC ranged from very competitive to not competitive at all, depending on the local growth factors such as soil quality and water availability (Kröber *et al.*, 2015). El Kasmioui and Ceulemans (2012) concluded that SRC in Europe are not financially viable, unless a number of additional conditions were fulfilled, such as biomass price, yield and government support. When the chips are used on the farm itself, the profitability should be checked by comparing the production costs with the spared expenses from fuel for heating. A demonstration by Phitech on a Walloon farm indicated the possibility to substitute 100L of fossil fuels with a price of €60 with 1.3 cubic metres of fresh chips from SRC which could be produced at a cost of 10 to €20. According to their own calculations, one hectare of SRC could substitute 4000 – 6000L of fossil fuels and become profitable from the second rotation (Phitech, personal communication, October 22,

doi.org/10.21436/inbor.85964562

2021)[18]. Nonetheless, the owners of the biomass installation also acknowledged that this kind of investment is not something every farmer would be able to afford. The investment will have paid itself back within 10 to 15 years.

Benefits and costs for private investors

For a private investor it could be profitable to valorise unused terrain. Because of the lack of own resources and possibly also know-how to manage the plantation, the costs of the SRC plantation will be higher. Nonetheless, the rather extensive, and temporary but perennial nature of SRC could prove to be a profitable and environmentally beneficial way of utilising temporarily undeveloped land. To the authors' knowledge, this kind of investment has not yet been investigated with a real-life case in Belgium. El Kasmioui and Ceulemans (2013) however did a financial analysis for managing an SRC in Belgium from an investor's point of view who does not own any land. The investment was negative with a loss of 485 € ha^{-1} over 21 years. Nonetheless, deducting the 250 € ha^{-1} $year^{-1}$ that was used in the study for the land rent, the investment would be positive for someone already owning the land and only looking to valorise it.

4.2.3 The benefits and costs for a public investor

Where private investors mostly look at financial benefits for an investment using a cost-benefit analysis, public investors are able, and arguably also should, take into account multiple other aspects. Public investors can perform a *social* cost-benefit analysis, which is a more holistic approach, including social and environmental aspects that sometimes are not monetized or even monetizable.

Positive aspects can include:

1. Increased biodiversity in the landscape (see section 4.1).
2. More natural corridors in the landscape sustaining a more resilient and connected nature (see section 4.1).
3. Increased delivery of ecosystem services, including minimization of nutrient leaching and erosion control which leads to better water quality and carbon capture, which are public services (see section 4.1).
4. A more diverse and therefore possibly more attractive landscape (see next section 4.3).
5. Local production of energy supporting the local economy and decreasing the dependency on imported energy. The BENELUX calculated that of €100 spent on the production of energy using local wood, everything remains within the country and €52 within the region. This is in contrast to €100 spent on fossil fuels, of which €58 goes abroad and only €16 stays in the region (van Laarhoven, 2013).

Negative externalities can also arise like:

1. Substitution of food production with energy production. Both are basic necessities of a modern society and an equilibrium must be found between them. When left to the free market, the most profitable from an individual point of view will predominate, possibly

[18] More information can be found on their website: https://phitech.be/fr/energie-durable/chaudiere-biomasse-reseau-de-chaleur [last consulted on 22/02/2022]

leading to indirect land-use change in other places. These possible telecoupling effects will be discussed more in-depth in chapter 5.

2. As SRC has no guaranteed (large) return on investment, public funds could have more impact when invested elsewhere. This should, of course, be carefully analysed as this could be very case specific.

To summarise:
The costs of planting and managing an SRC plantation is high compared to the price of the chips it generates. For a private investor the price of the biomass should (drastically) increase to make the investment worthwhile. The current energy crisis could temporarily lead to sufficiently high woodchip prices but a stable market is needed for the investment to be profitable during its whole lifetime. Farmers who can valorise the chips on site can profitably assign their less valuable land to SRC and save on expenses for fossil fuels or compost. This does, however, require a large investment cost for the heating installation. Public investors can more easily make long-term commitments and can take non-monetary aspects into account when analysing the costs and benefits. This will be in the advantage of SRC as it brings environmental benefits and provides a stable income of biomass for local energy production. Private investors could also be renumerated for these positive environmental and social effects by means of PES schemes.

4.3 THE SOCIAL DIMENSIONS OF SRC

A change in the landscape always has an impact on the people who are part of, or interact with that same landscape. In addition, changes in one location sometimes cause changes in other locations. Whether this change is experienced as positive or negative by the various stakeholders, has partly to do with the change in the delivery of ecosystem services that accompany this change and/or with the economic impact this change might have. How the change is perceived by a stakeholder will also depend on its values, needs and goals. It can be culturally bound or simply personal. It is, however, clear that the social dimensions of SRC will be closely related to changes in ecological and economic factors and this relationship should not be overlooked (Raman *et al.*, 2015).

In this section we will evaluate the social impact of SRC in a systematic way by evaluating how every stakeholder group, as identified in chapter 3, will be affected by the implementation of SRC on a significant scale. Since there is a large gap in literature on these aspects, and not every stakeholder group was consulted, the authors made deductions on possible current and future positions of stakeholders regarding SRC. These deductions are indicated in the text.

4.3.1 The impact of SRC on actors in the biomass production chain

The owners of the SRC plantations will gain income and the service providers together with the transport companies will benefit from more work in the local area, provided the financial balance of the plantation is positive. However, a large enough area should be planted with SRC for a plantation owner to invest in the necessary machinery, or alternatively enough plantations should be present within a certain area to make the transport of its machinery cost-efficient for service providers. Transport of biomass should also be minimised and done efficiently to avoid

 doi.org/10.21436/inbor.85964562

a negative carbon balance. This means that the size, spatial planning, harvesting cycles and number of plantations in an area should ideally be coordinated for optimal transport.

Employment opportunities may rise or decrease, depending on the substituted land use and intensity of the SRC plantation. Small-scale and decentralised implementation of SRC plantations that source a local power or conversion plant can increase local job opportunities (Van der Horst & Vermeylen, 2011). This is, however, only the case if the SRC is implemented on land that formerly did not support local jobs. SRC only requires a limited amount of labour as it is more extensive than conventional agriculture. Substituting cropland for SRC would therefore not necessarily mean an increase in job opportunities as there is less labour required (Fürtner *et al.*, 2022). Large-scale implementation of SRC where all the biomass is exported out of the region will most probably mean a loss in job opportunities (Van der Horst & Vermeylen, 2011).

The composting, material and energy industry will compete for this new resource, depending on the state of technology (Camia *et al.*, 2021). For the moment the wood from SRC would mainly be a useful resource for the composting and energy industry. The introduction of wood from SRC as a new resource could potentially decrease the price of other resources, such as chips from forestry, as supply of woody biomass would increase. This might in the short term relieve some pressure from forest ecosystems. However, with a predicted increase in demand for biomass, this would probably only be short-lived. Moreover, new applications can lead to reallocation of land and resources (Van der Horst & Vermeylen, 2011)**.** Innovative applications can change the relative profitability and therefore also the allocation of the resource and land used to provide it. For example, if bio-naphtha or components made in the process of converting SRC wood to bio-naphtha, have a higher market value, in the short term demand may exceed the supply and other sources of biomass will be looked at to feed this new economy. This could lead to reallocation of woody biomass now used for electricity and heat production or material industries towards this new and more profitable application. It could lead to increased pressure on domestic forest ecosystems or to increased biomass imports with possible displacement effects. Moreover, farmers or other land owners may choose to change their land use towards producing the more profitable resource, leading to decreased supply of the commodity that was produced before, thus increasing its price.

With a new feedstock emerging and possible new applications, prices of some goods and services could go up or down. Increased domestic energy production from biomass could reduce the dependency on fossil fuels imported from elsewhere. Next to the increased energy security this increase in domestic energy generation could decrease the energy prices. Here it should be acknowledged that biomass from SRC would probably be only a fraction of the energy mixture and thus only have a small impact. When new applications using biomass emerge that have a higher value, the reallocation of biomass towards this application could increase the market price of biomass and thereby also the price of products that are now being produced with this biomass. Nonetheless, the higher value end-product would probably lead to increased wealth.

4.3.2 The impact of SRC on actors present in the landscape

Acceptance of the local inhabitants is a key prerequisite for new biomass projects (ARBOR, 2015; Volk *et al.*, 2004)**.** The main impact local inhabitants may experience is changes in the local landscape and the consequent impacts on aesthetic, cultural values and attractiveness for recreation. An extensive analysis on the optimal planning of SRC within the landscape has been done in the United Kingdom (Bell & McIntosh, 2001). They identify possible positive effects of introducing SRC into a landscape as it can be an interesting and dynamic geometrical element in the landscape which can create depth. However, there are also a number of potential risks to the landscape quality. SRC can be experienced as an intrusive element that blocks the view or sunlight in a landscape as its growth rate is much higher than that of a forest and the height exceeds that of agricultural crops. Moreover, when planted in large homogeneous strips, it becomes a very dominant element in the landscape. The constant change in the landscape, going from a bare plain to a young forest in the matter of a few years can also be experienced as a negative impact. Table 4.2 provides specific guidelines for implementing SRC in the landscape, according to landscape type, as constructed by Bell & McIntosh (2001). The table was adapted with images from Belgium. Even though every landscape has opportunities to accommodate SRC without causing negative visual effects, lowland landscapes with high levels of tree and woodland cover in combination with arable or mixed farming, have the most potential. This was also confirmed by Boll et al. (2015). Next to roads, houses, monuments or viewpoints, SRC should be avoided or carefully planned in terms of distance, orientation, variations in cutting cycles and integration of more permanent structures such as shrubs or trees.

For recreation, the landscape impact will probably be the most determining factor. However, no studies have been done to assess the recreational value of SRC. Linear SRC could be seen as a form of agroforestry, which was shown to have positive recreational values (Borremans *et al.*, 2018)

Local farmers can benefit from their own or neighbouring SRC plantations (see Section 4.1), but they can also feel threatened because of a new possibly competing land use or because they can experience negative effects on their own production. Even though the effects of agroforestry are already studied in-depth and disseminated in Flanders such as through the project Agroforestry Vlaanderen and its follow-up project Agroforestry 2025, the same cannot be said for SRC. In essence, farmers often have very little interest in growing woody crops on their fields as was also concluded by Meiresonne in 2006 and little has changed since as can be seen by the evolution of SRC in Belgium in section 1.3. There are several economic reasons for this:

- The current market for SRC is practically non-existent as a result of which it is difficult to find an outlet for the wood produced.[19] (Meiresonne, 2006; Zyadin *et al.*, 2017)
- It is usually less economically profitable compared to agricultural crops. (Fürtner *et al.*, 2022; Meiresonne, 2006)
- It is costly and requires heavy intervention to till or remove the root system of the SRC when the land is put back into agricultural production. (Meiresonne, 2006)
- Farmers fear that there will be more game damage as a result of the additional habitat and shelter provided by the SRC. (Meiresonne, 2006)

[19] Although this reason might be outdated or stem from a lack of knowledge of farmers of how and where to sell woodchips or lacking own heating installations rather than actual missing markets.

But also some barriers that stem from an unfavourable policy/legislative environment:

- There is fear that the fields that are planted with SRC will change destination and be labelled as permanent forest use. As a result, agriculture will never be possible again and the value of the land will decrease. (Fürtner *et al.*, 2022; Meiresonne, 2006)
- When farmers acquire new land, it is often only leased for one year, which makes the use of perennial crops impossible. Apart from this, the Leasing Law also does not provide any security. (Meiresonne, 2006)
- The legislation on SRC is unclear and difficult to untangle (see section 2.5 and 2.6).

Besides the purely financial reasoning, other reasons for hesitant uptake of perennial energy crops by farmers can be identified by acknowledging that they are not just profit-maximisers (Raman et al., 2015). In their study Raman et al. (2015) identified farmers' interest in and agreement with the production of perennial energy crops. However, farmers often regard food production as their moral purpose while energy production is something that should only be done on marginal lands and most farmers did not regard their own land as marginal. In Slovakia, a study was performed to investigate the farmers willingness to adopt short rotation woody crops and a main psychological barrier was that farmers did not identify themselves with this type of production (Ranacher *et al.*, 2021). It could be concluded that agriculture and forestry (including for farmers SRC) are two different cropping systems with their own technologies and expertise and they rarely interact. Farmers are not used to perennial crops and often also not interested in them (Meiresonne, 2006; Warren *et al.*, 2016). This mental disconnection between agriculture and woody biomass production is interesting as formerly this was a normal part of the farming activities. Hedgerows and coppice cultures have historically been part of the Flemish agricultural landscape as a source of timber, firewood, food, land demarcation and protection against drought, wind, floods and erosion (Van Den Berge, 2021). Practices such as basket weaving are also directly connected with SRC, specifically from willow (Fehér *et al.*, 2020). Returning to a farm landscape with woodsides could thus also be perceived as the revival of traditional knowledge and practices. This was shown for agroforestry in Flanders and possibly also applies to SRC (Borremans *et al.*, 2018).

Hunters will have more game available as SRC provides a habitat for small and large game, such as pheasants, wild boars, … Nonetheless, frictions could arise with neighbouring farmers that see their crops damaged by the game. In Wallonia there is a relatively large interest in planting SRC by hunters. ValBiom reported that about half the plantations in Wallonia are not on agricultural land but are used by hunters to provide shelter for game (ValBiom, personal communication, September 23, 2022).

Table 4.2: Landscape types and their sensitivity towards SRC and potential strategies to cope with them. Table according to Bell & McIntosh (2001) adapted with images from Belgium (copyright Vildaphoto)

Landscape type	Characteristics	Landscape sensitivity	Location and design considerations
Enclosed 	Hedges and hedgerow trees create a pattern more dominant than the landform. Significant woodland cover interspersed with fields. Relatively small scale, short to medium distance views. High visual and ecological diversity.	Trees and hedges restrict visibility. Most sensitive locations may be along roads, paths or next to houses. SRC may be well concealed by field boundaries.	- Plant at field scale. - Regular field scale harvesting in rotation will maintain diversity within landscape. - There may be opportunities to enhance gappy hedges and plant additional trees within the hedgerows, during the life of the SRC crop.

doi.org/10.21436/inbor.85964562

Landscape type	Characteristics	Landscape sensitivity	Location and design considerations
Open with flat topography 	Few enclosing features. Landscape scale is large. Visual diversity is low.	Extensive views across open land may mean that SRC has a low visual impact if it occupies middle or background views. Landscape has the capacity to absorb extensive areas of planting.	- Large scale planting is appropriate, with rotational harvesting also in large units, forming an interlocking pattern. - Reduce the scale of harvesting units towards edges to enhance visual interest. - Include and maintain strategically sited open areas along edges to provide a sense of depth. - Link with small scale woodlands and other features in the landscape, where present.
Open with undulating and rolling topography 	Landform is dominant. Few enclosing features. Landscape scale medium to large.	Capacity to absorb medium to large scale planting linked to landform shapes. Views are controlled by height of undulations, may be extensive from vantage points, but otherwise limited.	- Identify the main landscape features in the topography (ridges and low points). Aim to link planting pattern to them, where ownership allows. - Planting on lower lying areas will have lowest impact. - Aim for larger planting and harvesting units towards high points, decrease scale at lower elevations. - Plant bold interlocking shapes, using landform as a guide rather than the field pattern

Landscape type	Characteristics	Landscape sensitivity	Location and design considerations
			- Link into any established woods, where possible
Slopes 	Might contain woodland on lower slopes, associated with watercourses. The field pattern may be significant. Scale is medium to small. High ecological and visual diversity.	Might be highly visible, especially from elevated viewpoints. Highly sensitive to change if overlooked.	- Identify existing features within landscape and link SRC planting to these, e.g. other woodland, watercourses. - Aim for irregular patterns of planting, e.g. staggered rather than obvious geometric blocks.

doi.org/10.21436/inbor.85964562

4.3.3 The position of civil society towards SRC

Local action groups

It is unknown how local action groups would react to SRC. To our knowledge, the largest plantation of SRC has been done by the POPFULL project of the University of Antwerp. Here 14,5 ha were planted, making it the largest plantation in the Benelux in 2007 (R. Ceulemans, personal communication, 2021). There was no public protest against this plantation. Nonetheless, people were worried about the possible use of genetically modified organisms (GMOs) in the plantation. Based on this case the authors argue that no local action groups are expected to oppose SRC when it is implemented with care for the landscape and when it does not substitute highly valuable (social or ecological) terrain or when it does not use contested methods/species such as GMO's (own deduction). Researchers also report a decreasing opposition against GMO field tests and increased interaction between the researchers leading the tests and the opposition groups (W. Boerjan, personal communication, June 16, 2022).

Environmental NGOs

Environmental NGOs have, in the past, opposed large scale biomass production as a source for energy and biofuels (Birdlife International *et al.*, 2020; Brachet *et al.*, 2018; Farkas, 2015; Swart *et al.*, 2021), but acknowledged the possible positive effects of small-scale decentralised biomass use (https://www.natuurpunt.be/pagina/biomassa). Their main concerns arise from a lack of GHG saving potential compared to fossil fuels, (in)direct land use changes causing biodiversity loss (by displacement effects) and, unsustainable harvesting practices, land grabbing, competition with other uses and fine particles emitted during the incineration of biomass causing pollution. Even though these concerns are mainly targeting first generation biofuels and the use of forest biomass for energy production, it can be expected that civil society will at least be sceptical about the use of SRC for bioenergy. This was also confirmed by an interview conducted with an actor from a civil society organisation in Belgium and by the study of Dandy (2010) on short rotation forestry[20]. For SRC to gain the support of civil society, it will need to prove it is not prone to the same detrimental effects as the other biomass sources. This can be key as the stance of civil society can, to a large extent, influence the public opinion. This was also demonstrated during the recent revision of the European Renewable Energy Directive, where 38,000 out of 39,046 demands were made during the stakeholder consultation to exclude biomass as renewable energy and to limit its use to what is locally available as waste (European Commission, 2021c). This was the result of an organised action by several NGOs denouncing unsustainable practices caused by the large-scale use of first and second generation biofuels (Birdlife International et al., 2020).

Social NGOs

Social NGOs are not expected to be within the direct sphere of influence of the SRC production system. Naturally, as SRC could possibly affect local job markets, local energy independence and national energy prices, they could become involved in a later stage (own deduction).

---

[20] Although this is a production system with longer rotations, we assume that stakeholder perceptions will be comparable.

Farmers associations

The official position of Farmers associations on SRC is unknown. There could be a certain interest as publications in *Sierteelt & Groenvoorziening* and *Landbouwleven* show, but there could also be scepticism because of possible substitution of arable land for SRC and changes in the conventional farming practices**.** Whereas individual farmers make decisions based primarily on their own interest, associations of farmers will look at the costs and benefits for the whole farming sector. Farmers in Flanders are under pressure of low market prices for agricultural goods and high production costs with an increased and suffocating upscaling as a consequence (Departement Landbouw & Visserij, 2021c; Dumortier & Vanhoven, 2021). Because of this upscaling, incentivized by government policies, most of the small landscape elements have been actively removed in the past 40 years to make larger plots for larger farms. With new policy interest in small landscape elements and ecological attention zones, SRC could be seen as a way to reinstate the former agricultural landscape in a profitable way. This could be achieved by planting SRC in between fields and bordering waterways, making up the obligatory 5% ecological attention zones of the arable land. The wood could be sold or used on site, depending on local infrastructure and market prices (own deduction). Nonetheless, as discussed in section 4.3.2, SRC could become yet another competing land use, increasing the prices of agricultural land and thus increasing the pressure on farmers. Additionally SRC might be perceived by the associations as unfitting within the current agricultural system or just not the responsibility of farmers, as was the case for the individual farmers in the study of Raman et al. (2015).

4.3.4 Local policy interest in SRC

Even though there are plenty of smaller-scale initiatives on biomass for energy supported or even initiated by local governments, SRC is often not considered. Most initiatives focus on the valorisation of wood that is already present in the landscape: "*Kempens energiehout", "Loket onderhoud buitengebied", "HOUT=GOUD", "Limburgs groen voor een groene economie", "Trees from Traffic", "Houtige Biomassa" and "Stère"* from Energielandschap Oost-Vlaanderen*,…* Nonetheless, these initiatives result in biomass chains which can fairly easily be used for SRC wood chips as well. Should in the future SRC be more readily available, it is possible that there would also be an increased local policy interest (own deduction).

"*Agentschap Natuur en Bos"* and "*Bosgroepen*" which are respectively the regional agency for nature and forest and a non-profit organisation supporting Flemish forest owners with their forest management, reported to regard SRC as agriculture rather than forestry and therefore it lies beyond their scope. Nonetheless, they need to grant the permits necessary for compliance with the Forest Decree and the Nature Decree and are therefore important actors. SRC can best be planted neighbouring existing forests for the visual aspects and to connect forests to create more ecological value (Bell & McIntosh, 2001; Haughton *et al.*, 2016). In the light of reforestation and afforestation pledges on the European and Flemish level, this might scare potential SRC owners that have land next to forests as they fear it could be bought up by the agency in the near future as it will be a perfect plot to start the reforestation process or create natural corridors. The agency could potentially also be interested in supporting the transition in the biobased-economy by kickstarting the pledged reforestations with SRC or regular poplar

 doi.org/10.21436/inbor.85964562

plantation which is an ideal preparation of the soil and microclimate (Thomaes & De Keersmaeker, 2011) and would yield biomass that consequently does not have to be harvested from our forests (own deduction). Even though this might be an interesting and potentially promising approach to conserving our current forests, it is rather unlikely that this will be considered as the expertise is lacking and normal reforestations would probably be more acceptable both for their own organisations as the broader public (own deduction). The Walloon counterpart of the nature agency is the Service Public de Wallonie (SPW) Agriculture, Ressources naturelles et Environnement. The urbanism permits are granted by the SPW Aménagement du territoire et urbanisme. Both are therefore also important actors but who seem to have no more interest in SRC as their Flemish counterparts do.

In Wallonia a number of non-profit organizations exist that promote the cultivation and use of woody biomass such as ValBiom (Valorisation de la biomasse), AWAF (Association pour l'agroforesterie en Wallonie et à Bruxelles), CTA de Strée (Centre des Technologies Agronomiques de Strée), CDAF (centre de Développement Agroforestier de Chimay), NatAgriWal. These are active in informing, educating and aiding interested farmers in developing their projects. Only ValBiom also has a clear interest in SRC but is mainly approached for miscanthus plantations (ValBiom, personal communication, 23/09/2023).

"*Regionale landschappen*" are non-profit organisations centred around the sustainable and multifunctional management of landscapes, maintaining and strengthening nature, landscape, heritage and recreation by bringing together inhabitants and stakeholders. Their view on SRC is unknown. Nonetheless their quest for multifunctionality might lead to their interest and support for SRC but this is rather unlikely given that there are other historic land uses which can also provide bioenergy in a more extensive way with a smaller landscape impact, such as hedges and pollards. Their interest for bioenergy, which up until now was mainly through valorisation of this landscape wood, could shift to a more proactive approach where also SRC could play a role should there be interest and support from local stakeholders (own deduction). They could play a key role in connecting the different actors in the production chain and the local inhabitants to foster a participative local bioeconomy.

Cities and municipalities are for the moment not using SRC. Nonetheless they could strategically incentivize SRC and act as a buyer for the wood in order to support the transition towards carbon neutrality (own deduction). The article of Broeckx et al. (2011) introduced the cities and municipalities to SRC and its benefits via the journal *Groencontact* (Broeckx *et al.*, 2011). Multiple local governments have already started warming their buildings with heat generated from the combustion of wood (e.g. Bocholt, Eeklo,...). This wood comes from landscape management (roadsides, parks etc.) but could also come from SRC. By incentivizing local farmers or owners of "marginal land" to assign a part of their land to SRC, they could increase their independence of fossil fuels, and foster a stronger regional (bio)economy. They could also act as connectors of the supply chain and provide a stable market for the local plantation owners. This might be especially interesting in highly deforested areas with few small landscape elements left, as this would also be beneficial for nature and possibly the landscape. Local governments also play an important role in the granting of permits of the Field Code.

"Vlaamse landmaatschappij" is an important stakeholder as it checks compliance with the legislation and regulations concerning agriculture. Their view on SRC is unknown.

4.3.5 (Inter)national and regional policy interest in SRC

As seen in chapter 2, at an international, national and regional level there is the acknowledgement that SRC could be beneficial for both green energy production and biodiversity in the (agricultural) landscape. Nonetheless, the projections of the Flemish government on the short term development of the SRC market is rather conservative (Departement Landbouw & Visserij, 2021b). Both an interview with a government official and the projections of the development of SRC seem to indicate the absence belief that SRC can have a real impact in the coming decade. Further research on SRC is also not a priority of policymakers, as was reported during an interview with an actor within Flemish policy. This should, in fact, not come as a surprise, since the research and communication on SRC in Flanders has already been quite extensive in the past decade (see mainly the POPFULL research project which had extensive scientific and popular outreach and was even visited by the erstwhile prince of Belgium but also the work of INBO, gathered in Meiresonne, 2006). This has however not been followed with the predicted increase in area under SRC. Nonetheless, this could change with the emergence of new technologies, such as biofuels, biocomponents or materials or external shocks such as the current energy and geopolitical crisis.

In Wallonia there is a clear policy interest in hedgerows with the funding scheme Yes We Plant. This programme has the ambition to plant 4.000 km of hedgerows and/or one million trees. Also linear SRC are supported by this programme and can receive up to €4 per meter. In Flanders a similar approach could be taken.

To summarise:

The social impact of SRC is hard to predict as it depends on a variety of factors which are often case-specific. Stakeholder involvement will in any case be key when converting land to SRC plantations. Gradual deployment of SRC in the landscape, with care for landscape types, would probably be accepted by local stakeholders and would not disrupt the markets. Increases in domestic biomass production from SRC could be beneficial for Belgian society but this can be met with resistance from local actors, civil society and competing industries. The different stakeholders, on all levels, will need to be first made aware of the benefits and pitfalls of biomass from SRC and then connected to each other. This will be imperative to create the necessary policy changes that can incentivize land owners to plant SRC. It should be noted, however, that there are more barriers than financial feasibility and clear legislation. Many farmers were reported not to be interested in or have any affinity with woody biomass as their moral purpose is food production. Looking back at the historic landscape and proving that woody elements are a part of Belgian agricultural history could help in shifting this idea. Local governments and actors such as the *Regionale Landschappen* and municipalities could lead by example and integrate SRC into their already existing biomass chains, thereby creating a stable demand for SRC wood.

doi.org/10.21436/inbor.85964562

4.4 Summary and recommendations on the direct impact of SRC

Small-scale implementation of SRC on less valuable lands will be beneficial for nature and society and more acceptable for farmers owning the land. However, this will most likely not be economically feasible. As long as this lack in profitability is not tackled, it is unlikely that farmers or companies will invest in SRC. Through incentives from policy and through streamlining legislation, this first barrier can be lifted while simultaneously favouring those locations where SRC can have the most beneficial impact: in the agricultural landscape as a connector or on marginal (industrial) sites. To facilitate this, it would be best if one policy domain took responsibility of SRC instead of the current situation where neither the forest nor the agricultural sector feels connected to it. We argue that it would best fit within the agricultural sector as the time horizons are far less than regular forestry. Alternatively SRC could get its own statute such as has been (partially) constructed for agroforestry. Once legislation is adapted and policy measures are in place, information campaigns on how to use SRC to become (more) energy independent as a farmer, company or local government and which funding possibilities are available, could kickstart the process of incorporating SRC in our landscape. Public investors could lead by example. Before the market picks up on SRC as a viable source of biomass and possible new applications emerge, legislation should already be in place to make sure that it does not substitute valuable nature, carbon-rich land uses, or highly productive land for food production. Regulations should also be in place to ensure stakeholder consultations take place should significant portions of a landscape be used for SRC.

5 The indirect and spillover effects of large scale short rotation coppice

The concerns that civil society raises against large-scale introduction of biomass used for energy purposes were already briefly mentioned in section 4.3.3. Since these are indeed valid concerns, we will discuss the extent to which these apply to SRC systems in Belgium should SRC be planted in a large scale and how to potentially mitigate these impacts.

5.1 GHG emissions

Large-scale introduction of SRC for the production of energy could lead to GHG emissions rather than reductions. This will depend on a variety of factors:

1. **The soil organic carbon content** of the land on which the SRC is planted:
   In case the SRC is planted on former intensive agricultural land, the change to SRC will lead to sequestration of carbon in the soil, which is stored there for at least the whole life of the plantation (Whitaker *et al.*, 2018). A fraction will stay there even after the root system has been uprooted to make place for a new plantation or land use (Wachendorf *et al.*, 2017). Should the soil on which the SRC is planted already be high in soil carbon (for example forest soils or historic permanent grassland), there might be a net loss of soil carbon due to the introduction of SRC (Don *et al.*, 2012).
2. **The former land cover** of the land on which the SRC is planted:
   If the SRC substitutes land that was used for food or feed production, this might lead to other land elsewhere to be changed to agricultural land, to compensate. This is called indirect land use change and often leads to deforestation elsewhere. This indirect change can amount up to between 66 and 89% of the total GHG emission due to land use change (Schubert *et al.*, 2009) and could thereby render the balance negative.
3. **The supply chain:**
   Transport, conversion processes and possible waste products have an impact on the GHG balance, although they are only minor compared to the emissions from direct and indirect land use change (Njakou Djomo *et al.*, 2015b). Nonetheless, wood is not an energy dense product and contains much water, making its transport over long distances inefficient. It should be produced close to the place of consumption or densified locally.

5.2 Biodiversity loss

Large-scale introduction of SRC in Belgium could lead to biodiversity loss. This can happen on a local scale where SRC is planted on land with a high value for nature, such as some marginal lands or forest land (Pedroli *et al.*, 2013). On a global scale this can happen when substituting crops for food or feed. In this case the loss in biodiversity happens due to the same mechanism as the GHG losses through indirect land-use change. The land that will be brought under agricultural production to compensate for the loss of agricultural land here, often has a high

doi.org/10.21436/inbor.85964562

biodiversity value. This means that, even though the biodiversity in Flanders might benefit from more SRC on agricultural land, global biodiversity would likely decrease.

5.3 Competition with food production

SRC can compete with food production. This is not only a problem because of the aforementioned points (GHG emissions and biodiversity loss) but also because food is a basic human resource. Nonetheless, in a globalised country such as Belgium, SRC plantations will not decrease the availability of food but substituting agricultural crops with SRC would mean that more import of food or higher yields of agricultural crops are needed to maintain current consumption levels. However, large-scale implementation of SRC could compete with food production on a global scale and increase the food prices. This large-scale implementation is highly unlikely to be the case in Belgium, where food production still is economically more feasible on highly productive agricultural land, than biomass production. Next to competing with food production, the implementation of SRC could in a very specific case lead to higher availability of land for food: when substituting first generation biomass crops. In 2014 it was calculated that about 6.800 ha of agricultural land was used for energy crops like corn, wheat and sugar beets in Flanders (Van Kerckvoorde & Van Reeth, 2014). As both the energy balance (Dimitriou & Rutz, 2014) and the ecological indicators (see section 4.1 on ecological impact) are in favour of SRC as opposed to the intensive agricultural practices of energy crops, substituting these energy crops with SRC would mean there is no loss in food production, and that for the same amount of energy produced, less land would be necessary. This is of course also a hypothetical scenario as energy demand has been ever increasing and more energy efficient systems would most likely lead to more energy use (Herring, 2006), rather than freeing land for other purposes.

5.4 Investments

Large scale implementation of SRC leads to investments in infrastructure, research and technology. Even though it is clear that these investments can be beneficial for society, they also pose some risks:

1. Large infrastructure will be able to process large quantities of wood. As technology advances, multiple sources of wood could be used to feed these processes. This poses the threat of increased use of woody biomass that could be used in other, more climate efficient ways (such as from the building or compost industry). Moreover, higher prices could incentivize forest owners to increase harvesting, leading to possible degradation of forests.
2. Large biomass installations will probably not limit their imports to locally sourced biomass if not required by legislation. Rather the most inexpensive biomass sources will be used. This can lead to increased harvesting or land substitution in other regions with less strict regulations impacting the GHG balance, global biodiversity and possibly even land tenure rights. A tax on e.g. transport distance could partly mitigate this.

3. As large investments have to be made, the payback time could be exceeding the actual usefulness of the technology and thereby hold back further transitioning to a carbon negative society.
4. The costs that are needed to develop biomass conversion plants might be better invested into other things with a higher societal return on investment. The analysis of this is, however, beyond the scope of this report.

To summarise

When SRC is planted on land with a low soil carbon and it does not substitute food production it will probably have a positive GHG balance, meaning it will successfully mitigate climate change. When transport distances increase, this gain will decrease

Large-scale unregulated implementation of SRC would most probably have detrimental effects for the environment in Belgium, Europe and elsewhere and could lead to a number of other unwanted side effects. Nonetheless, with sound and enforced policies in place, the development of an economy around biomass from SRC could also have large benefits for nature and society. Some key policy checks include:

- No substitution of forests, loss of biodiversity or loss of soil organic carbon because of planting of SRC
- In the event that biomass should become more valuable (for example because of high electricity or fuel prices), policies should be in place to protect food production
- Clear cascaded use of SRC biomass to incentivize an efficient and circular bio-economy
- Controlled building of industrial infrastructure, adapted to the sustainably available amount of wood from SRC to avoid using other, less sustainable sources.

Coupling back to section 1.4, if the mentioned 21.000 hectares that would hypothetically be eligible for SRC would actually be used, the effects could probably be positive rather than negative if it would be done taking into account the recommendations of section 4.1. Nonetheless, further study is required to develop a land allocation decision support tool to confirm this.

doi.org/10.21436/inbor.85964562

6 References

ARBOR (2015). ARBOR Strategy Report: Accelerating Renewable Energies through Valorisation of Biogenic Organic Raw Material.

Baum S., Bolte A. & Weih M. (2012). High value of short rotation coppice plantations for phytodiversity in rural landscapes. GCB Bioenergy 4 (6): 728–738. https://doi.org/https://doi.org/10.1111/j.1757-1707.2012.01162.x.

Bell S. & McIntosh E. (2001). Short Rotation Coppice in the Landscape. Edinburgh, 1–8 p.

Beltman J.B., Hendriks C., Tum M. & Schaap M. (2013). The impact of large scale biomass production on ozone air pollution in Europe. Atmospheric Environment 71: 352–363. https://doi.org/10.1016/j.atmosenv.2013.02.019.

Berhongaray G., Cotrufo F.M., Janssens I.A. & Ceulemans R. (2019). Below-ground carbon inputs contribute more than above-ground inputs to soil carbon accrual in a bioenergy poplar plantation. https://doi.org/10.1007/s11104-018-3850-z.

Berhongaray G., El Kasmioui O. & Ceulemans R. (2013). Comparative analysis of harvesting machines on an operational high-density short rotation woody crop (SRWC) culture: One-process versus two-process harvest operation. Biomass and Bioenergy 58: 333–342. https://doi.org/10.1016/J.BIOMBIOE.2013.07.003.

Birdlife International, Natural Resources Defence Council, WWF, Fern, Southern Environmental Law Center, EKO energy ecolabel, Za Zemiata, PFPI, Biofuelwatch, Robin Wood, Environmental Paper Network, Transport & Environment, Dogwood alliance & Wild Europe (2020). Open letter: Ending EU support for burning trees and crops for energy.

Bloemen J., Fichot R., Horemans J.A., Broeckx L.S., Verlinden M.S., Zenone T. & Ceulemans R. (2017). Water use of a multigenotype poplar short-rotation coppice from tree to stand scale. GCB Bioenergy 9 (2): 370–384. https://doi.org/10.1111/gcbb.12345.

Boll T., von Haaren C. & Rode M. (2015). The Effects of Short Rotation Coppice on the Visual Landscape. In: Bemmann A., Butler-Manning D., Ammer C., Bredemeier M. & Lamersdorf N. (eds.). Bioenergy from Dendromass for the Sustainable Development of Rural Areas. Wiley-VCH Verlag GmbH & Co, p. 105–119.

Borremans L., Reubens B., Nelissen V. & Wauters E. (2018). Culturele Ecosysteemdiensten in Agroforestrysystemen. Brussel, 16 p. www.agroforestryvlaanderen.be.

Brachet I., Caloprisco P., Coelho V., Connoly T., Eräjää S., Fauconnier J.-F., Herman M.-O., Luebbeke I. & Zuidema I. (2018). Pitfalls and Potentials The role of bioenergy in the EU climate and energy policy post 2020 - NGO recommencations. 10 p.

Broeckx L., El Kasmioui O. & Verlinden M. (2011). Populier, energieleverancier. Groencontact 37 (5): 18–21.

Busch G. (2009). The impact of Short Rotation Coppice cultivation on groundwater recharge - a spatial (planning) perspective. Landbauforschung-vTI Agriculture and Forestry Research 3 (59): 207–222. www.rwe.com;

Busch G. & Thiele J.C. (2015). The Bioenergy Allocation and Scenario Tool (BEAST) to Assess Options for the Siting of Short Rotation Coppice in Agricultural Landscapes: Tool

Development and Case Study Results from the Göttingen DistrictAssess Options for the Siting of Short Rotation Co. In: Manning D.B., Bemmann A., Bredemeier M., Lamersdorf N. & Ammer C. (eds.). Bioenergy from Dendromass for the Sustainable Development of Rural Areas. Wiley-VCH Verlag GmbH & Co, p. 21–44. https://doi.org/10.1002/9783527682973.CH4.

Camia A., Giuntoli J., Jonsson R., Robert N., Cazzaniga N.E., Jasinevičius G., Avitabile V., Grassi G., Barredo J.I. & Mubareka S. (2021). The use of woody biomass for energy production in the EU. Publications Office of the European Union, Luxembourg, 182 p. https://doi.org/10.2760/831621.

Cornelis B. (2015). Of hoe plantexperimenten een nieuwe thuis creëren voor ree- en ander wild. Jagen 10 (59): 17–20.

Dandy N. (2010). Stakeholder Perceptions of Short-rotation Forestry for energy. 37 p. https://cdn.forestresearch.gov.uk/2008/12/perceptions_of_srf_iterature_review_2010.pdf.

Dauber J., Emmerson M., Jones M., Stout J. & Finnan J. (2011). Strategic overview of influences of bioenergy crop production on biodiversity and ecosystems services in Ireland. Dublin, 12 p. https://www.tcd.ie/research/simbiosys/images/SIMBIOSYS Bioenergy Crops Sectoral Review.pdf.

De Somviele B., Meiresonne L. & Verdonckt P. (2009). Van Wilg tot Warmte - Potenties van Korteomloophout in Vlaanderen. In: Fonds Duurzaam Afval- en Energiebeheer.

Departement Landbouw & Visserij (2021a). Vergroening – ecologisch aandachtsgebied: Korte-omloophout - campagne 2021. https://lv.vlaanderen.be/sites/default/files/attachments/fiche_vergroening_-_korte_omloophout_-_versie_29012021.pdf.

Departement Landbouw & Visserij (2021b). Gemeenschappelijk Landbouwbeleid Strategisch Plan deel 2.

Departement Landbouw & Visserij (2021c). Landbouwrapport 2020 (LARA). Brussel.

Departement Omgeving (2022). Programmatische aanpak stikstof - PLAN-MER en Openbaar Onderzoek. Brussel. https://www.lne.be/mer-dossierdatabank.

Dillen S.Y., Djomo S.N., Al Afas N., Vanbeveren S. & Ceulemans R. (2013). Biomass yield and energy balance of a short-rotation poplar coppice with multiple clones on degraded land during 16 years. Biomass and Bioenergy 56: 157–165. https://doi.org/10.1016/J.BIOMBIOE.2013.04.019.

Dimitriou I. & Aronsson P. (2011). Wastewater and sewage sludge application to willows and poplars grown in lysimeters-Plant response and treatment efficiency. Biomass and Bioenergy 35 (1): 161–170. https://doi.org/10.1016/j.biombioe.2010.08.019.

Dimitriou I., Baum C., Baum S., Busch G., Schulz U., Köhn J., Lamersdorf N., Leinweber P., Aronsson P., Weih M., Berndes G. & Bolte A. (2011). Quantifying environmental effects of Short Rotation Coppice (SRC) on biodiversity , soil and water. In: IEA Bioenergy. 34 p. http://ieabioenergytask43.org/wp-content/uploads/2013/09/IEA_Bioenergy_Task43_TR2011-01.pdf.

Dimitriou I. & Rosenqvist H. (2011). Sewage sludge and wastewater fertilisation of Short Rotation Coppice (SRC) for increased bioenergy production - Biological and economic potential. Biomass and Bioenergy 35 (2): 835–842.

https://doi.org/10.1016/j.biombioe.2010.11.010.

Dimitriou I. & Rutz D. (2014). Sustainability criteria and recommendations for short rotation woody crops. https://www.srcplus.eu/images/D23Sustainability_criteria.pdf.

Dimitriou I. & Rutz D. (2015). Sustainable Short Rotation Coppice - A Handbook. WIP Renewable Energies, Munich, Germany, 108 p. https://www.srcplus.eu/images/Handbook_en.pdf.

Dochy O. (2011). Advies betreffende de impact van korteomloophout op de biodiversiteit op drie locaties in het buitengebied van. 1–28 p. https://www.vlaanderen.be/inbo/publicaties/advies-betreffende-de-impact-van-korteomloophout-op-de-biodiversiteit-op-drie-locaties-in-het-buitengebied-van-west-vlaanderen.

Don A., Osborne B., Hastings A., Skiba U., Carter M.S., Drewer J., Flessa H., Freibauer A., Hyvönen N., Jones M.B., Lanigan G.J., Mander Ü., Monti A., Njakou Djomo S., Valentine J., Walter K., Zegada-Lizarazu W. & Zenone T. (2012). Land-use change to bioenergy production in Europe: implications for the greenhouse gas balance and soil carbon. GCB Bioenergy 4 (4): 372–391. https://doi.org/10.1111/j.1757-1707.2011.01116.x.

Drewer J., Finch J.W., Lloyd C.R., Baggs E.M. & Skiba U. (2012). How do soil emissions of N2O, CH4 and CO2 from perennial bioenergy crops differ from arable annual crops? GCB Bioenergy 4 (4): 408–419. https://doi.org/10.1111/j.1757-1707.2011.01136.x.

Dumortier M. & Vanhoven W. (2021). We hebben weer meer boeren nodig: Over de wedloop tussen voedselproductie en biodiversiteit. Oikos 98 (2): 21–35. https://purews.inbo.be/ws/portalfiles/portal/39584032/Oikos_98_03_AGRO_ECOLOGIE_Dumortier_en_Vanhove.pdf.

El Kasmioui O. & Ceulemans R. (2012). Financial analysis of the cultivation of poplar and willow for bioenergy. Biomass and Bioenergy 43: 52–64. https://doi.org/10.1016/J.BIOMBIOE.2012.04.006.

El Kasmioui O. & Ceulemans R. (2013). Financial Analysis of the Cultivation of Short Rotation Woody Crops for Bioenergy in Belgium: Barriers and Opportunities. BioEnergy Research 6 (1): 336–350. https://doi.org/10.1007/s12155-012-9262-7.

Englund O., Börjesson P., Mola-Yudego B., Berndes G., Dimitriou I., Cederberg C. & Scarlat N. (2021). Strategic deployment of riparian buffers and windbreaks in Europe can co-deliver biomass and environmental benefits. Communications Earth & Environment 2021 2:1 2 (1): 1–18. https://doi.org/10.1038/s43247-021-00247-y.

ENOVER, Nationale Klimaatcommissie, Belgische Federale Overheid, Vlaamse Gewest, Brussels Hoofdstedelijk Gewest & Waals Gewest (2021). Nationaal Plan Nationaal energie-en klimaatplan- Deel A.

European Commission (2021a). Revision of the Regulation on the inclusion of greenhouse gas emissions and removals from land use, land use change and foresty. 0201. https://eur-lex.europa.eu/resource.html?uri=cellar:ea67fbc9-e4ec-11eb-a1a5-01aa75ed71a1.0001.02/DOC_1&format=PDF.

European Commission (2021b). The new common agricultural policy: 2023-27. https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/new-cap-2023-27_en#documents (accessed September 28, 2021).

European Commission (2021c). EU renewable energy rules - review.

https://energy.ec.europa.eu/system/files/2021-03/summary_opc_0.pdf.

European Commission (2022). COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS REPowerEU Plan. Brussels, p. 230. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&qid=1653033742483.

European Commission DG for Energy (2021). Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the E. https://ec.europa.eu/info/files/amendment-renewable-energy-directive-implement-ambition-new-2030-climate-target_en.

European Parliament & Council of the European Union (2009a). Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32009L0028.

European Parliament & Council of the European Union (2009b). Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amend. Vol. L 140.

European Parliament & Council of the European Union (2018a). DIRECTIVE (EU) 2018/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on the promotion of the use of energy from renewable sources (recast). Vol. L 328. THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION, Brussels. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC.

European Parliament & Council of the European Union (2018b). Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation. In: Official Journal of The European Union, Vol. 19. THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION. http://data.europa.eu/eli/reg/2018/841/oj.

Farkas L. (2015). Grenzen aan biomassa in België - De economische en ecologische onzin van nieuwe grootschalige biomassacentrales in Vlaanderen en Wallonië. https://static1.squarespace.com/static/58da8202579fb36928249bc2/t/58ef4c7df5e231091c3202d4/1492077701441/2015-12-16+-+Briefing+Biomassa+Rapport+NL.pdf.

Fehér A., Končeková L., Halmová D., Prus P., Izakovičová Z. & Dragoi M. (2020). Vascular plants diversity in short rotation coppices: A reliable source of ecosystem services or farmland dead loss? IForest 13 (4): 345–350. https://doi.org/10.3832/ifor3055-013.

Ferré C., Mascetti G. & Comolli R. (2021). High-Density Poplar SRC Accumulates More Soil Organic Carbon Than Very-High-Density SRC. Agronomy 2021, Vol. 11, Page 584 11 (3): 584. https://doi.org/10.3390/AGRONOMY11030584.

Fischer M., Zenone T., Trnka M., Orság M., Montagnani L., Ward E.J., Tripathi A.M., Hlavinka P., Seufert G., Žalud Z., King J.S. & Ceulemans R. (2018). Water requirements of short rotation poplar coppice: Experimental and modelling analyses across Europe. Agricultural and Forest Meteorology 250–251: 343–360. https://doi.org/10.1016/j.agrformet.2017.12.079.

Fuertes A., Oliveira N., Cañellas I., Sixto H. & Rodríguez-Soalleiro R. (2021). An economic overview of Populus spp. in Short Rotation Coppice systems under Mediterranean conditions: An assessment tool for decision-making. Renewable and Sustainable Energy Reviews 151 (July). https://doi.org/10.1016/j.rser.2021.111577.

Fürtner D., Perdomo Echenique E.A., Hörtenhuber S.J., Schwarzbauer P. & Hesser F. (2022). Beyond Monetary Cost-Benefit Analyses: Combining Economic, Environmental and Social Analyses of Short Rotation Coppice Poplar Production in Slovakia. Forests 13 (2): 349. https://doi.org/10.3390/F13020349/S1.

Giordano M. & Meriggi A. (2009). Use by small mammals of short-rotation plantations in relation to their structure and isolation. Hystrix, the Italian Journal of Mammalogy 20 (2): 127–135. https://doi.org/10.4404/HYSTRIX-20.2-4443.

Grassi G., Fiorese G., Pilli R., Jonsson K., Bluijdea V., Korosuo A. & Vizzarri M. (2021). Brief on the role of the forest-based bioeconomy in mitigating climate change through carbon storage and material substitution. European Commission, 16 p. https://publications.jrc.ec.europa.eu/repository/handle/JRC124374.

Haughton A.J., Bohan D.A., Clark S.J., Mallott M.D., Mallott V., Sage R. & Karp A. (2016). Dedicated biomass crops can enhance biodiversity in the arable landscape. GCB Bioenergy 8 (6): 1071–1081. https://doi.org/10.1111/gcbb.12312.

Herring H. (2006). Energy efficiency—a critical view. Energy 31 (1): 10–20. https://doi.org/10.1016/J.ENERGY.2004.04.055.

Horemans J.A., Arriga N. & Ceulemans R. (2019). Greenhouse gas budget of a poplar bioenergy plantation in Belgium: CO2 uptake outweighs CH4 and N2O emissions. GCB Bioenergy 11 (12): 1435–1443. https://doi.org/10.1111/gcbb.12648.

Huisman W. (1990). Sound Propagation Over Vegetation-covered Ground. Katholieke Universiteit Nijmegen, Nijmegen, 173 p. http://openlibrary.org/books/OL12852710M/Sound_Propagation_Over_Vegetation-covered_Ground.

Istenič D., Božič G., Zalesny R.S. & Pilipovi´c A.P. (2021). Short-Rotation Willows as a Wastewater Treatment Plant: Biomass Production and the Fate of Macronutrients and Metals. Forests 2021, Vol. 12, Page 554 12 (5): 554. https://doi.org/10.3390/F12050554.

Kahle P. & Janssen M. (2020). Impact of short-rotation coppice with poplar and willow on soil physical properties. Journal of Plant Nutrition and Soil Science 183 (2): 119–128. https://doi.org/10.1002/jpln.201900443.

Kahle P., Möller J., Baum C. & Gurgel A. (2013). Tillage-induced changes in the distribution of soil organic matter and the soil aggregate stability under a former short rotation coppice. Soil and Tillage Research 133: 49–53. https://doi.org/10.1016/J.STILL.2013.05.010.

Koskela J., de Vries S.M.G., Kajba D. & von Wühlisch G. (2004). Populus nigra Network, Report of the seventh (25–27 October 2001, Osijek, Croatia) and eighth (22–24 May 2003, Treppeln, Germany) meetings. 131 p. https://books.google.com/books/about/Populus_Nigra_Network.html?id=fGbOvZRKVYwC.

Kröber M., Heinrich J. & Wagner P. (2015). The Economic Assessment of Short Rotation

Coppice Plantations and Their Profitability Relative to Annual Crops in Sachsen, Germany. In: Manning D.B., Bemmann A., Bredemeier M., Lamersdorf N. & Ammer C. (eds.). Bioenergy from Dendromass for the Sustainable Development of Rural Areas. Wiley-VCH Verlag GmbH & Co, p. 317–330. https://doi.org/10.1002/9783527682973.CH24.

Laureysens I., Bogaert J., Blust R. & Ceulemans R. (2004). Biomass production of 17 poplar clones in a short-rotation coppice culture on a waste disposal site and its relation to soil characteristics. Forest Ecology and Management 187 (2–3): 295–309. https://doi.org/10.1016/J.FORECO.2003.07.005.

Li W., Ciais P., Makowski D. & Peng S. (2018). A global yield dataset for major lignocellulosic bioenergy crops based on field measurements. Scientific Data 5 (1): 180169. https://doi.org/10.1038/sdata.2018.169.

Liekens I., Van der Biest K., Staes J., De Nocker L., Aertsens J. & Broekx S. (2013). Waardering van ecosysteemdiensten - een geüpdate handleiding. 176 p.

Lupp G., Bastian O. & Grunewald K. (2015). Energy crop production - a complex problem for assessing ES. In: Grunewald K. & Bastian O. (eds.). Ecosystem Services - Concept, Methods and Case Studies. Springer, Berlin, p. 112–118. https://doi.org/https://doi.org/10.1007/978-3-662-44143-5.

Meiresonne L. (2006). Kansen , mogelijkheden en toekomst voor de populierenteelt in Vlaanderen Korte-omloophout voor energieproductie : plaats in het Vlaams bosbeleid. INBO.R.2006.11. In opdracht van Bos & Groen. Instituut voor Natuur- en Bosonderzoek, Geraardsbergen

Meiresonne L. (2016). Advies over het gebruik van korteomloophout voor fytoremediatie. p. 1–9. INBO.A.3413. Instituut voor Natuur- en Bosonderzoek

Meiresonne L. & Jansen I. (2018). Grauwe abeel Selectie van geschikte klonen voor bebossingsprojecten. Brussel, 87 p. Interne rapporten van het Instituut voor Natuur- en Bosonderzoek. Instituut voor Natuur- en Bosonderzoek, Brussel

Ministère de l'Agriculture et de l'Alimentation (2021). La Politique Agricole Commune 2015-2022. 30–33.

Mohr A. & Raman S. (2015). Lessons from first generation biofuels and implications for the sustainability appraisal of second generation biofuels. Efficiency and Sustainability in Biofuel Production: Environmental and Land-Use Research 63: 281–310. https://doi.org/10.1016/j.enpol.2013.08.033.

Müller-Kroehling S., Hohmann G., Helbig C., Liesebach M., Lübke-Al Hussein M., Al Hussein I.A., Burmeister J., Jantsch M.C., Zehlius-Eckert W. & Müller M. (2020). Biodiversity functions of short rotation coppice stands - results of a meta study on ground beetles (Coleoptera: Carabidae). Biomass and Bioenergy 132 (December 2019): 105416. https://doi.org/10.1016/j.biombioe.2019.105416.

Njakou Djomo S., Ac A., Zenone T., De Groote T., Bergante S., Facciotto G., Sixto H., Ciria Ciria P., Weger J. & Ceulemans R. (2015a). Energy performances of intensive and extensive short rotation cropping systems for woody biomass production in the EU. In: Renewable and Sustainable Energy Reviews, Vol. 41. Elsevier Ltd, p. 845–854. https://doi.org/10.1016/j.rser.2014.08.058.

Njakou Djomo S., Witters N., Van Dael M., Gabrielle B. & Ceulemans R. (2015b). Impact of feedstock, land use change, and soil organic carbon on energy and greenhouse gas performance of biomass cogeneration technologies. Applied Energy 154: 122–130.

https://doi.org/10.1016/j.apenergy.2015.04.097.

Pedroli B., Elbersen B., Frederiksen P., Grandin U., Heikkilä R., Krogh P.H., Izakovičová Z., Johansen A., Meiresonne L. & Spijker J. (2013). Is energy cropping in Europe compatible with biodiversity? - Opportunities and threats to biodiversity from land-based production of biomass for bioenergy purposes. Biomass and Bioenergy 55: 73–86. https://doi.org/10.1016/j.biombioe.2012.09.054.

Piotrowska N.S., Czachorowski S.Z. & Stolarski M.J. (2020). Ground beetles (Carabidae) in the short-rotation coppice willow and poplar plants—synergistic benefits system. Agriculture (Switzerland) 10 (12): 1–23. https://doi.org/10.3390/agriculture10120648.

Raman S., Mohr A., Helliwell R., Ribeiro B., Shortall O., Smith R. & Millar K. (2015). Integrating social and value dimensions into sustainability assessment of lignocellulosic biofuels. Biomass & Bioenergy 82: 49. https://doi.org/10.1016/J.BIOMBIOE.2015.04.022.

Ranacher L., Pollakova B., Schwarzbauer P., Liebal S., Weber N. & Hesser F. (2021). Farmers' Willingness to Adopt Short Rotation Plantations on Marginal Lands: Qualitative Study About Incentives and Barriers in Slovakia. Bioenergy Research 14 (2): 357–373. https://doi.org/10.1007/S12155-020-10240-6/TABLES/7.

Ruttens A., Boulet J., Weyens N., Smeets K., Adriaensen K., Meers E., Van Slycken S., Tack F., Meiresonne L., Thewys T., Witters N., Carleer R., Dupae J. & Vangronsveld J. (2011). Short rotation coppice culture of willows and poplars as energy crops on metal contaminated agricultural soils. International journal of phytoremediation 13 (1): 194–207. https://doi.org/10.1080/15226514.2011.568543.

Schrama M., Vandecasteele B., Carvalho S., Muylle H. & van der Putten W.H. (2016). Effects of first- and second-generation bioenergy crops on soil processes and legacy effects on a subsequent crop. GCB Bioenergy 8 (1): 136–147. https://doi.org/10.1111/gcbb.12236.

Schubert R., Schellnhuber H.J., Buchmann N., Epiney A., Grießhammer R., Kulessa M., Messner D., Rahmstorf S. & Schmid J. (2009). Future bioenergy and sustainable land use. 1–365 p. https://doi.org/10.4324/9781849774505.

Souch C.A., Martin P.J., Stephens W. & Spoor G. (2004). Effects of soil compaction and mechanical damage at harvest on growth and biomass production of short rotation coppice willow. Plant and Soil 263: 173–182. https://doi.org/https://doi.org/10.1023/B:PLSO.0000047734.91437.26.

Sperandio G., Suardi A., Acampora A. & Civitarese V. (2021). Environmental Sustainability of Heat Produced by Poplar Short-Rotation Coppice (SRC) Woody Biomass. Forests 2021, Vol. 12, Page 878 12 (7): 878. https://doi.org/10.3390/F12070878.

Swart F., Visschers M. & Vollenbroek J. (2021). Opinie: Om klimaatdoelen te halen moet Europa stoppen met verbranding van biomassa | De Volkskrant. De Volkskrant. https://www.volkskrant.nl/columns-opinie/opinie-om-klimaatdoelen-te-halen-moet-europa-stoppen-met-verbranding-van-biomassa~bd1231aa/.

Thomaes A. & De Keersmaeker L. (2011). Onder een tentje van populier. Natuur.focus 10 (4): 166–170.

Van Den Berge S. (2021). Role of hedgerow systems for biodiversity and ecosystem services in agricultural landscapes. Ghent University. http://hdl.handle.net/1854/LU-8687480%0A%0AMLA.

Van der Horst D. & Vermeylen S. (2011). Spatial scale and social impacts of biofuel production.

Biomass and Bioenergy 35 (6): 2435–2443. https://doi.org/10.1016/j.biombioe.2010.11.029.

Van Kerckvoorde A. & Van Reeth W. (2014). Hoofdstuk 14 - Ecosysteemdienst productie van energiegewassen (INBO.R.2014.1987641). Stevens, M. et al. (eds.), Natuurrapport - Toestand en trend van ecosystemen en ecosysteemdiensten in Vlaanderen. Technisch rapport Mededeling.

van Laarhoven J.P.R.M. (2013). Duurzaam gebruik van energiehout in de Benelux. 31 p. https://www.benelux.int/nl/publicaties/publicaties-overzicht/duurzaam-gebruik-van-energiehout/.

Van Renterghem T., Attenborough K., Maennel M., Defrance J., Horoshenkov K., Kang J., Bashir I., Taherzadeh S., Altreuther B., Khan A., Smyrnova Y. & Yang H.S. (2014). Measured light vehicle noise reduction by hedges. Applied Acoustics 78: 19–27. https://doi.org/10.1016/J.APACOUST.2013.10.011.

Vanbeveren S. & Ceulemans R. (2019). Biodiversity in short-rotation coppice. Renewable and Sustainable Energy Reviews 111: 34–43. https://doi.org/10.1016/j.rser.2019.05.012.

Vanbeveren S., De Francesco F., Ceulemans R. & Spinelli R. (2018). Productivity of mechanized whip harvesting with the Stemster MkIII in a short-rotation coppice established on farmland. Biomass and Bioenergy 108: 323–329. https://doi.org/10.1016/J.BIOMBIOE.2017.11.024.

Vanbeveren S., Schweier J., Berhongaray G. & Ceulemans R. (2015). Operational short rotation woody crop plantations: Manual or mechanised harvesting? Biomass and Bioenergy 72: 8–18. https://doi.org/10.1016/j.biombioe.2014.11.019.

Verheyen K., Buggenhout M., Vangansbeke P., De Dobbelaere A., Verdonckt P. & Bonte D. (2014). Potential of short rotation coppice plantations to reinforce functional biodiversity in agricultural landscapes. Biomass and Bioenergy 67: 435–442. https://doi.org/10.1016/j.biombioe.2014.05.021.

Verlinden M., Broeckx L., El Kasmioui O., Vanbeveren S. & Ceulemans R. (2015). Bio-energieplantages met snelgroeiende populieren: mogelijkheden in Vlaanderen. (52): 3–6. https://bosrevue.bosplus.be/bosrevue/editie/2015/06/28/Bio-energieplantages-met-snelgroeiende-populieren-mogelijkheden-in-Vlaanderen.

Vervisch B. & Verdonckt P. (2015). Nieuws : Studiedag “beplantingen in de kippenuitloop.” Inagro. https://www.inagro.be/Artikel/guid/6be0af5f-b8eb-40e0-acd0-472a0399a2a1_934.

Virano Riquelme V., Fontenla-Razzetto G., Tavares Wahren F., Feger K.-H., Heil B., Heilig D., Kovacs G. & Julich S. (2021). The Impact of Poplar Short Rotation Coppice on Topsoil Physical Properties and Related Water Conditions. BioEnergy Research 14: 399–408. https://doi.org/10.1007/s12155-021-10269-1/Published.

Volk T.A., Verwijst T., Tharakan P.J., Abrahamson L.P. & White E.H. (2004). Growing fuel: A sustainability assessment of willow biomass crops. Frontiers in Ecology and the Environment 2 (8): 411–418. https://doi.org/10.1890/1540-9295(2004)002[0411:GFASAO]2.0.CO;2.

Wachendorf C., Stuelpnagel R. & Wachendorf M. (2017). Influence of land use and tillage depth on dynamics of soil microbial properties, soil carbon fractions and crop yield after conversion of short-rotation coppices. Soil Use and Management 33 (2): 379–388. https://doi.org/10.1111/SUM.12348.

Wallonie agriculture SPW (2021). Rapport de 2021 du plan stratégique relevant de la PAC. 912.

Warren C.R., Burton R., Buchanan O. & Birnie R. V (2016). Limited adoption of short rotation coppice: The role of farmers' socio-cultural identity in influencing practice. Journal of Rural Studies 45: 175–183. https://doi.org/https://doi.org/10.1016/j.jrurstud.2016.03.017.

Whitaker J., Field J.L., Bernacchi C.J., Cerri C.E.P., Ceulemans R., Davies C.A., DeLucia E.H., Donnison I.S., McCalmont J.P., Paustian K., Rowe R.L., Smith P., Thornley P. & McNamara N.P. (2018). Consensus, uncertainties and challenges for perennial bioenergy crops and land use. GCB Bioenergy 10 (3): 150–164. https://doi.org/10.1111/gcbb.12488.

Wille D. (2016). Duurzaamheidscriteria en een afwegingskader voor de inzet van houtige stromen. 166 p. https://publicaties.vlaanderen.be/view-file/20039.

Williams M.A., Feest A., Williams M.A. & Feest A. (2019). The Effect of Miscanthus Cultivation on the Biodiversity of Ground Beetles (Coleoptera: Carabidae), Spiders and Harvestmen (Arachnida: Araneae and Opiliones). Agricultural Sciences 10 (7): 903–917. https://doi.org/10.4236/AS.2019.107069.

Williams M.A., Feest A., Williams M.A. & Feest A. (2022). The Effect of Willow Short Rotation Coppice Cultivation on the Biodiversity Quality of Ground-Layer Invertebrates. Agricultural Sciences 13 (3): 378–392. https://doi.org/10.4236/AS.2022.133026.

Yes We Plant (s.d.). Le Vademecum - Yes ! We plant ! https://yesweplant.wallonie.be/home/le-vademecum.html (accessed October 6, 2022).

Zitzmann F., Reich M. & Schaarschmidt F. (2021). Potential of small-scale and structurally diverse short-rotation coppice as habitat for large and medium-sized mammals. Biologia 76: 2195–2206. https://doi.org/10.1007/s11756-021-00686-0.

Zyadin A., Natarajan K., Igliński B., Iglińska A., Kaczmarek A., Kajdanek J., Pappinen A. & Pelkonen P. (2017). Farmers' willingness to supply biomass for energy generation: evidence from South and Central Poland. Biofuels 8 (4): 421–430. https://doi.org/10.1080/17597269.2016.1225647.

Appendix

Annex 1: Aan welke regelgeving is de aanplant, beheer en kap van KOH onderhevig?

Rotatielengte Ruimtelijke bestemming	Minder dan 3 groeiseizoenen	Meer dan 3 groeiseizoenen
Ruimtelijk Kwetsbaar Gebied (zie bijlage 1)	Begin bij punt 1	Begin bij punt 2
Agrarisch Natuurdecreet beschermd gebied (zie bijlage 2)	Begin bij punt 3	Begin bij punt 3
Niet-Agrarisch Natuurdecreet beschermd gebied (zie bijlage 2)	Begin bij punt 4	Begin bij punt 4
Ander gebied niet verbost[21]	Begin bij punt 5	Begin bij punt 5
Ander gebied verbost	Begin bij punt 1	Begin bij punt 2

1) Dit terrein/deze aanplant valt niet onder het Bosdecreet a. Het beheer van de KOH is niet vergunningsplichtig onder het bosdecreet zolang de aanplant binnen de drie jaar na de laatste exploitatie gerooid wordt en erna terug als landbouwgrond gebruikt wordt. De eindkap moet gemeld worden aan het ANB en de landbouwkundig ingenieur van Dienst Landbouw. (artikel 87 van het Bosdecreet) - Was de laatste exploitatie langer dan 3 groeiseizoenen geleden? Ga door naar 2. - Voor de aanplant is er mogelijk een vergunning nodig, ga hiervoor naar 3	2 3
2) Dit terrein/deze aanplant valt onder het Bosdecreet a. Voor de aanplant is er een gemeentelijke bebossingsvergunning nodig (Veldwetboek artikel 35 bis, §5). Je hebt een goedgekeurd beheerplan nodig voor het beheer en voor de eindkap moet er een omgevingsvergunning tot ontbossing aangevraagd worden met een bijhorend boscompensatie voorstel. Het gebruik van gewasbeschermingsmiddelen kan geregeld worden door de overheid (artikel 21 van het Bosdecreet).	6

[21] met houtopslag van minder dan 22 jaar

 doi.org/10.21436/inbor.85964562

Behoort de ruimtelijke bestemming ook tot "Kwetsbaar gebied natuur" (lijst in bijlage 2)? Ga door naar 2b b. Er mag geen gebruik gemaakt worden van bemesting (artikel 41bis van het Mestdecreet).	6
3) Dit terrein/deze aanplant valt niet onder het Natuurdecreet Het Natuurdecreet specifieert dat de maatregelen genomen voor de natuur in al de agrarische gebieden buiten de beschermingszones, de landbouwbedrijfsvoering of het teeltproces niet kunnen regelen. Toch is er voor aanplant mogelijk een <u>omgevingsvergunning voor het wijzigen van de vegetatie</u> nodig wanneer de reeds aanwezige vegetatie beschermd is. Indien het om een verpachte grond gaat, ga verder naar 7.	8 7
4) Dit terrein/deze aanplant valt onder het Natuurdecreet (z)KOH wordt gezien als natuur wanneer het niet in agrarisch gebied zit (ANB richtlijn 2006/01, titel I.1.13). Er is voor aanplant, oogst en eind-kap een <u>omgevingsvergunning voor het wijzigen van de vegetatie</u> nodig. Dit kan ook opgenomen worden in een beheerplan. Daarbovenop moet men nagaan of er een <u>omgevingsvergunning voor stedenbouwkundige handeling</u> nodig is voor beheersmaatregelen en de eindkap. (artikel 13 van het Natuurdecreet) Indien het om agrarisch gebied gaat, ga verder naar 5.	8 5
5) Dit terrein/deze aanplant is niet vergunningsplichtig KOH valt niet onder het Bosdecreet (Bosdecreet artikel 3, §2.4), noch onder het Natuurdecreet. In de meeste gevallen is er dus geen vergunningsplicht. Toch kan men best nagaan of er een <u>omgevingsvergunning voor stedenbouwkundige handeling</u> nodig is voor beheersmaatregelen en de eindkap. Indien het om agrarisch gebied gaat, ga verder naar 6.	8 6
6) Dit terrein/deze aanplant is eventueel onderhevig aan het Veldwetboek Agrarische- en bosgebieden zijn onderhevig aan afstandsregels wat betreft de aanplanting naast gebieden met een gelijke of andere	

bestemming. In de voor de landbouw bestemde gedeelten van het grondgebied is bosaanplanting verboden op minder dan zes meter van de scheidingslijn tussen twee erven; bovendien is vergunning van het college van burgemeester en schepenen vereist. Hetzelfde geldt voor niet-landbouw bestemde gronden die grenzen aan gronden bestemd voor de landbouw. Indien het om agrarisch gebied gaat dat verpacht wordt ga door naar 7.	8 7
7) Dit terrein/deze aanplant is onderhevig aan de Pachtwet Als pachter moet je een schriftelijke toestemming hebben van de verpachter om bomen aan te planten op de gepachte grond. Dit kan in principe van toepassing zijn op KOH, gezien het geen landbouwteelt is. Er bestaan ook compensatieregels voor het vermeerderen of verminderen van de waarde van het gepachte goed door de aanplant van bomen. (Artikel 28) Daarnaast mag de verpachter, indien die de pacht intrekt na afloop van de pachtperiode, in de daaropvolgende 9 jaar geen bomen planten op het perceel, tenzij het om tuinbouw gaat. Hierop kan bij de vrederechter wel een uitzondering gevraagd worden. (Artikel 10)	8
8) Dit terrein/deze aanplant is mogelijks onderhevig aan het Landschapsdecreet of het Onroerenderfgoeddecreet Het **Onroerenderfgoeddecreet** stelt in artikel 4.1.10 dat wanneer er een kap is van een onroerend goed, opgenomen in de vastgestelde inventaris van houtachtige beplantingen met erfgoedwaarde dit eerst moet goedgekeurd worden door Agentschap Onroerend Erfgoed.	9
9) Dit terrein/deze aanplant is mogelijks onderhevig aan lokale regelgeving die strenger is dan eerder aangegeven algemene regels Het is steeds aangeraden om voor uw specifieke geval de gemeente, het ANB, Agentschap Onroerend Erfgoed en het Departement Landbouw en Visserij te contacteren.	

 doi.org/10.21436/inbor.85964562

Bijlage 1: de Ruimtelijk Kwetsbare Gebieden.

De **Vlaamse Codex Ruimtelijke Ordening** artikel 1.1.2, 10° verstaat onder de Ruimtelijk kwetsbare gebieden

a) De volgende gebieden, aangewezen op plannen van aanleg:
   1) agrarische gebieden met ecologisch belang,
   2) agrarische gebieden met ecologische waarde,
   3) bosgebieden,
   4) brongebieden,
   5) groengebieden,
   6) natuurgebieden,
   7) natuurgebieden met wetenschappelijke waarde,
   8) natuurontwikkelingsgebieden,
   9) natuurreservaten,
   10) overstromingsgebieden,
   11) parkgebieden,
   12) valleigebieden,

b) Alsook gebieden, aangewezen op ruimtelijke uitvoeringsplannen, en sorterend onder één van volgende categorieën of subcategorieën van gebiedsaanduiding :
   1) bos,
   2) parkgebied,
   3) reservaat en natuur,
   4) het Vlaams Ecologisch Netwerk, bestaande uit de gebiedscategorieën Grote Eenheden
c) Natuur en Grote Eenheden Natuur in Ontwikkeling, vermeld in het decreet van 21 oktober 1997 betreffende het natuurbehoud en het natuurlijk milieu,
d) De beschermde duingebieden en de voor het duingebied belangrijke landbouwgebieden, aangeduid krachtens artikel 52, § 1, van de wet van 12 juli 1973 op het natuurbehoud

Bijlage 2: de Kwetsbare Gebieden Natuur

Het **Mestdecreet** artikel 41bis §1 luidt:

op landbouwgronden gelegen in [4 gebieden, aangewezen op gewestelijke ruimtelijke uitvoeringsplannen en sorterend onder de categorie van gebiedsaanduiding "**bos**" of "**reservaat en natuur**", definitief vastgesteld met toepassing van de Vlaamse Codex Ruimtelijke Ordening, elke vorm van bemesting verboden met uitzondering van bemesting door rechtstreekse uitscheiding bij begrazing, waarbij twee grootvee-eenheden (GVE) per hectare op jaarbasis worden toegelaten.

En artikel 41ter §1:
niet-intensieve graslanden in bosgebieden, zoals aangeduid op de plannen, vastgesteld met toepassing van het decreet betreffende de ruimtelijke ordening, gecoördineerd op 22 oktober 1996, en op landbouwgronden gelegen in **natuurgebieden, natuurontwikkelingsgebieden of**

natuurreservaten zoals aangeduid op de plannen vastgesteld met toepassing van het decreet betreffende de ruimtelijke ordening, gecoördineerd op 22 oktober 1996, elke vorm van bemesting verboden met uitzondering van bemesting door rechtstreekse uitscheiding bij begrazing, waarbij twee grootvee-eenheden (GVE)per ha op jaarbasis worden toegelaten.

Bijlage 3: Natuurdecreet beschermde gebieden

Artikel 13, § 4 en § 5 van het Natuurdecreet stelt dat een omgevingsvergunning nodig is voor het wijzigen van de vegetatie of KLE in de volgende gebieden[22]:

1) Groengebieden,
2) Parkgebieden,
3) Buffergebieden,
4) Bosgebieden,
5) Natuurontwikkelingsgebieden,
6) Valleigebieden,
7) Brondgebieden,
8) Agrarische gebieden met ecologisch belang of waarde,
9) Agrarische gebieden met bijzondere waarde,
10) Alle gebieden met een vergelijkbare bestemming als al de voorgaande opgesomde gebieden.

Alsook voor het wijzigen van KLE en hun vegetatie in de volgende gebieden:

11) Landschappelijk waardevolle agrarische gebieden,
12) Agrarische gebieden,
13) Alle gebieden met een vergelijkbare bestemming als al de voorgaande opgesomde gebieden.

Bijlage 4: ANB interne richtlijn over KOH

ANB richtlijn 2006/01, titel I.1.13 stelt:

"Deze aanplantingen (red: bedoeld wordt "KOH en wissenteelt") horen eerder in de landbouwsfeer thuis, waar overigens landbouwmethodes als besproeiing en bemesting gangbaar zijn. Vandaar dat uitzondering gemaakt wordt voor de korte omloop-houtteelt, dit evenwel beperkt tot deze teelten die geplant worden op daartoe geëigende (in principe agrarische) bestemmingen."

Bijlage 5: Definitie van vegetatie volgens Omzendbrief LNW/98/01

Omzendbrief LNW/98/01 vermeldt:

"Onder vegetatie moet worden verstaan : de natuurlijke en halfnatuurlijke begroeiing met alle spontaan gevestigde kruid-, struweel- en bosbegroeiingen, en dit onafhankelijk van het feit of het abiotisch milieu al dan niet door de mens beïnvloed of gevormd is. Het betreft zowel

[22] Doorstreping van gebieden wijst erop dat deze al in de Vlaamse Codex Ruimtelijke Ordening genoemd werden als kwetsbare gebieden en een KOH op deze gebieden de facto al onderhevig is aan het meer stringente Bosdecreet. Hierdoor moeten de vergunningen van het Natuurdecreet niet meer aangevraagd worden.

 doi.org/10.21436/inbor.85964562

begroeiingen in het water als op het land. Ook bossen worden ertoe gerekend onafhankelijk van het feit dat de boomlaag is aangeplant of niet.”

Annex 2: Interview list and questions

Field visits: 2 farmers and 1 SRC company (Phitech)

Interviews (online):

- Academia (UGent, UAntwerpen)
- Research Institute (INBO, VITO)
- Civil society (Bond Beter Leefmilieu, Bosgroepen)
- Government (EWI, VLM)
- Energy industry (2Valorise)

Question 1. Which factors influence the profitability of SRC

Question 2. What are the (potential) positive effects of SRC on the quality of the environment (ES, biodiversity, landscape, living environment)?

Question 3. What are the (potential) negative effects of SRC on the quality of the environment?

Question 4. Who are in favour and who are opposed to SRC in Flanders and why?

Question 5. What other woody biomass flows could be used for bio-fuel production?

Question 6. What are the advantages and disadvantages of these alternatives compared to SRC?

Question 7. Are these alternatives more feasible than SRC (in terms of availability and impact)?

Question 8. Which other persons would be interesting to have this conversation with?