Wageningen UR
(University & Research centre)

For quality of life

Jan E. G. van Dam

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BioBased Economy

Wageningen UR mission

‘To explore the potential of nature to improve the quality of life’

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Three partners

Wageningen University

Nine applied research institutes

Van Hall Larenstein University of Applied Sciences

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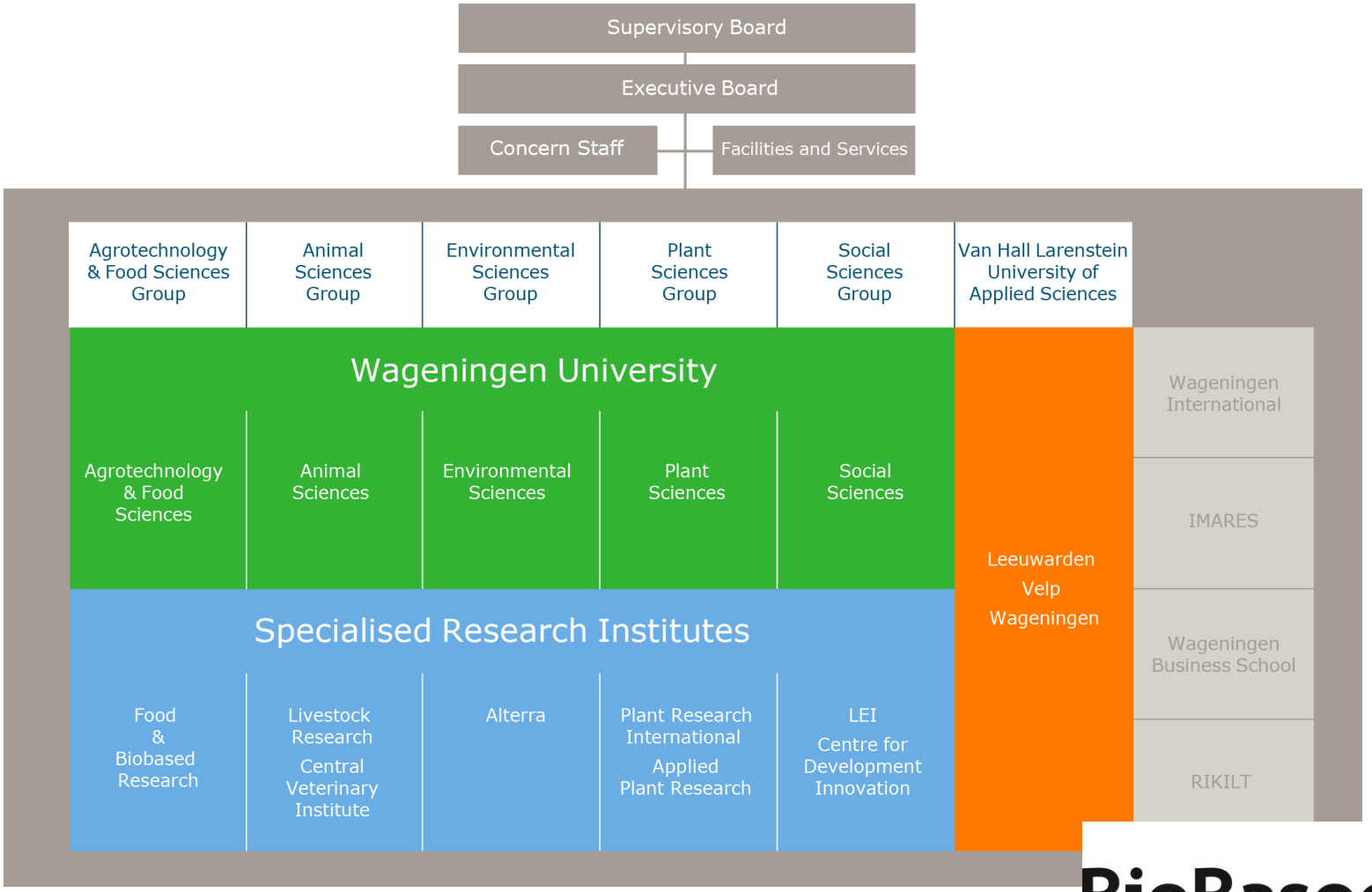
Organisational structure



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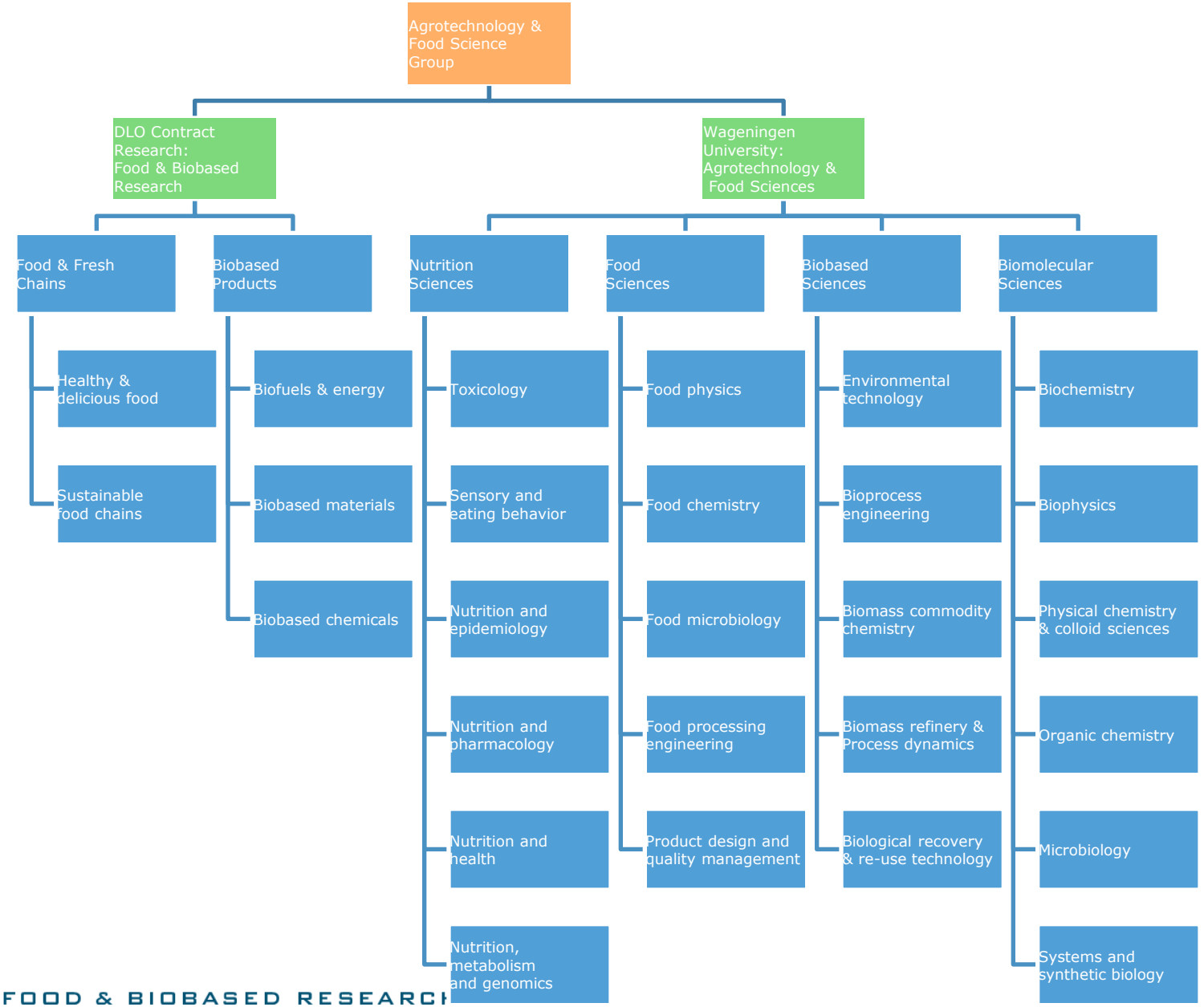

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Kenaf fibre crop for bio-economic industrial development

Jan E.G. van Dam

10-10-2012

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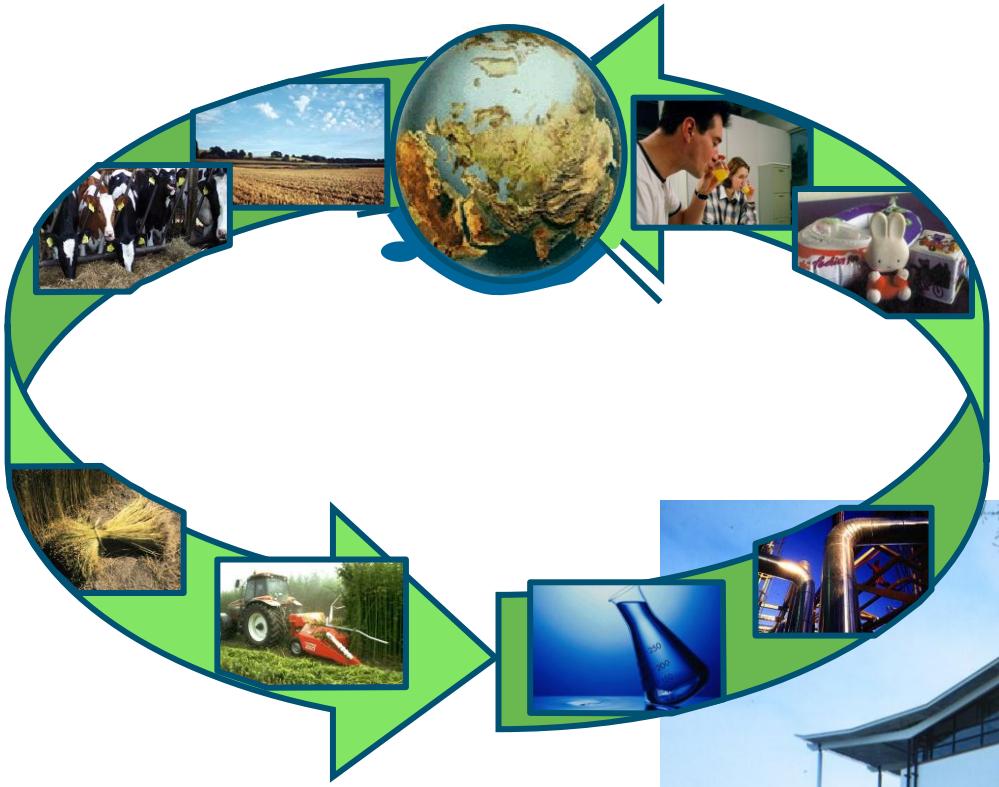
Biobased products at Wageningen UR



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Biobased Products

- Development of:
  - industrial processes
  - industrial products
- Based on:
  - renewable (plant, animal, micro-organism) based resources
  - 'Green' chemistry

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Expertises Biobased Products

- Sustainable logistics & chains
- Biomass production and pretreatment
- Proteins, lipids and carbohydrates
- Biobased materials
- Biobased chemicals
- Bio-fuel technologies

Biobased Products and Fibre crops

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- Bio-refinery for green materials, green chemistry and sustainable production
- Fibre and cellulose projects for CO_2 neutral product development
- Application research flax, hemp, jute, **kenaf**, abaca, ramie, cotton, bamboo, straws,
  - Quality supply chain: Agronomy – processing – end-use
  - Extraction / degumming technology
  - Processing / Modification

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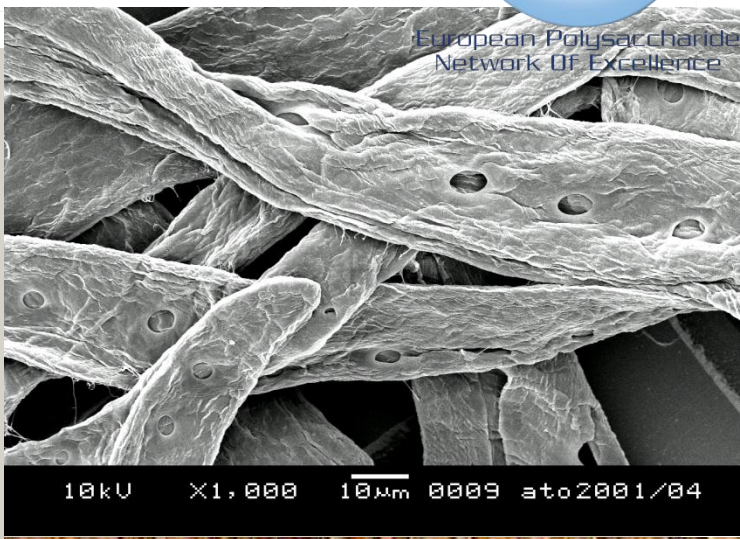
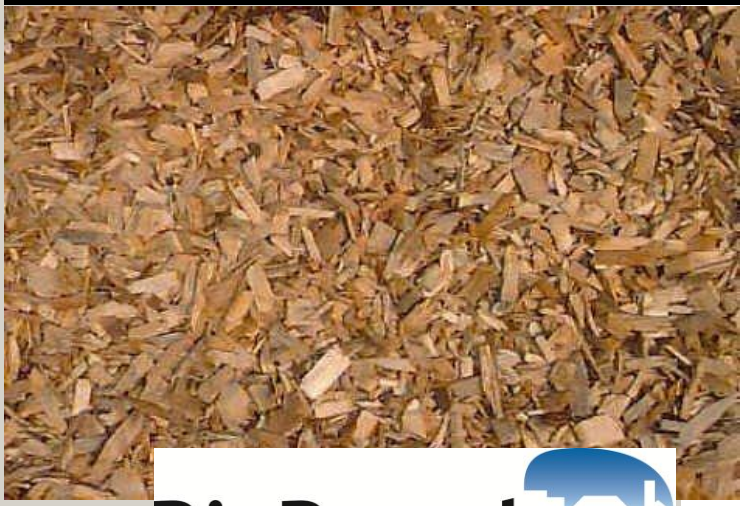
Cellulose fibre feedstock

- Raw material choice:
  - virgin, recycled, wood or non-wood fibres
- Fibre analysis
  - chemical, physical, morphologic
- Refine to valuable components
  - fibre, dissolving cellulose, lignin, chemicals, glues, energy





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Cellulose feedstock

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- Primary cellulose
  - Wood and Fibre crops
- Secondary cellulose (residues)
  - Forestry and agro-food production
- Tertiary (recycled) cellulose
  - Municipal waste
  - Recycled paper
  - Recycled textiles
  - Building waste

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Cellulose quality specifications

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- crystalinity (amorphous, crystal type),
- Polymerisation degree (DP),
- fibredimensions (length, diameter),
- purity (α-cellulose, % hemicellulose, lignine, pectines, silica, fats, ..),
- porosity, colour,
- surface properties (hydrophobicity),
- mechanical strength properties
- water absorbency, water retention, etc.

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Markets and developments

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- Textiles
- Non-woven
- Wood, timber
- Pulp, paper and board
- Cellulose dissolving pulp
- Cellulosic films, plastics & derivatives
- Building materials
- Cellulosic fibre Composites
- Lignocellulosic Biorefinery & green chemicals

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Cellulose production

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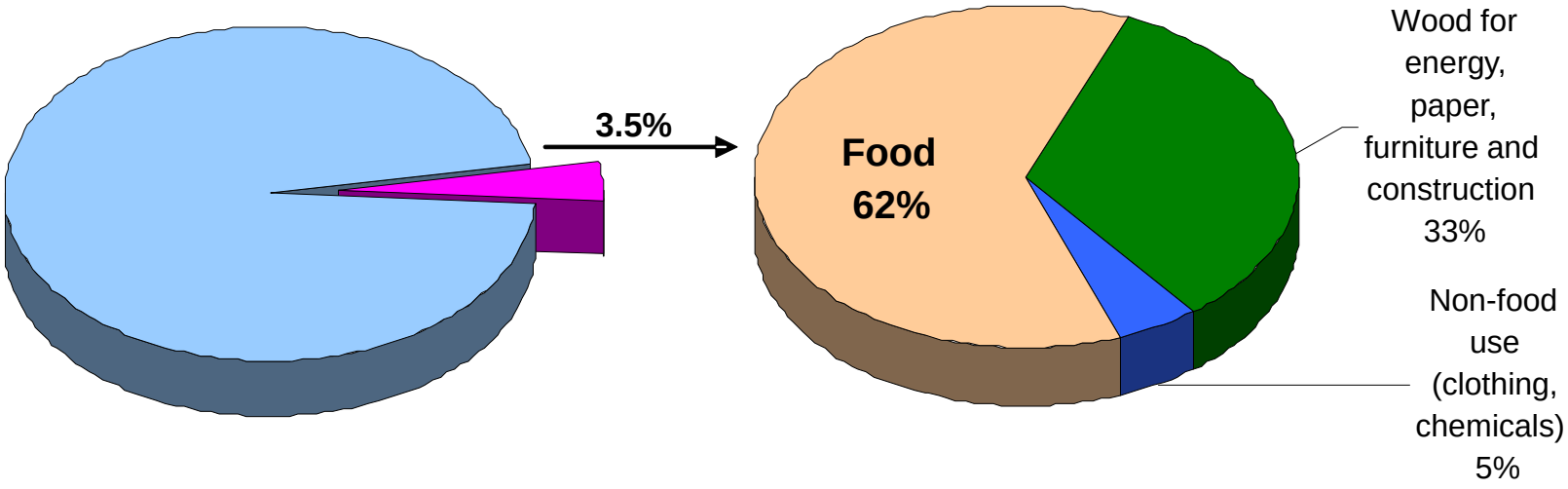
World production biomass
170×10^9 t / y

Human consumption
6×10^9 t / y



Cellulose $50\text{-}70 \times 10^9$ t/y

Non-food 2.3×10^9 t / y

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Cellulose price increase 2011

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Straw	50-100	€ / ton
Wood chips	100	
Pulp	650-900	
Raw hemp	350 - 650	
Flax	1500-1800	
Raw cotton	1700 - 2500	
Dissolving cellulose	1750	
Viscose / rayon	2000	
Celluloid	3300	

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Cellulose feedstock

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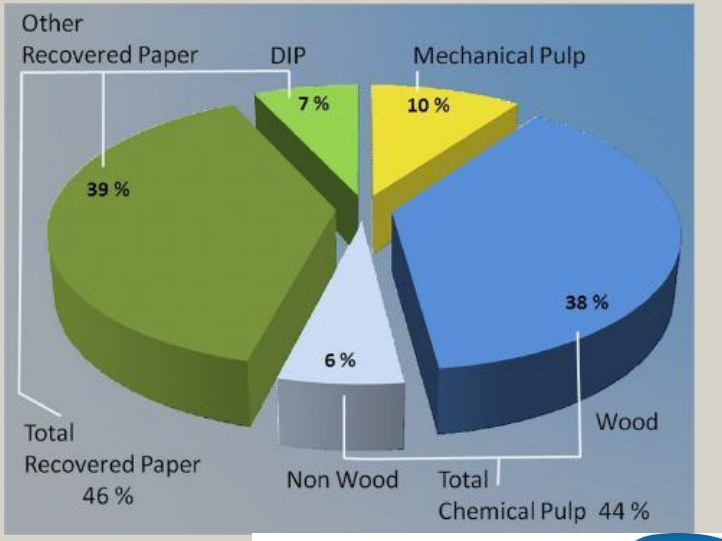
- Shift of market demand for cellulose
  - Carbohydrate source for 2e generation bio fuels
  - Biorefinery and 'green chemistry

- Effects on paper industries:
  - Digitalisation
  - Interest for alternative
  - fibre sources



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Cellulose production

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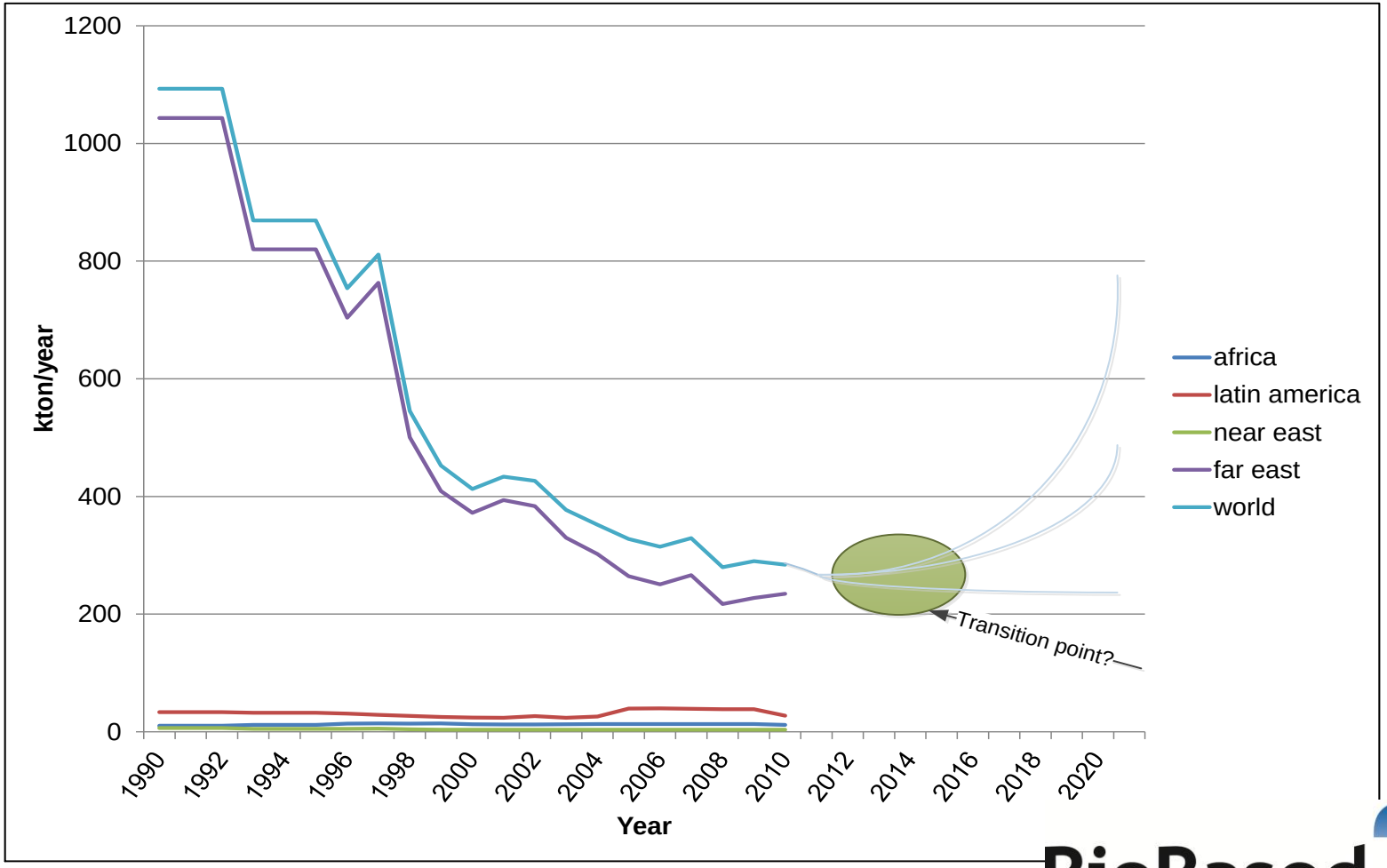
cellulosic fibres	10^3 ton/yr	major producing countries
cotton	25.000	China, Brazil, India, Pakistan, USA, Uzbekistan
flax	300	EU, China
hemp	90	China, EU
jute	2.500	Bangladesh, India
kenaf	350	China, Thailand
ramie	280	China, Brazil
abaca	70	Philippines, Ecuador
coir	500	India , Sri Lanka
sisal	300	Brazil, Kenya, Tanzania

Kenaf production decline



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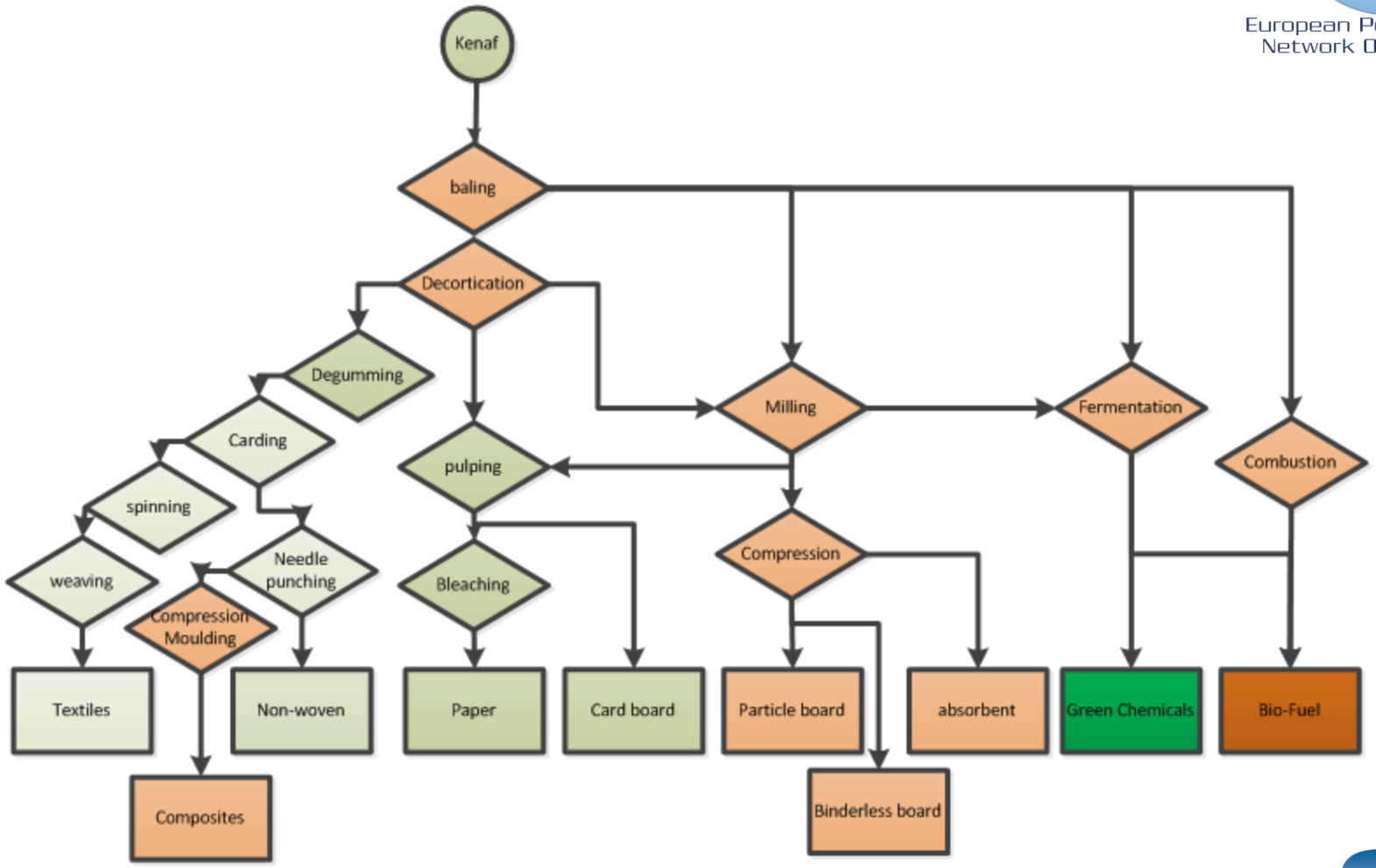
Kenaf post-harvest processing



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Fibre crops that matter

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- Cotton
- Flax
- Hemp
- Kenaf
- Jute
- Sisal
- Coir
- Abaca

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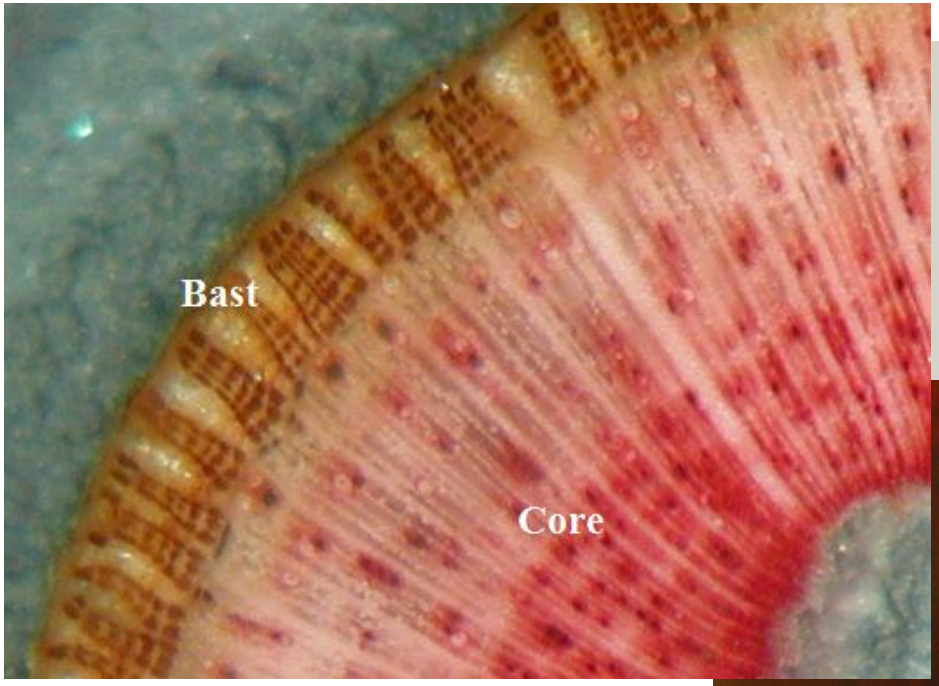
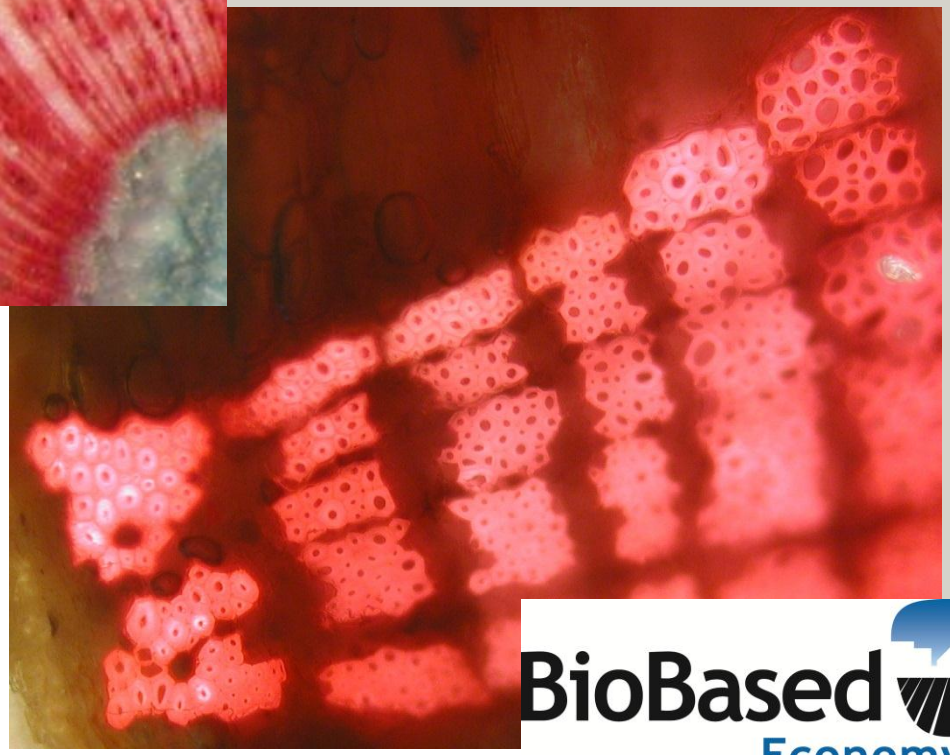
Morphological properties of fibres

Fibre	Length (mm)		Diameter (μm)	Fineness
	Technical	Elementary	Elementary	(denier)
Cotton		15-56	12-25	
Flax	300-900	13-60	12-30	1.7-17.8
Hemp	1000-3000	5-55	16-50	3-20
Kenaf	**900-1800**	**1.5-11**	**14-33**	**50**
Jute	1500-3600	0.8-6	5-25	13-27
Ramie	>1500	40-250	16-125	4.6-6.4
Nettle	190-800	5-55	20-80	
Abaca	1000-2000	3-12	50-280	38-400
Banana	450-1000	2.7-5.5	50-250	55-95
Sisal	600-1000	0.8-8	100-400	
Pineapple	750-1000	5-6	3-8	
N Zeal flax		3.2-10	10-20	
Coir	150-350	0.3-1.0	12-24	
Miscanthus		1.6		
Esparto		0.5-3.5	9	

Kenaf microscopic image





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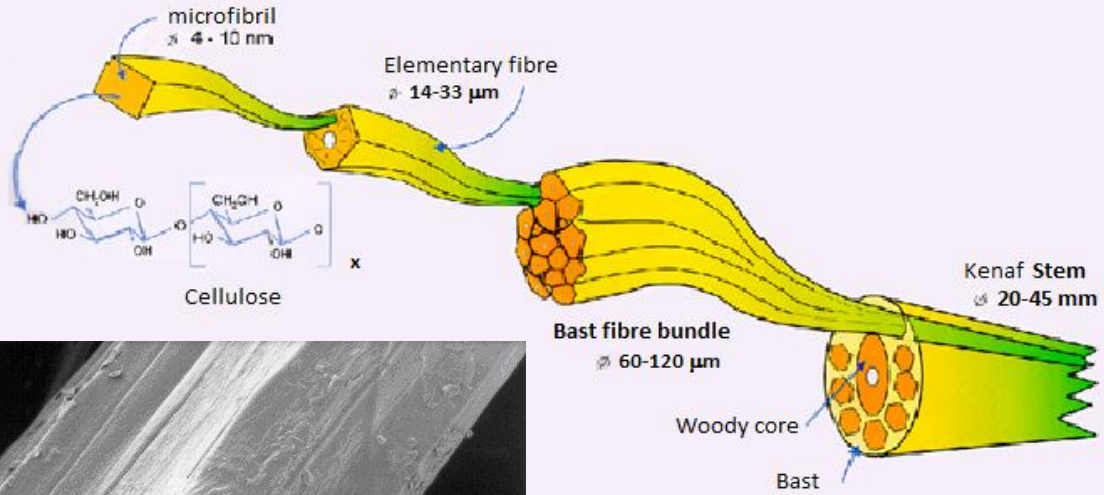
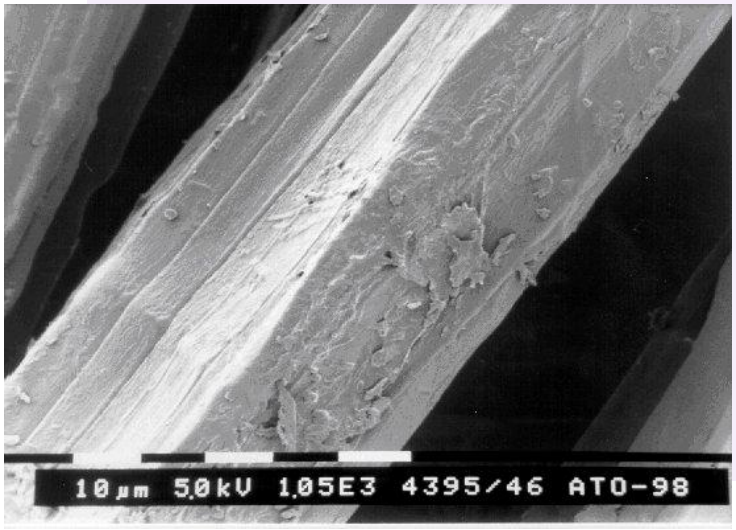
Kenaf fibre bundle





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Chemical composition of fibres

	Cotton	Flax	Hemp	Kenaf	Jute	Ramie	Abaca	Sisal	Coir
Ara	0.3	0.7	0.8	0.4	0.4	0.3	0.6	1.2	1.0
Xyl	0.2	1.0	1.2	13.3	9.2	0.3	10.9	16.2	14.4
Man	0.1	4.1	4.3	0.8	0.7	1.2	0.3	0.1	0.1
Gal	0.2	3.7	2.4	0.5	0.4	1.9	0.2	0.2	0.4
Glc	91.2	72.4	70.1	**56.2**	59.4	76.6	61.4	44.8	34.6
Rha	0.0	0.3	0.3	0.3	0.1	0.7	0.1	0.0	0.2
UA	2.2	3.2	2.8	5.1	2.5	3.0	.4.3	1.9.	5.2
Lignin	0.4	2.9	3.8	9.4	14.6	0.5	10.3	21.9	34.9
Ash	1.6	1.8	4.1	1.5	0.7	4.2	1.0	0.8	1.3

Fibre reinforced composites

- Agrofibre compounds for injection moulding
- Biopolymers
- Cement composites /light weight construction
- Fibre boards and panels

Injection moulded products from natural- fibre/plastic granules

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Composites in automotive applications

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- Non-woven mats combined with plastics.
- LCA advantage weight reduction

Source hempflax

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Fibre composite market

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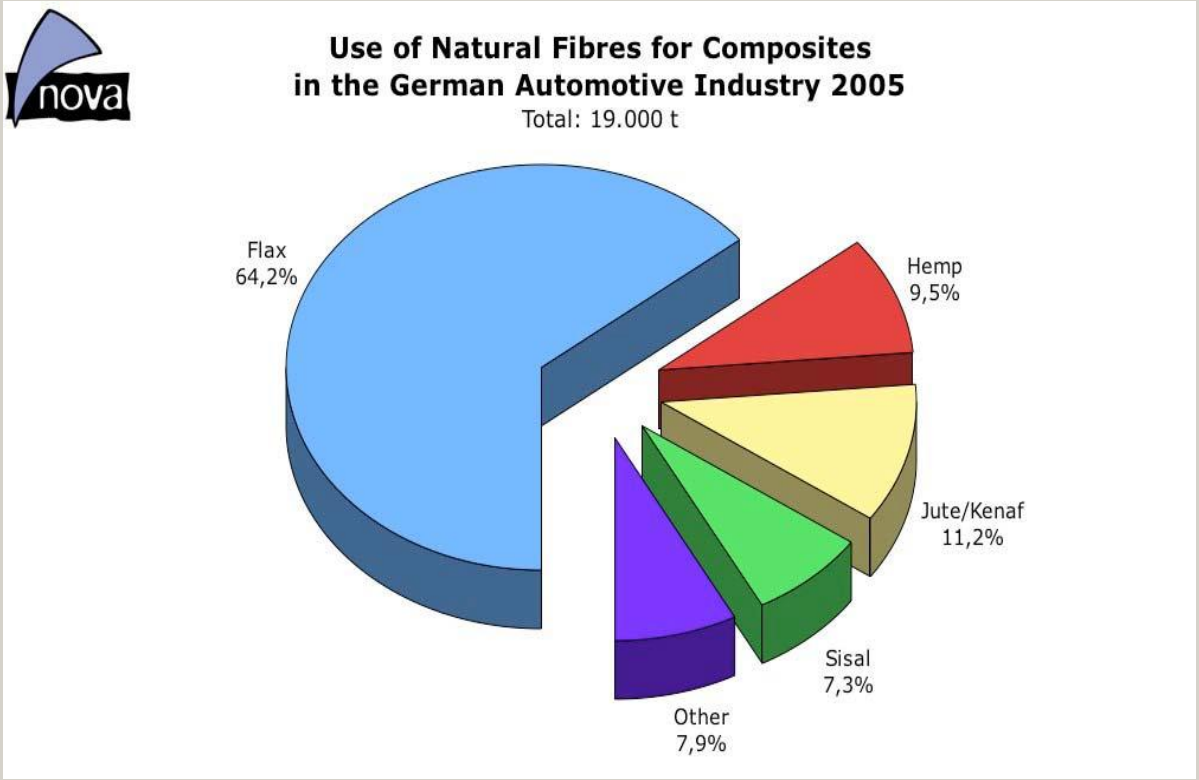

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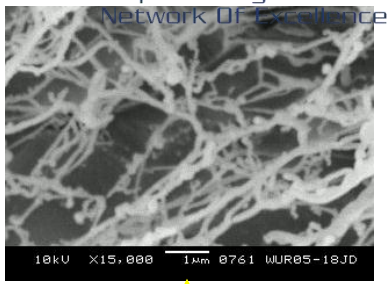
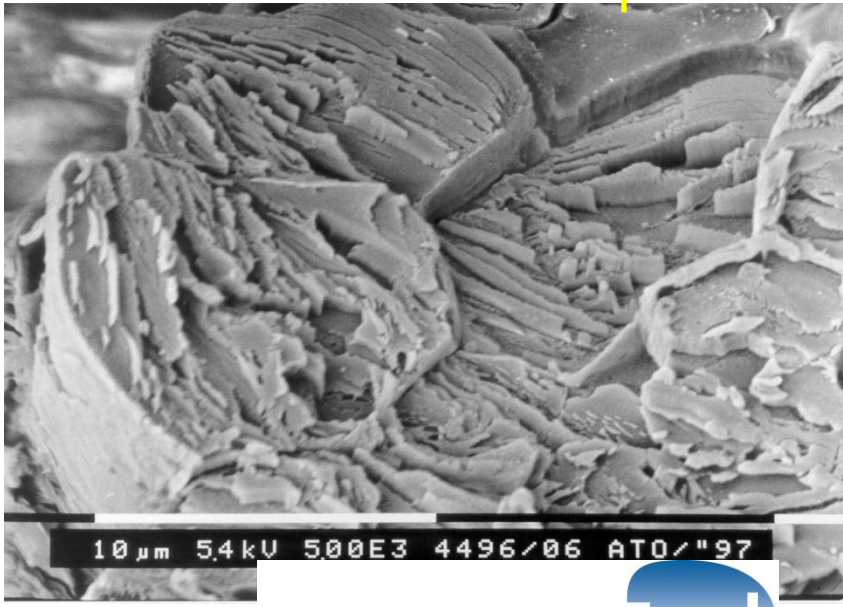
Markets kenaf products

Product	fibre form	fibre price range €/ton
Sacking, hessian, canvas	woven fabric / textile	High 800-2000
Ropes, cordage	twined	500-900
Composites	fabric / non-woven / chopped fibre	300-500
Non-woven tissue	non-woven	200-400
Geotextile	nets, non-woven	-
Insulation	non-woven	-
Paper and board	pulped	400-650
Fibre boards	refined / milled / chipped	-
Absorbent (moisture / oil)	core particles / non-woven	-
Green chemicals	fermented and biorefined	50-100
Bio-fuel, activated carbon	combustion and carbonized	-
Mulch, compost	composted	50-100

Polymer and Fibre Technology

- Nanofibre from cellulosic pulp
- refiner conditions
- properties
  - Diameter 50-100 nm
  - High specific surface
  - High strength and modulus
  - Translucent
  - Durable
  - Biodegradable (moist)
  - Renewable, CO_2 neutral
- Chemical modification
  - adhesion





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Economic feasibility

- Market demands
  - Technical performance / availability
- Cost of processing / modification
  - Acceptable costs range of treatment
  - Investment for implementation
- Economic scale of fibre processing / modification

Conclusions

- The use of kenaf in different consumer products has been demonstrated
- When supplies of kenaf raw materials match the demand of industries it may play a significant role in the bio-economic developments

Thank you
for
your
attention

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