



## Introduction

- Biofuels have the potential to reduce reliance on fossil fuels while reducing environmental impacts and greenhouse gas emissions.
- Biofuel makes a small contribution to our energy demand while fossil fuels contribute approximately 87 percent of energy, having a negative impact of increase in global warming.
- To limit global warming, biofuel production should be increased. This would require large scale deployment of biofuel feedstock production and advanced technologies in biofuel production.
- The food versus fuel debate calls into question the ethics of diverting land from food to biofuel production.

## Food versus Fuel

- Bioenergy production from first generation (edible) biofuel feedstock may compete with food production and as a consequence affect food security.
- A shift towards increasing production of second generation (non-edible) biofuel feedstocks and third generation biofuels along with advanced technologies of genetically engineered algae biomass would avoid the competition for food.
- Food and bioenergy need not compete for land, instead, biofuel crops should be integrated into existing landscape and agricultural lands in a multifunctional approach to improve use as food, fuel and for other ecosystem services.



## Biomass Feedstock



**1<sup>st</sup> Generation**

### Edible biomass

- Starch crop (Wheat, corn)
- Sugar crops (Sugarcane, sugar beet)
- Oil seed crop (Oil palm, rapeseed)



**3<sup>rd</sup> Generation**

### Algae biomass

- Microalgae
- Macroalgae
- Genetically engineered algae



**2<sup>nd</sup> Generation**

### Non-edible biomass

- Perennial energy crop (e.g., Willow, Poplar)
- Short rotation forestry crops (Eucalyptus)
- Agricultural residues (wheat straw, rice husk)
- Forestry residues (Forest thinning, saw dust)



**4<sup>th</sup> Generation**

## Implication of use of feedstock for biofuel

<ul style="list-style-type: none"> <li>• Impact on food security due to competition for direct land use.</li> <li>• Deforestation and increases in greenhouse gas (GHG) emission.</li> <li>• Loss of biodiversity.</li> <li>• Compete for water resources.</li> </ul>	<ul style="list-style-type: none"> <li>• Production may not have direct impact on food production since they are grown for different purposes, mainly for animal feed production.</li> </ul>
<ul style="list-style-type: none"> <li>• Do not compete for food.</li> <li>• Produce high amounts of biomass and environmental benefits.</li> <li>• Generate negative emissions using carbon capture and storage (BECCS).</li> </ul>	<ul style="list-style-type: none"> <li>• Planting on marginal land avoids competition for land use and food.</li> <li>• Integrate into existing landscape and agricultural lands in a multifunctional approach to offer multiple benefits including use as fuel and other ecosystem services.</li> </ul>
<ul style="list-style-type: none"> <li>• No competition for food and land.</li> <li>• Do not require arable or big land area for production.</li> <li>• Carbon sink source.</li> </ul>	<ul style="list-style-type: none"> <li>• Promising sustainable biofuel feedstock due to high biofuel productivity and ability to capture large amounts of carbon dioxide</li> <li>• Research ongoing.</li> </ul>
<ul style="list-style-type: none"> <li>• No competition for food and land.</li> <li>• Do not require arable or big land area for production.</li> </ul>	<ul style="list-style-type: none"> <li>• Sustainable biofuel feedstock in future, due to high biofuel productivity and ability to capture large amount of carbon dioxide.</li> <li>• Early stages of technology development.</li> </ul>