Towards developing a new Mangrove Silvicultural System in India for short rotation biomass production

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A true mangrove

- Assemblage of tropical trees and shrubs of the intertidal zone, ability to form pure stands - Avicennia officinalis, Sonneratia apetala, Sonneratia caeseolaris, Rhizophora mucronata, Excoecaria agallocha, Hertiera fomes, Ceriops decandra, Ceriops tadal, Bruguiera gymnorrhiza
- Morphological and physiological specialization for adaptation to the habitat
- Taxonomic isolation from terrestrial relatives,
- Structural attributes of species richness, canopy height, basal area, tree density, and understory relate to salinity, tidal fluctuation, sedimentation, and wave energy
- Primarily based on a detrital food web but a herbivoral food web also exists

Distribution of mangroves in India

Total spread 474000 ha

Increased from 404600 ha in thirty years

Comparison of height and density per ha

Source: Upadhyaya & Mishra, *Proc Indian Natn Sci Acad* **80** No. 3 September 2014

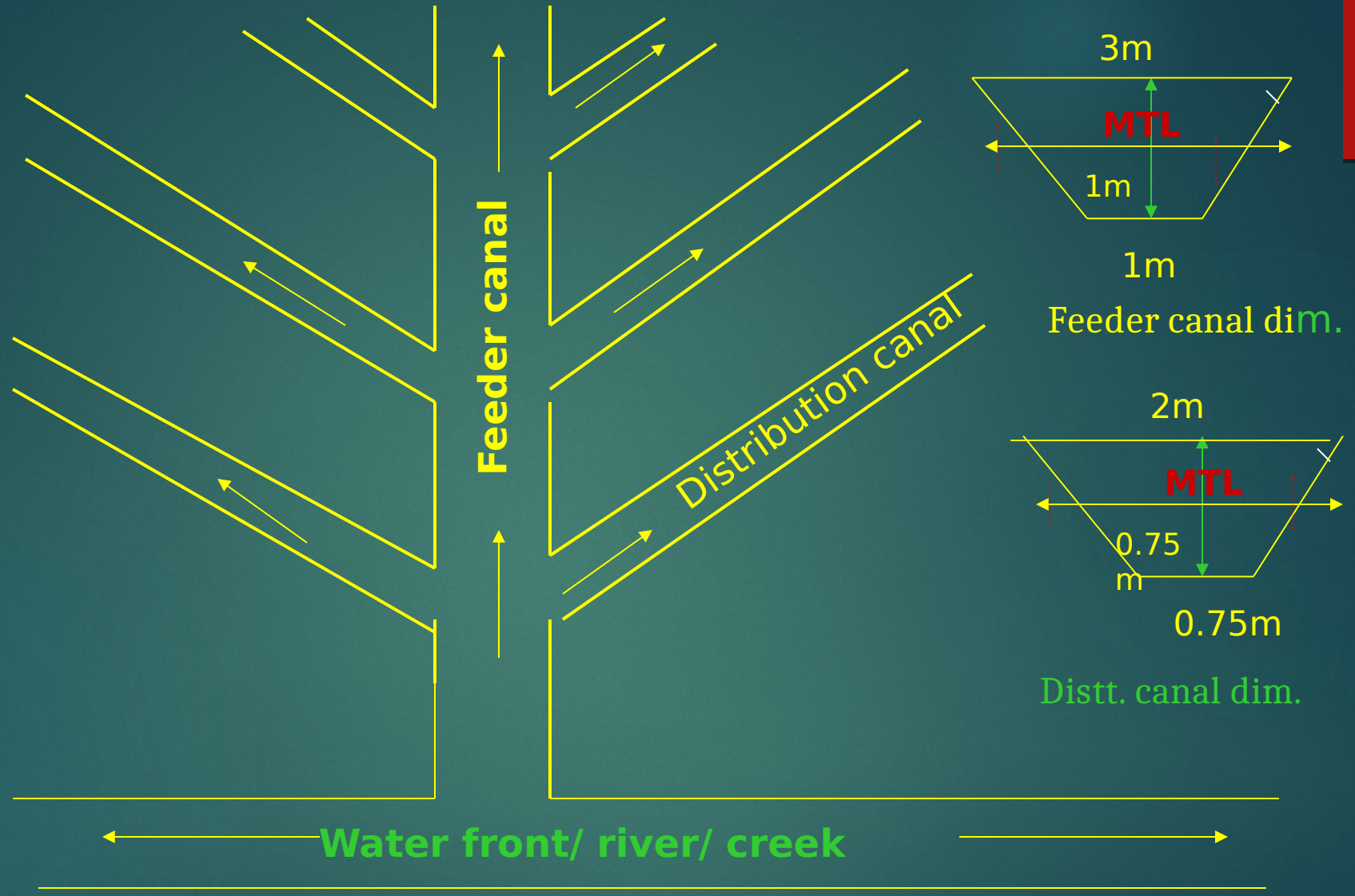
Latitude (^{0})	Height (m)	Density/ ha.	Major species	Locality	Authors
1.2	21.3	Data not available	*Sonneratia spp.*	Indonesia	Komiyama *et al*. (1998)
1.2	22.3	,,	*R. apiculata*	,,	Komiyama *et al*. (1998)
1.2	22.4	,,	,,	,,	Komiyama *et al*. (1998)
1.2	15.5	,,	,,	,,	Komiyama *et al*. (1998)
1.2	26.4	,,	*B. gymnorrhiza*	,,	Komiyama *et al*. (1998)
5	15	,,	*R. apiculata*	Malaya	Ong *et al*. (1981)
8	11	,,	*R. apiculata*	Thailand	Christensen (1978)
8.2	3.9	,,	*Rhizophora spp.*	Sri Lanka	Amarasinghe & Balasubramanium (1992)
8.2	7.2	,,	,,	,,	Amarasinghe & Balasubramanium (1992)
8.2	10.3	,,	,,	,,	Amarasinghe & Balasubramanium (1992)
12	12.5	,,	*R. mucronata*	Andaman Island *R. apiculata*	Mall *et al*. (1991)
12	22.5	Data not available	*B. gymnorrhiza*	Andaman Island *C. teal*	Mall *et al*. (1991)
20	5.07	7186	*H. fomes* *E. agallocha*	Dangmal bock Bhitarakanika, Orissa	Present study
20	4.11	13536	*E. agallocha* *C. decandra*	Kakranasi bock Bhitarakanika, Orissa	Present study
20	4.70	16094	*E. agallocha* *C. decandra*	Thakurdia bock Bhitarakanika, Orissa	Present study

Reproductive strategies

- Mangroves have limited capacity for vegetative propagation though Avicennias do coppice
- Primarily dependent on seedlings for forest maintenance and spread: hydrochory and vivipary
- Vivipary increases the chances of successful establishment in an unpredictable environment that inhibits germination of seeds
- Salinity not a requirement for growth, most mangroves can grow in freshwater, but freshwater species more adapted to those conditions usually overwhelm them

Restoring degraded and destroyed mangroves

- Area under mangroves in India barely half of the potential lands converted to other uses over past 100 years
- Raising mangroves by planting mangrove propagules on the banks of canals formed in degraded mangrove areas
- “artificial treatment of 10% of a degraded area induces natural regeneration in the remaining 90% through the process of ecological succession”
- Step 1: A network of canals are formed in a degraded area
- Step 2: The canals are allowed to be flushed by tidal water for about two to three months to reduce soil salinity
- Step3: Mangrove propagules are planted on the canal banks along the Mean Tide Line



Modified Fishbone design of Feeder and Distribution canals with Dimensions

View of canals formed in a degraded area in Fishbone design

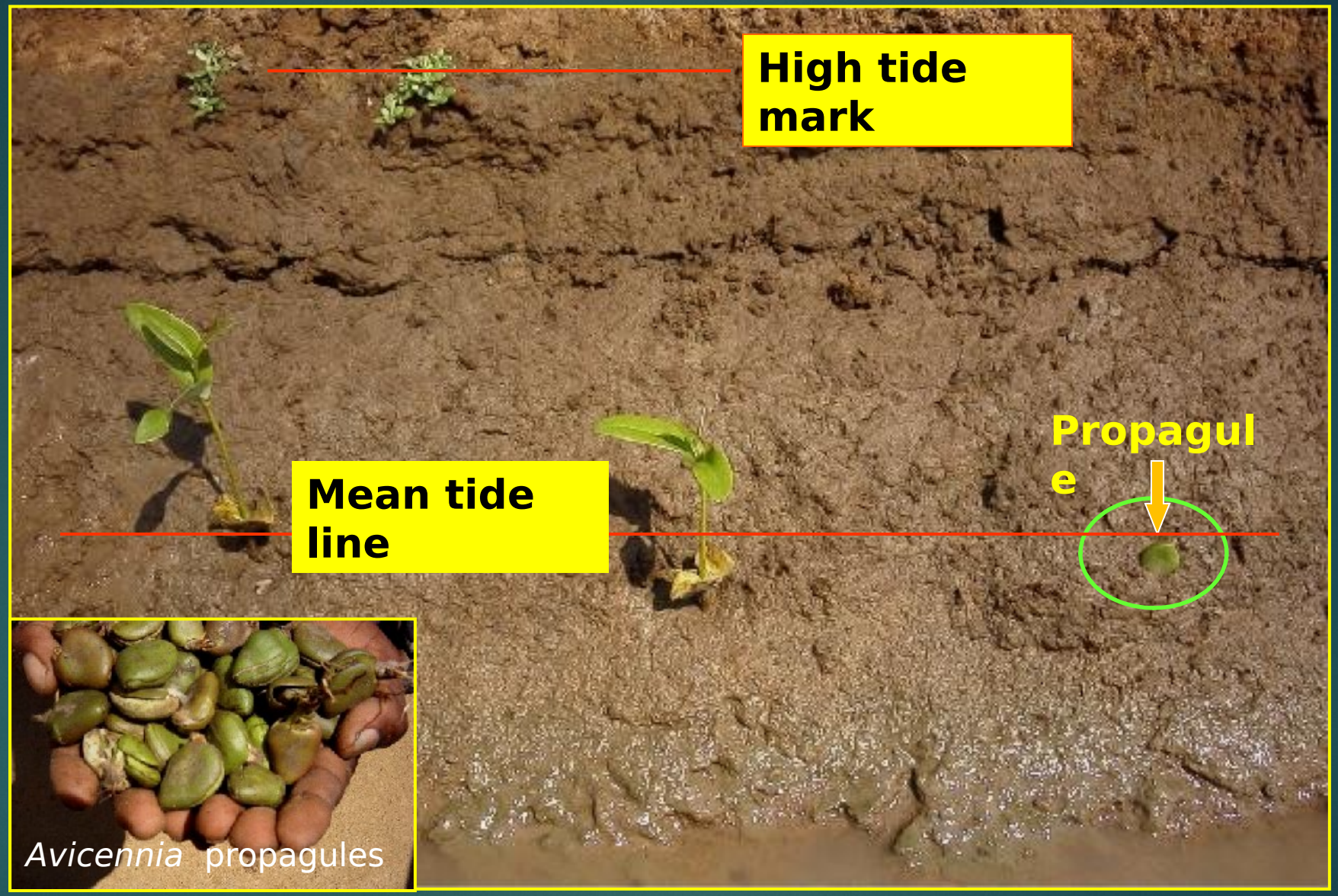
Feeder and Distribution canals in Modified Fishbone design

View of a Feeder canal

Top width: 3m; Bottom width: 1m; Depth: 1m

View of a Distribution canal

Top width: 2m; Bottom width: 0.75m; Depth: 0.75m



Planting of propagules along MTL

A two-year old canal bank plantation

3 year old canal bank plantation

Same plantation after 5 years

Aerial view of canals laid in Modified Fishbone design

Technology is available but further extension is slow

- Extension possible if coastal landowners become enthusiastic about planting mangroves in their lands under rice and salt production
- Reluctant because mangroves' ecological services benefit fishermen only rather than coastal landowners
- Joint Forest Management also does not work for the same reason (except in Sunderbans where NTFP are significant)

A no harvesting regime!

- Mangroves are usually not allowed to be harvested. Most felling illegal
- Even hygienic felling not permitted. In Sunderbans *Hertiera fomes* has declined by 79% since 1959 and 70% remaining affected by ‘top dying’ (due to increased salinity?).
- Dramatic declines in *Excoecaria agallocha* and *Xylocarpus mekongensis* also reported (Sarker et al, 2016)
- But affected trees can not be removed

Is harvesting possible ?

- Is harvesting possible without affecting ecological services?
- Will it help increase the productivity - and thereby enhance mitigation of climate change?
- Without increasing vulnerability of the ecosystem as well as of the communities?

Yes, if

- the harvesting can be confined to areas outside national parks and sanctuaries for biodiversity conservation
- Belowground biomass remains largely unaffected by harvesting
- Openings created by felling are filled up with natural or planted regeneration immediately
- The mangrove stock could be kept young and vigorous and yet almost fully stocked

Proposed system for Point Calimere

- *Avicennia* dominated
- Coppices reasonably well first time but vigor goes down sharply with subsequent felling
- Excellent biomass for fuel and charcoal. Best harvested at 8 to 10 years depending upon site productivity
- Harvesting by clearfelling over squares (<1ha) in a chess board pattern
- Harvesting about 4 months after natural seed regeneration
- Intensive post harvest management- suppression of coppice where sturdy natural regeneration is present
- Thinning in the 3rd, 5th year – fuelwood

Possible approaches in Bhitarkanika and Sunderbans

- Most areas under national parks and sanctuaries where no harvesting can be permitted
- Harvesting possible only around villages in specifically assigned areas
- For fuel and small timber for housing and boats
- First hygienic felling of all dead and dying trees in the area assigned to village
- Identification of sturdy pole sized regeneration of all species

A silviculture around regeneration

- Marking of trees around these identified regeneration the removal of which would free them to grow fast
- Harvesting of marked trees over a five year felling cycle
- Post harvest care of identified regeneration – ensuring free space to grow

Conclusions

- Younger trees are more resilient to changes in climate and less vulnerable to insects and diseases
- Policy of no harvesting in mangroves would render them old and more vulnerable to global warming
- Appropriate site specific silvicultural approaches to keep these mangroves in vigorous condition, while also meeting the timber and fuel demands, are needed
- These approaches should not diminish the ecological services offered by the mangroves

Thanks