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REVIEW OF LITERATURE ON SOIL CARBON AND PLANT DIVERSITY IN AGROFORESTRY SYSTEMS OF CALCAREOUS SOILS UNDER SALINE WATER IRRIGATION

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Abstract: Agroforestry traditionally includes trees under different systems, including silvopastoral, agrisilvicultural, agrosilvopastoral systems (Nair et al., 2009). The components of these systems include perennials such as trees and shrubs, crops and other herbaceous species, and animals. Agroforestry practices include woodlots, dispersed, hedgerows, boundary planting, home gardens, taungya among others. In addition to climate regulation function (through carbon sequestration), tree in agroforestry contribute to soil protection, water regulation, enhancement of local climate conditions, reduces impacts on natural forests and other environmental benefits (Mbow et al., 2014b). Integration of trees on farms has also been shown to improve land productivity and resilience of households through provision of diversified products for sustaining livelihoods (Kahiluoto et al., 2014; Lasco et al., 2014; Mbow et al., 2014a).

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Introduction:

In spite of the high potential of agroforestry systems to generate ecosystem services, they have received disproportionately lower attention than forest ecosystems (Kumar and Nair, 2004; Mcneely and Schroth, 2006). Limited data on the contribution of agroforestry systems to C sequestration in subSaharan Africa and the lack of easily adoptable methodologies and verification process of C sequestration undermine smallholders' potential for sequestering carbon (Kahiluoto et al., 2014). Robust methods for carbon accounting are needed for estimating changes in carbon pools over time and ascertaining the role of agroforestry as an alternative strategy for C sequestration. It is therefore timely, that our current understanding of agroforestry is evaluated and its realistic potential as a biological approach to C sequestration assessed. In this review, we sought to comprehensively review the existing literature and studies done within agroforestry in order to (1) analyse the need for carbon stock determination within agroforestry; (2) relationship between tree diversity on lands and carbon stocks and (3) determine tree biomass and soil carbon stocks within agroforestry systems. In doing so, we aim to provide synthesis of relationship between tree diversity on farmlands and tree biomass and provide an overview of carbon stock and stock changes determination on farmlands with an aim of providing a gap that future research can be done for accurate carbon determination.

Throughout the Globe several workers studied the plantation forests to understand their ecological consequences. Moir (1966) studied the influence of Ponderosa pine on herbaceous vegetation. Sydes & Grime (1981a, b) studied the effects of tree leaf litter on herbaceous vegetation in deciduous woodlands. Hill & Stevens (1981) worked on the density of viable seeds in soils of forest plantations in upland Britain and Crozier & Boerner (1984) tried to understand the effects on distribution patterns in understory herb vegetation under different tree species in mixed mesophytic forest. Kirby (1988) studied the Changes in the ground-cover flora under plantations on ancient woodland sites. Chou (1991) worked on Pinus radiata plantation and found perspectives of disease threats in large-scale Pinus radiata monoculture in New Zealand. Hansen et al. (1991) chalked out the biodiversity in managed forests and highlighted on conservation. Kelty (1992) compared the productivity of monocultures and mixed-species stands.

Impact of plantation on biodiversity and environment was studied by many other workers including Rosoman (1994), Maclaren (1995, 1996), Danielsen & Heegaard (1995), Halpern & Spies (1995), Chiarucci & Dedominicis (1995), Allen et al. (1995), McLaren (1996), and Michelsen et al. (1996).

Freedman (1998) and Freedman et al. (1994), found Impacts of plantation on biodiversity in the Greater Fundy Ecosystem. Chritensen & Emborg (1996) studied the biodiversity in natural versus managed forests in Denmark; Pott (1997) on plantation forestry in South Africa and its impact on biodiversity and water; Geldenhuys (1997) on native forest regeneration in pine and eucalypt plantations in the Northern Province of South

Africa; Oberhauser (1997) on s econdary forest regeneration beneath Pinus kesiya plantations in the northern Thai highlands; Keenan et al. (1997) on restoration of plant biodiversity beneath tropical tree plantations in Northern Australia; Hampson & Peterken (1998) on enhancing the biodiversity of Scotland's forest resources through the development of a network of forest habitats; Norton (1998) on indigenous biodiversity conservation and plantation forestry; Bunnell et al. (1998) on the problems in forestry and biological diversity. Lamb (1998) highlighted on large-scale ecological restoration of degraded tropical forest lands; and Nixon & Worrell (1999) indicated the impact of plantations on biodiversity. Mason et al. (1999) has worked on the use of native species in plantation forests, Lindenmayer (1999) on biodiversity conservation in managed forests, and Cannell (1999) on environmental impacts of monoculture forests. Scott et al. (1999) worked on soil carbon storage in plantation forests and pastures in New Zealand. Brockerhoff et al. (2001) estimated biodiversity in New Zealand plantation forests; Yirdaw (2001) on diversity of naturally-regenerated native woody species in forest plantations in the Ethiopian highlands. Peterken (2001) showed the ecological effects of introduced tree species in Britain. Strauss (2001) has studied on the plantations and native Australian forests; Hartley (2002) on rationale and methods for conserving biodiversity in plantation forests; Hofstede et al. (2002) studied the impact of pine plantations on soil and vegetation in the Ecuadorian High Andes; and Nagaike (2002) on differences in plant species diversity between conifer (Larix kaempferi) plantations and broad-leaved (Quercus crispula) secondary forests in central Japan. Humphrey et al. (2002) indicated the potential contribution of conifer plantations to the UK Biodiversity Action Plan. Henson (2003) and Henson & Chang (2003) worked on oil palm plantations and its effects including forest loss; Sample (2003) on forest plantations; Quine et al. (2003) on plantations; Van Wesenbeeck et al. (2003) on strong effects of a plantation with Pinus patula on Andean subparamo vegetation; Ehrenfeld (2003) on effects of exotic plant invasions on soil nutrient cycling processes in USA; Nagaike & Hayashi (2004) on effects of extending rotation period on plant species diversity in Larix kaempferi plantations in central Japan.

Review of literature:

Cusack & Montagnini (2004) studied the role of native species plantations in the recovery of understory woody diversity in degraded pasturelands of Costa Rica whereas Lee et al. (2005) on natural regeneration in exotic tree plantations in Hong Kong. Lemenih & Teketay (2005) traced the effects of prior land use on the recolonization of native woody species under plantation forests in the highlands of Ethiopia and Eyecott et al. (2006) worked on ecological patterns of plant diversity in plantation forest managed by clear felling in UK; Arrieta & Suarez (2006) on the contribution of Scots pine (Pinus sylvestris) plantations for the regeneration of holly (Ilex aquifolium) in Mediterranean Central Spain; Carnus et al. (2006) on planted forests and biodiversity; Nagaike et al. (2006) on plant species diversity in a managed forest landscape composed of Larix kaempferi plantations and abandoned coppice forests in central Japan, Newmaster et al. (2006) on restoration of floral diversity through plantations on abandoned agricultural land, Chey (2006) on impacts of forest conversion on biodiversity as indicated by moths, Shi et al. (2007) on the effects of diversity of arbuscular mycorrhizal fungi in the rhizosphere of Dipterocarpaceae in natural and plantation forests in China.

Barlow et al. (2007a) measured the biodiversity value of tropical primary, secondary, and plantation forests. Koonkhunthod et al. (2007) studied on composition and diversity of woody regeneration in a 37 year old teak (Tectona grandis) plantation in Northern Thailand, Barlow et al. (2007b) on litter fall and decomposition in primary, secondary and plantation forests in the Brazilian Amazon. Marcos et al. (2007) compared the community structure and soil characteristics in Pinus sylvestris plantations of different ages and a natural pine forest. Aubin et al. (2008) and Berndt et al. (2008) worked on relevance of exotic pine plantations as a surrogate habitat for ground beetles where native forest is rare, Pawson et al. (2008) on non-native plantation forests as alternative habitat for native forest beetles in a heavily modified landscape, Koh & Wilcove (2008) on the destruction of tropical biodiversity through the cultivation of oil palm, Onaindia & Mitxelena (2009) on potential uses of pine plantations to restore native forests in a highly fragmented river basin, Soo et al. (2009) on the floristic diversity responses in young hybrid aspen plantations to land-use history and site preparation treatments. Duan et al. (2009) traced the differences in plant species diversity between conifer plantations and natural forests in middle of the Loess

plateau. Gomez-Aparicio et al. (2009) also worked on pine plantations. Al-Nafisi et al. (2009) depicted the positive impacts of mangrove plantations on Kuwait's Coastal environment.

Pare et al. (2009) worked on regeneration and spatial distribution of seedling populations in Sudanian dry forests in relation to conservation status and human pressure, Hadi et al. (2009) on tree diversity and forest structure in nothern Siberut, Mentawai islands, Indonesia, Zakaria et al. (2009) on the composition of plant communities at six study plots in Penang forest reserves in Malaysia and Gonzales & Nakashizuka (2010) on broad-leaf species composition in Cryptomeria japonica plantations with respect to distance from natural forest and others. Recently Bremer & Farley (2010) worked on plantation forest and their effects on plant species richness. Pawson et al. (2013) worked on plantation forests, climate change and biodiversity. Very recently Braun and Vogt (2014) assessed the risks imposed by plantation forestry on plant biodiversity in the Hotspot Central Chile and Li et al. (2014) detected the effect of young poplar plantations on understorey plant diversity in china.

In Indiana sub-continent various scientists have worked in the related field i.e. on plantation forests and its impacts on plant diversity in India. Panigrahi et al. (1969) contributed to the Botany of the Terai Forests of the Bahraich District of Uttar Pradesh, Singh & Misra (1979) worked on structure and functioning of natural, modified and silvicultural ecosystem in Eastern Uttar Pradesh; Upreti (1982) studied the phytosociology and state of regeneration of Oak-Forest at Nainital, Das & Ramkrishanann (1985) on the litter dynamics in Khasi Pine (Pinus kesiya Royle ex Gordon). Pandey (1986) also worked on litter production and decomposition, mineral release and biochemical diversity of forests and plantation; Parthasarathy & Mahadevan (1987) on floristic account of forest types in Kalakad reserve forest, Western Ghats; Parthasarathy (1988) on phytogeographic analysis of the flora of Kalakad reserve forest Western Ghats; Singh & Singh (1991) on species structure, dry matter dynamics and carbon flux of a dry tropical forest; Gupta & Shukla (1991) on composition and dynamics of associated plant communities of sal plantations; Parthasarathy et al. (1992) on plant species diversity and human impact in the tropical wet evergreen forests of Southern Western Ghats; Singh et al. (1993) on production and decomposition of leaf litter in Sal, Teak, Eucalyptus and Polar forests in Uttar Pradesh; Visalakshi (1995) on vegetation analysis of two tropical dry evergreen forests in southern India; Nayar (1996) on Hotspots of endemic plants of India, Nepal and Bhutan; Parthasarathy & Karthikeyan (1997a, b, c) on diversity of trees and liana species and population structure in a tropical dry evergreen forest, biodiversity and population density of woody species in a tropical evergreen forest and plant biodiversity inventory and conservation.

Gopisundar (1997) worked on abundance, diversity and distribution of ground herbs in a tropical lowland evergreen rainforest at Agumbe, Karnataka; Shankar et al. (1998) on ecosystem reconstruction through 'taungya' plantations following commercial logging of dry mixed deciduous forests in Darjeeling Himalaya; Scott et al. (1999) on soil carbon storage in plantation forests and pastures; Pandey & Shukla (1999) on plant diversity and community patterns along the disturbance gradient in plantation forests of Sal (Shorea robusta); Pandey (1999) on comparative vegetation analysis and Sal regeneration in relation to their disturbance magnitude in some Sal forests. Parthasarathy (1999) studied the tree diversity and distribution in undisturbed and human-impacted sites of tropical wet evergreen forest in southern Western Ghats; Xiong & Nilsson (1999) on effect of plant litter on vegetation; Pandey (2000) on population status and regeneration strategy of some perennial legumes in plantation forests of North-Eastern Uttar Pradesh; Chittibabu & Parthasarathy (2000) on understory plant diversity in a tropical evergreen forest in Kolli hills, Eastern Ghats; Maikhuri et al. (2000) on the growth and ecological impacts of different agro-forestry tree species in central Himalaya; Jha et al. (2000) on deforestation and land use changes in Western Ghats; Bhat & Murali (2001) on phenology of understory species of tropical moist forest of Western Ghats region of Uttara Kannada district in South India; Pandey & Shukla (2001) on regeneration strategy and plant diversity status in degraded Sal forests; Shankar (2001) on high tree diversity in a sal dominated lowland forest of Eastern Himalaya; Pandey & Shukla (2003) on plant diversity in managed Sal forests of Gorakhpur; Webb & Sah (2003) on structure and diversity of natural and managed Sal forest in the Terai; Sagar et al. (2003) on tree species composition, dispersion and diversity along a disturbance gradient in a dry tropical forest region of India; Bhuyan et al. (2003) on tree diversity and population structure in undisturbed and human-impacted forest stands of tropical wet evergreen forest in Arunachal Pradesh; Padalia et al. (2004) on phytosociological observations on tree species diversity of Andaman Islands; Mishra et al. (2004) on anthropogenic disturbance on plant diversity and community structure of a sacred grove in Meghalaya; Sharma (2005) on impact of coal mining on vegetation; Raghubanshi et al. (2005) on the invasive alien species and Biodiversity in India; Goutam & Devoe (2006) on cological and anthropogenic niches of Sal forest and prospects for

multiple-product forest management; Kumari & Tripathi (2007) on phytosociological studies of the pteridophytes in Terai forest of North India; Timilsina et al. (2007) on community analysis of Sal forests; Reddy et al. (2007) phytosociological observations on tree diversity of tropical forest of Simlipal Biosphere Reserve, Orissa; Kumar (2008) on litter decomposition and calcium, potassium release in Acacia auriculiformis plantation forest floor; Sukumaran & Raj (2008) on rare, endemic, threatened (RET) trees and lianas in the sacred groves of Kanyakumari district; Mishra et al. (2008) on vegetation ecology of the Simlipal Biosphere Reserve, Orissa; Baishya et al. (2009) on distribution pattern of above-ground biomass in natural and plantation forests of humid tropics in northeast India, Tripathi & Singh (2009) on species diversity and vegetation structure across various strata in natural and plantation forests in Katerniaghat Wildlife Sanctuary; Rasingam & Parthasarathy (2009) on diversity of understory plants in undisturbed and disturbed tropical lowland forests of Little Andaman Island; Rawat et al. (2009) on structure of understorey vegetation in native and exotic plantations of Semi-Arid Regions of Punjab; Kulkarni et al. (2009) on biomass production by Sesbania sesban L. when grown under different tree environments; Mani & Parthasarathy (2009) on tree population and above-ground biomass changes in two disturbed tropical dry evergreen forests of peninsular India; Bremer & Farley (2010) on plantation and its role to restore biodiversity; Panda (2010) on the role of fungi in relation to litter decomposition associated with Casuarina equisetifolia L. in coastal sand dunes of Orissa; Panda et al. (2010) on litter decomposition dynamics associated with cashew nut plantation in coastal habitat of Orissa; Thapa et al. (2011) on effect of plantation on plant biodiversity and soil status of tropical forest ecosystem in Meghalaya, northeast India.

Most of the works done previously in West Bengal are either on floristic aspects or in the field of ethnobotany and a very few are on ecological aspects of plantation and natural vegetation. Initially the flora and vegetation of Bengal was explored by Hooker (1848, 1854b), Hooker & Thomson (1855), Long (1857, 1858, 1859a, 1859b), Clarke (1876, 1885), King (1886), Haines (1896, 1906), Carter (1917), Cowan (1929b), Prain (1930b), Agharkar & Ghosh (1931), Anonymous (1935, 1960, 1963, 1966a, 1997), Biswas (1940) Shebbeare (1941), Chatterjee (1958a), Ghosh & Daniel (1959), Ghosh (1959), Mehra & Bir (1964), Chaudhuri (1965b), Chandra & Bhattacharyya (1966), Biswas (1966), Hara (1966, 1971), Mathew (1966, 1969, 1971, 1981), Bennet (1969), Biswas (1971), Basak (1973), Hooker (1972-1897, 1904, 1907), Hara et al. (1978, 1979, 1982), Bhattacharyya & Maiti (1983), Krishna & Das (1972), Sain (1959, 1974), Yonzone (1975), Jain et al. (1975), Ohashi (1975), Chanda (1977), Kundu et al. (1981), Majumdar et al. (1984), Mukherjee (1984) and others. Then Tamang & Yonzone (1982) studied the vegetation of North Bengal. Giri & Nayar (1983b), Das & Chanda (1986), Kundu & Pal (1997), Mukherjee (1998) studied and listed the threatened and endemic plants of Bengal. Kapoor et al. (1989) worked on forest and vegetation of Darjeeling Himalayas, A.K. Samanta (1998) on taxonomy and phytosociology of the Angiospermic Climbers of Darjeeling and Sikkim Himalaya. Maiti & Guha Bakshi (1981), De & Mukhopadhyay (1984) worked on invasion of exotic weeds in West Bengal as well as the Weed flora. Hore & Tripathi (1985), Das et al. (1985), C.R. Das (1985), Bhujel (1986), Mukherjee & Deb Roy (1987), Das & Chanda (1987, 1988 & 1990) worked on flowering calendar of the angiospermic flora of Darjeeling hills. Basu & Paul (1989), Das & Lahiri (1990, 1997), Chakraborty (1991, 1996), Grierson & Long (1983, 1984, 1987, 1991, 1999), Das & Lama (1992), Patra et al. (1992), Mondal (1992), Noltle (1994, 2000), Samanta (1995, 1996, 2006a, 2006b), Das (1995, 2004), Bhattacharyya (1996), Mahata et al. (1998), Mukherjee & Chaudhuri (1998), Chakravarty et al. (1999), Basu & Pradhan (2000), Rai (2001), Das et al. (2002), Rai & Das (2002, 2005), Saha (2005) further studied on composition and diversity of Bengal flora. Kundu (2006) studied and listed the threatened and endemic plants of Bengal. Then different aspects of flora of West Bengal was further explored by Maiti (2004), Das & Ghosh (2007), Bhunia et al. (2008), Kumar et al. (2009), Panda et al. (2009). Das et al. (2008) worked on Plant resources in the protected areas and proposed corridors of Darjeeling. Naskar (1986) studied the Avicennia L. plantation and its role on brackish water fisheries. Chaudhury (1964), Sengupta (1967c), Yonzone et al. (1981), Yonzone & Mondal (1982), Mukherjee & Rai (1984), Yonzone et al. (1984, 1985, 1996), Pal (1988), Basnet & Chetri (1999), Basu & Gautam (2002), Rai & Bhujel (2002), Chettri et al. (2005), Panda (2006, 2009), Rai et al. (2007a, 2007b) and Soren et al. (2008) worked on ethnobotany of Bengal whereas Biswas & Chopra (1940) on common medicinal plants of Darjeeling and the Sikkim Himalayas. Biswas (1956a) worked on common medicinal plants of Darjeeling and Sikkim Himalaya and Rai et al. (2008) invented the medicinal trees in lower hills of Darjeeling.

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