Research article

Community Participation in Saline Soil Restoration Using a Diverse Tree Planting Technique: A Case Study of Nongsim Sub-district, Borabue, Mahasarakam, Thailand

ADCHARAPORN PAGDEE*
Faculty of Science, Khon Kaen University, Khon Kaen, Thailand
E-mail: adcpag@kku.ac.th

Received 19 December 2011 Accepted 2 April 2012 (* Corresponding Author)

Abstract: This research aims to restore saline soil areas using a diverse tree planting technique: a case study of Nongsim sub-district, Borabue, Mahasarakam, Thailand. The study focuses on community participation aspects in the restoration attempt, including community perspectives toward the research project, participation motivations and community's use of saline soil areas. Diverse trees both native and introduced species were planted in an approximate 1.6 ha experimental plot adjacent to a village reservoir in 2008. Community surveys were conducted on a yearly basis since 2009 to examine villager perspectives toward the project, together with workshops to inform the community about research findings and get their feedbacks. In the 4-year period, 23 tree species, including eight fast-growing natives, four fast-growing introduced and 11 coastal habitat species, over 2,000 individuals were planted, but 20 species survived. Considering survival and growth rates, potential species for saline soil restoration are *Combretum quadrangulare* Kurz.*,* *Casuarina equisetifolia* J. R.&G. Forst.*,* *Pandanus odoratissimus* L.f. and *Albizia lebbeck* (L.) Benth. Community surveys, including group interviews of 11 village leaders and questionnaires of over 350 villagers from all villages in Nongsim sub-district, reveal that the community strongly agreed with the research project because they wanted crop yield improvement by restoring saline soil. Planting trees could also help increase community green areas. The majority of villagers were willing to plant trees in their farmlands, but limited land and amounts of seedlings hinder them from doing so. Furthermore, the majority of farmers (94.7%, n=76) encountering saline soil problems, used their farmland especially for rice cultivation, despite low yields because of limited amount of land. The economic value estimated in 2010 from use of saline soil paddies for rice growing is 45,577.12 Baht/household/year (n = 66) or 4,245.22 Baht/Rai (1 ha = 6.25 Rai).

Keywords community participation, saline soil, restoration, diverse tree planting technique, Borabue

INTRODUCTION

The United Nations Environment Program estimates that approximately 20% of agricultural land and 50% of cropland in the world is salt stressed (Flowers and Yeo, 1995). Salt-affected soils occur in more than 100 countries of the world with a variety of extents, nature and properties (Rengasamy, 2005). Worldwide, they cover a total area of about one billion hectares (Toth et al., 2008). Table 1 summarizes the potential risks of salinisation in all over the world. Salts, mostly NaCl accumulate at the soil surface and a saline crust is formed during the dry season through capillary action (Quantin et al., 2008). The excessive salt amounts adversely affect soil physical and chemical properties, as well as microbiological processes (Lakhdar et al., 2009). Subsequently, salinity and sodicity affect plant growth and crop yields because of osmotic effects and sodium toxicity (Marschner, 1995).

Table 1 Percentage of salt-affected soils in different countries worldwide

Country	Salt-affected area	References
Australia	30% total area	Rengasamy (2005)
Egypt	9.1% total area	Mashali et al. (2005)
Hungary	10% total area	Varallyay (1992)
Iran	28% irrigated land	Khel (2006)
Kenya	14.4% total area	Mashali et al. (2005)
Nigeria	20% irrigated land	FAO (2000)
Russia	21% agricultural land	Dobrovol'skii and Stasyuk (2008)
Syria	40% irrigated land	FAO (2000)
Thailand	30% total area	Yuvaniyama (2001)
Tunisia	11.6% total area	Mashali et al. (2005)
USA	25–30% irrigated land	Wichelns (1999)

Source: Lakhdar et al., 2009

Salt affected soil is a serious problem in Thailand, especially in the Northeast Plateau where salt bearing rocks are common (Mahasarakam formation). Yuvaniyama (2003) reported that saline soils cover areas of approximately 38.7 million Rai (6.25 Rai = 1 ha) of the region's land area, of which 1.5 million Rai was classified severely saline soil, while 19.4 million Rai was considered areas of potentially affected saline soil. Usually saline soils appear in lowlands or discharge areas in which lands are suitable for rice cultivation. Arunin (1987) stated that the reason for the spread of salinisation is primarily the removal of forest cover leading to increased groundwater recharge. This factor has been exacerbated by anthropogenic activities including dam construction, low technology salt extraction, groundwater use and irrigation.

Soil salinity partly contributes to a major agricultural, economic and social problem in the Northeast. It drastically affects soil fertility and rice productivity (Quantin et al., 2008), which in turn affects farmer's income since the majority of northeasters are rice farmers. Rice yields and economic returns are about one third when grown in saline soil compared with nearby unaffected areas (Hall et al., 2004). Furthermore, the Research Institute for Thailand Development (2007) estimated the average economic costs of saline soils in 2,518 million Baht each year. Saline soil restoration is therefore very crucial for rice productivity improvement, which means possible increase of farmer's income.

Many different methods are used on reclamation, as physical amelioration (deep plowing, sub soiling, sanding, and profile inversion), chemical amelioration (amending of soil with various reagents: gypsum, calcium chloride, and limestone), and electro-reclamation (treatment with electric current) (Raychev et al., 2001). Alternatively, growing salt tolerant species represents the only cost effective means of revegetation although this means a significantly different species mix to that which existed before disturbance (Ho et al., 1999; Abdelly et al., 2006). Although many of these salt tolerant species can survive in saline soils and transpire sufficient water to lower water tables (Barrett-Lennard, 2002), they are not often used by farmers. Therefore the farmers are discouraged from participating in revegetation activities, which require long-term care. Many revegetation areas are abandoned after the restoration project is over while saline soils remain unsuccessfully treated. This research aims to restore saline soil areas using a diverse tree planting technique: a case study of Nongsim sub-district, Borabue, Mahasarakam, Thailand. The study focuses on community participation aspects in the restoration attempt, including community perspectives toward the research project, participation motivations, and community's use of saline soil areas.

METHODOLOGY

Diverse tree species planting

This research project began in 2008 by planting diverse tree species in the approximate 1.6 ha experimental plot in a discharge salt affected soil area, adjacent to Akkasatrsuntorn Reservoir, Nong Sim Sub-district, Borabue District, Mahasarakham Province, Thailand. The land is state-owned under the Royal Irrigation Department authority, but villagers are allowed to access the land for grazing and fishing at the Reservoir. A workshop was conducted prior to the planting in which village leaders, Nongsim Sub district Administrative Organization (SAO) officials, governmental authority representatives and villagers participated in to discuss on tree species selection and possible participation in the research project. Two main criteria for the selection are survival potential and possible use of trees by the locals. Diverse trees both native and introduced species were planted in the late rainy season of 2008 with a planting space of 2x2 m. New trees were planted the following years to replace dead trees and to maintain the area with tree coverage. Tree monitoring, consisting of estimates of survival Eq. (1) and growth Eq. (2) rates, was done twice a year in March and September from 2008 to 2011.

$$\text{Survival rate of a species} = \frac{N_t \times 100}{N_0} \tag{1}$$

Where N_t = number of individuals of a species counted from the current monitoring period

N_0 = number of individuals of a species counted from the previous monitoring period

$$\text{Growth rate of a species} = \frac{[H_t - H_0] \times 100}{H_0} \tag{2}$$

Where H_t = average height of a species measured from the current monitoring period

H_0 = average height of a species measured from the previous monitoring period

Community participation survey

Community participation is one of the keys to effective natural resource management (Pagdee et al., 2006). The study aims to examine community perspectives toward the research project, participation motivations, and community's use of saline soil areas. Community surveys were conducted on a yearly basis from 2009, including village leader interviews and semi-questionnaire surveys. At the end of each research fiscal year (in September) a workshop was organized at Nongsim SAO office to inform the community about research findings and obtain their feedbacks. Data analysis is descriptive-based, including evaluation of community participation and economic valuation of saline soil areas used by the locals.

RESULTS AND DISCUSSION

During four years (2008-2011), 23 tree species, including eight fast-growing natives, four fast-growing introduced, and 11 coastal habitat species, over 2,000 individuals were planted and 20 species survived with an overall survival rate of 82.27% (Table2). Considering survival and growth rates, potential species for saline soil restoration are *Combretum quadrangulare* Kurz., *Casuarina equisetifolia* J. R.&G. Forst., *Pandanus odoratissimus* L.f., and *Albizia lebbeck* (L.) Benth. In addition to high survival and growth rates, villagers can use these trees for firewood, fodder and fiber. Furthermore, these planted trees help revegetate the area in which about 30% was barren land and the rest was only covered with grasses and forbs when the planting was started in 2008. The survey conducted in March 2011 showed that 100% of the experimental plot is now vegetated and the maximum tree height reached 3m (Fig. 1).

The community surveys (2009-2011) involved group interviews of all 11 village leaders and questionnaires of over 350 household representatives from all villages in Nongsim sub-district. The questionnaire surveys in 2008 and 2010 revealed that the majority of participants (55.5%, n=200 in 2008 and 50.3%, n=171 in 2010) did not recognize the project, and even those who did so did not clearly understand the project's main objectives. The number had decreased because of more persistent attempts to inform villagers about the project through village leaders, Nongsim SAO, village broadcast and project post. Nevertheless, the community strongly agreed with the research project because they wanted crop yield improvement by restoring saline soil. Planting trees could also help increase community green areas. Table 3 presents villager perspectives toward the research project. Providing sufficient tree seedlings and distributing them throughout a group of villagers scored the highest number of "disagreement". Villagers expressed that they were not informed of when and where tree seedlings would be distributed. As a result, only a small group of villagers, especially those who lived in a coordinating village received seedlings, while villagers in farther away villages did not. Furthermore, the majority of villagers were willing to plant trees in their farmlands for saline soil restoration, but limited land and amounts of seedlings hinder them from doing so.

Table 2 Tree species, number of individuals survived and average tree height

No.	Species	Number of individuals survived (%)	Average height in cm (% change)
1	*Acacia auriculiformis* Cunn.	77 (100.00)	125.06 (145.22)
2	*Acacia mangium* Willd.	123 (87.86)	116.72 (25.50)
3	*Acacia tomentosa* Willd.	1 (1.28)	0.00 (NA)
4	*Calphyllum inophyllum* L.	17 (36.96)	15.02 (0.14)
5	*Cassia siamea* Lam.	169 (64.26)	46.31 (78.11)
6	*Sesbania grandiflora* Desv	22 (95.65)	5.68(-18.93)
7	*Barringtonia asiatica* (Linn.) Kurz	1 (14.29)	1.50 (50.00)
8	*Cerbera odollam* Gaertn.	6 (60.00)	61.08 (1.79)
9	*Pandanus odoratissimus* L.f.	15 (100.00)	87.21 (40.66)
10	*Pterocarpus macrocarpus* Kurz	10 (100.00)	66.45 (44.47)
11	*Hibiscus tiliaceus* L.	11 (100.00)	183.17 (46.53)
12	*Albizia lebbeck* (L.) Benth.	152 (100.00)	51.13 (21.74)
13	*Thespesia populnea* (L.) Sol. ex Correa	8 (100.00)	61.93 (-8.92)
14	*Tamarindus indica* Linn.	26 (96.30)	8.04(-10.62)
15	*Pithecellobium dulce* (Roxb.) Benth.	188 (78.99)	72.63 (23.10)
16	*Casuarina equisetifolia* J.R. & G. Forst.	50 (47.62)	192.51 (27.49)
17	*Casuarina junghuhniana* Mig.	0 (NA)	0.00 (NA)
18	*Combretum quadrangulare* Kurz.	475 (99.16)	42.39 (11.56)
19	*Azadirachta indica* Juss. var. *siamensis* Valeton	89 (91.75)	9.11 (13.83)
20	*Melaleuca cajuputi* Powell	5 (NA)	105.33 (NA)
21	*Heritiera littoralis* Ait.	2 (100.00)	13.00(-59.38)
22	*Derris indica* (Lamk.) Bennet	10 (83.33)	38.72 (-9.95)
23	*Simarouba glauca* DC	0 (NA)	0.00 (NA)
Total	20 species survived	1,457 trees survived	

Note: data recorded on March 27, 2011, NA = not applicable for calculation

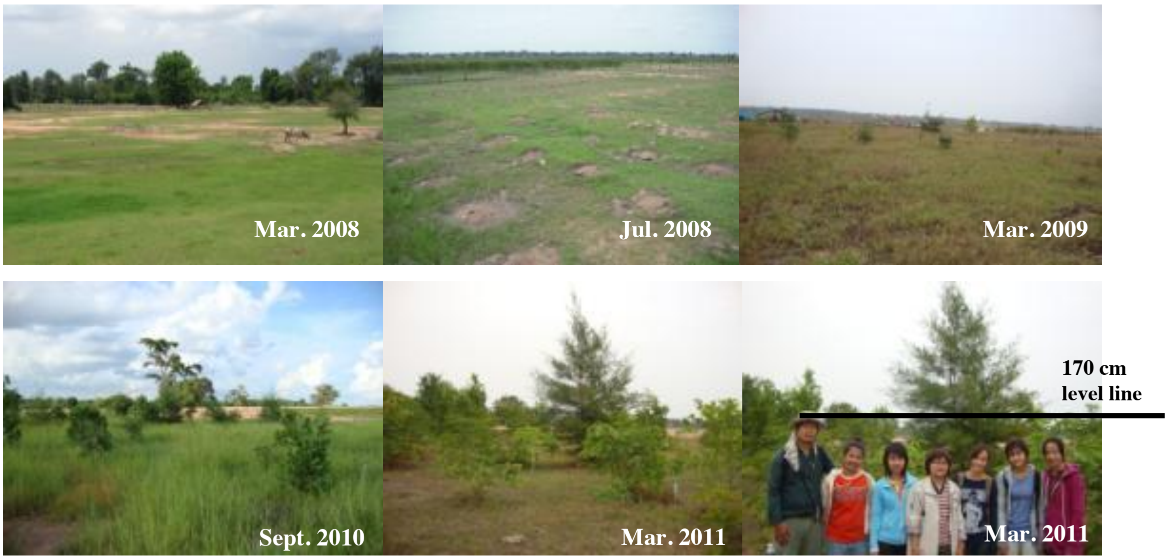

Fig. 1 Change of vegetation cover in the experimental plot (2008-2011)

Table 3 Community perspectives toward the saline soil restoration project (n=171 in 2010)

Item	Percent of respondents			
	(3)	(2)	(1)	(0)
1) Effectively inform villagers about the project	51.2	39.5	8.1	1.2
2) Clear research objectives and activities	36.0	38.4	20.9	4.7
3) Providing equal opportunity for villagers to participate in the tree selection meeting	44.2	27.9	20.9	7.0
4) Tree species planted can be used by villagers	32.6	53.5	12.8	1.2
5) The project encouraged the community to start similar saline soil restoration activities in other areas in the sub district	32.6	52.3	11.6	3.5
6) Trees planted could help reduce soil salinity in the community	43.0	43.0	11.6	2.3
7) Community participation in tree planting and monitoring was one of the keys to project success	44.2	44.2	11.6	0.0
8) Providing enough tree seedlings and then distributing them to a large number of villagers	55.3	20.0	14.1	10.6
9) Villagers gained knowledge about soil salinity	36.0	53.5	9.3	1.2

Note: (0) = disagree, (1) = slightly agree, (2) = moderately agree, (3) = strongly agree

In addition, the workshops got positive feedbacks from the community. Villagers expressed a better understanding about saline soils and reclamation techniques. Moreover, they could exchange ideas and experiences with researchers and villagers from other villages, which helped broaden their visions. Some villagers expressed their interests in participating in salt-affected soil restoration. They would start planting trees in their farmland, but needed supports from governmental agencies, especially in providing tree seedlings. Finally, the majority of villagers (94.7%, n=76) encountering saline soil problems used their farmland, especially for rice cultivation despite low yields because of limited amount of land. The economic value estimated in 2010 from use of saline soil paddies for rice growing is 45,577.12 Baht/household/year (n = 66) or 4,245.22 Baht/Rai (1ha = 6.25 Rai).

CONCLUSIONS

Soil salinity is one of the main land resource problems in the Northeast of Thailand. This research illustrates that planting diverse tree species can help to revegetate areas affected by salts. The selection of tree species needs to consider not only survival potential but also possible use by the locals. The latter will encourage villagers to participate in restoration activities since they can perceive some benefits gained from doing so and not the burden instead. Finally, informing the community on a regular basis about the restoration project, including research findings will help villagers to better understand about soil salinity as well as making them feel being part of the study. As a result, a long-term care and commitment can be possible when local communities involve in the restoration.

ACKNOWLEDGEMENT

This research was funded by Khon Kaen University Research Funds (2007-2011). Time and contributions from all villagers, village leaders and Nongsim Sub-district Administrative Organization are greatly appreciated. Special thanks go to Somsanook Village leader who helps to coordinate with the locals and looks after the experimental plot throughout four years of the study.

REFERENCES

Abdelly, C., Barhoumi, Z., Ghnaya, T., Debez, A., Ben Hamed, K., Ksouri, R., Talbi, O., Zribi, F., Ouerghi, Z., Smaoui, A., Huchzermeyer, B. and Grignon, C. 2006. Potential utilization of halophytes for the rehabilitation and valorization of salt-affected areas in Tunisia. Biosaline Agric. Salinity Tolerance Plants: 163-172.

Arunin, S. 1987. Manageent of saline and alkaline soils in Thailand. Paper presented at the Regional Expert Consultation on the Management of Saline/Alkaline Soils, FAO. FAO Regional Office for Asia and the Pacific, Bangkok.

Barrett-Lennard. 2002. Restoration of saline land through revegetation. Agricultural Water Management, 53, 213-226.

Dobrovol'skii, G.V. and Stasyuk, N.V. 2008. Fundamental Work on Saline Soils of Russia, vol. 41. Eurasian Soil Science, Pleiades Publishing, Ltd., 100-101.

FAO. 2000. Global Network on Integrated Soil Management for Sustainable Use of Salt-affected.

Flowers, T.J. and Yeo, A.R. 1995. Breeding for salinity resistance in crop plants: where next. Australian Journal of Plant Physiology 22, 875-884.

Hall, N., Greiner, R. and Yongvanit, S. 2004. Adapting modeling systems for salinity management of farms and catchments in Australia and Thailand. Mathematics and Computers in Simulation, 64, 319-327.

Ho, G.E., Samaraweera, M.K.S.A. and Bell, R.W. 1999. Revegetation directly on salt affected gold ore refining residues - A case study. M.H. Wong, J.W.C. Wong, & A.J.M. Baker (Eds.). Remediation and Management of Degraded Lands. Lewis Publishers, Boca Raton, Florida, 123-135. USA.

Khel, M. 2006. Saline soils of Iran with examples from the alluvial plain of Korbal, Zagros mountainsSoil and Desertification-Integrated Research for the Sustainable Management of Soils in Drylands. Proceedings of the International Conference, Hamburg, Germany, May 2006.

Lakhdar, A., Rabhi M., Ghnaya, T., Montemurro, F., Jedidi, N. and Abdelly, C. 2009. Effectiveness of compost use in salt-affected soil. Journal of Hazardous Materials, 171, 29-37.

Marschner, H. 1995. Mineral Nutrition of Higher Plants.2nd Edition. Academic Press, London, UK, 437.

Mashali, A., Suarez, D.L., Nabhan, H. and Rabindra, R. 2005. Integrated management for sustainable use of salt-affected soils.FAO. Soils Bulletin, Rome.

Pagdee, A., Yeon-su, K., and Daugherty, P.J. 2006. What makes community forest management successful: A meta-study from community forests throughout the world. Society and Natural Resources, 19, 33-52.

Quantin, C., Grunberger, O., Suvannang, N. and Bourdon, E. 2008. Land management effects on biogeochemical functioning of salt-affected paddy soils. Pedosphere 18(2), 183-194.

Raychev, T., Popandova, S., Jozefaciuk, G., Hajnos, M. and Sokoowska, Z. 2001. Physicochemical reclamation of saline soils using coal powder. Int. Agrophys, 15, 51-54.

Rengasamy, P. 2005. World Salinisation with emphasis on Australia. Comp. Biochem. Phys. A141, 337-348.

Toth, G., Montanarella, L. and Rusco, E. 2008. Updated map of salt affected soils in the European Union threats to soil quality in Europe. European Communities. 61-74.

Yuvaniyama, A. 2001. Managing problem soils in northeast Thailand, in S.P. Kam, C.T. Hoanh, G. Trebuil, B. Hardy (Eds.), Natural Resource Management Issues in the Korat Basin of Northeast Thailand: An Overview, IRRI Limited Proceedings, 7, 147-156.

Yuvaniyama, A. 2003. Saline soil mitigation and management (in Thai). Academic handout from a research and development group for saline soil management. Soil Management Research and Development Institute, Land Development Department. 101.

Varallyay, G. 1992. Soil data base for sustainable land use - Hungarian case study. in Proc. Int. Symp. on soil Resilience and Sustainable Land Use. Bp, 28, September-2 October, 1992.

Wichelns, D. 1999. An economic model of water logging and salinization in arid regions. Ecol. Econ. 30, 475-491.