International Journal of Social Forestry (IJSF), 2012, 5(2): 145-157
ISSN 1979-2611, www.ijsf.org
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SWOT ANALYSIS FOR THE APPLICATION OF BIODRAINAGE TECHNOLOGY TO PHYTOREMEDIATE WATER LOGGED SITES

Kumud Dubey[1]

Abstract:
Irrigation potential has been increased in recent years for the increased and sustained yield of agricultural products. The introduction of canal irrigation has caused a rise in ground water table leading to water logging and secondary salinisation. Presently, about one-third of the world's irrigated area faces the threat of water logging. About 4981.43 sq Km area in Uttar Pradesh is suffering from water logging resulting in reduced productivity. To address the need of farmers, a project has been started aiming to phytoremediate the waterlogged area through the application of Biodrainage. Biodrainage may be defined as "Draining out of excess soil water in atmosphere through deep-rooted plants using their bio-energy" (Chauhan et al. 2012) and it consist of the planned planting of trees with high transpiring rate (Khamzina et al. 2005). Fast growing tree species may performed as effective Biodrainage System. The deep root systems of these trees make them proficient water users in compared to the crop plants (Heuperman et al. 2002). Fast growing species like Eucalyptus, Acacia nilotica, Casuarina glauca, Terminalia arjuna, Pongamia pinnata and Syzygium cuminii, etc. are suitable species for Biodrainage. As an initial step, water logged site of eastern U.P. had been surveyed and SWOT analysis performed to study the feasibility of the project as well as the preferable Biodrainage species to be planted with acceptability among the farmers. Analysis was done by questionnaire-based interviews of the farmers on random sampling basis. For this, a questionnaire covering all parameters for studying the Strength, Weakness, Opportunities and Threats of Biodrainage Technology was prepared. In Meetings, farmers were informed about the Biorainage and its advantages and they were interviewed on the basis of a prepared questionnaire. The analysis led to conclusions that the affected farmers were keen to adopt the Biodrainage product activities willingly in order to ameliorate their waterlogged sites through plantations of selected species. However, they were a little bit apprehensive regarding the future land use of their fields. The results obtained may be useful in further planning and successful implementation of the project.

Keywords: *biodrainage, waterlogged site, SWOT analysis*

[1] Centre for Social Forestry and Eco-Rehabilitation, Allahabad 3/1, Lajpat Rai Road, Allahabad, India. Email : dkumud@yahoo.com

Introduction

Recent trends and future demographic projections suggest that the need to produce more food, fuel, fodder and fibre will necessitate effective utilization of land resources under crop cultivation. For achieving this target the productive potential of our agricultural land as well as canal irrigation have to be increased. Irrigated agriculture, covering about 17% of the total cropped area of the world, contributes 40% of the total food production (INCID 2003). In India, only one-third area under irrigation produces two-third of the food grains.

The introduction of canal irrigation has caused a rise in ground water table leading to waterlogging and secondary salinisation. Presently, about one-third of the world's irrigated area facing the threat of water logging, about 60 Mha has already become waterlogged and 20 Mha salt-affected (Heuperman et al. 2002). According to the estimate of the Ministry of Water Resources of the Government of India, in canal command areas of the country 2.46 Mha is waterlogged and 3.30 Mha salt-affected. India has the largest irrigated area in the world with an ultimate irrigation potential of 139.91 Mha. of which 98.84 M ha has been utilized by the end of tenth plan (India 2007). However, unscientific use of water, along with other natural and manmade causes, leads to water logging, soil salinity and consequently, sub optimal agricultural production (Sarangi and Bundela 2011). Currently at least 20 per cent of the world's irrigated land is salt affected and/or irrigated with waters containing elevated levels of salts. Several major irrigation schemes have suffered from the problems of salinity and sodicity, reducing their agricultural productivity and sustainability. (Ghassemi *et al.* 1995, Quadir *et.al.* 2008). Several major irrigation schemes throughout the world have suffered from the problems of salinity (Gupta and Abrol 2000, Herczeg *et al.* 2001, Cai *et al*. 2003, Sarraf 2004). Introduction of canal irrigation has led to rising water table and consequent water logging and salinity problems (Kumar, 2004). The Ministry of Agriculture estimated in 1984-85 that an area of 8.53 million hectares was suffering from the problem of waterlogging in both irrigated and unirrigated areas. Water logging is a widespread problem in non-irrigated areas, where low-lying depressions serve as discharge areas, and on irrigated lands (Heuperman *et al.* 2002). In arid and semi-arid climates, in addition to water logging the major problem associated with irrigation, in the absence of drainage, is salinization. In India also Salinization/alkalization and waterlogging have rendered a sizeable area of arable lands unproductive (Dwivedi 2006). Out of total 2.269 million ha or 9.40% of geographical area of Uttar Pradesh is covered by wastelands. About 0.4913 million ha area in Uttar Pradesh is suffering from water logging resulting in reduced productivity. Water logging is mainly due to seepage from canal, water stagnation on the surface and/or shallow groundwater levels. High rainfall in low land

gradient areas also contributes to water logging. In Uttar Pradesh water logging is associated with alkalinity. The problem is acute in the districts coming under north eastern plains, eastern plains, Gangetic plains, eastern tarai and their periphery (Chaudhary *et al.* 2005).

Attempts made by various departments, organizations and agencies so far for prevention of flood and water logging and reclamation of the degraded lands have not been satisfactory in Uttar Pradesh. The problems of water logging and salinity can be effectively tackled by conventional engineering based subsurface drainage systems provided these are properly designed, installed, maintained and operated. Conventional subsurface drainage systems are of two types, vertical (tube wells) and horizontal (drainpipe) systems. When properly designed, installed and maintained, these systems are efficient in lowering the water table and preventing water logging and salinization; but these are more expensive and cause environmental problems. Moreover, they require periodic maintenance. Under such a situation, biodrainage is envisioned as a benign and cost effective technology to lower the rising water table so as to take it well below (>1.5 m) the root zone of crop plants (Angrish *et al.* 2006). Biodrainage is the vertical drainage of soil water through evapotranspiration by vegetation. The term biodrainage is relatively new, although the use of vegetation to dry out soil profiles has been known for a long time. Biodrainage is economically attractive because it requires only an initial investment for planting the vegetation, and when established, the system could produce economic returns by means of fodder, wood or fibre harvested (Heuperman *et al.* 2002). There is consensus that biodrainage, when properly implemented, can lower the water table. It could solve problems associated with waterlogged areas and canal seepage. It has been demonstrated that under ideal conditions, a tree canopy may lower water tables by 1–2 m over a time period of 3–5 years (Kapoor 2002). Fast growing tree species may performed as effective Biodrainage System. The deep rooting characteristics of these trees make them extremely efficient users of water in compared to the crop plants. Fast growing tree species like *Eucalyptus,* known for luxurious water consumption under excess soil moisture condition, are suitable for biodrainage. Other suitable species for biodrainage may be *Acacia nilotica, Casuarina glauca, Terminalia arjuna, Pongamia pinnata* and *Syzygium cuminii,* etc. These species can be planted in blocks in the form of farm forestry or along the field boundary in the form of agroforestry. In developing countries like India, since farmers have small holdings and cannot afford to put their whole chunk of land under tree plantations, Agroforestry can be a viable and remunerative option, which provides an additional income as tree biomass (timber, fuel wood etc), in addition to regular income from agricultural crop produce. Many workers have recommended rehabilitation of such salt-affected, waterlogged lands

through tree plantations having biodrainage quality (Dash *et al.* 2005, Dash *et al.* 2008, Dhyani 2007, Ram *et al.* 2008, Angrish *et al.* 2009, Bala *et al.* 2009, Ram *et al.* 2011, Roy Chowdhury *et al.* 2011).

For solving the water logging problem through the application of Biodrainage, an Indian Council of Forestry Research and Education, Dehradun funded project is going on in eastern Uttar Pradesh. Since the Biodrainage concept was new for the area, an initial step was a SWOT analysis to study the feasibility of the project and preferable Biodrainage species to be planted, along with their acceptability among the farmers. The present study deals with this SWOT analysis of the application of Biodrainage to solve the problem of water logging, soil salinization and high water table in the area. The analysis of bio-drainage interventions was carried out through focus group discussions with the farmers during the survey for exploring the possible application of biodrainge to combat the water logging problem and soil salinization (Roy Chowdhury *et al.* 2011).

SWOT Analysis

SWOT analysis is one kind of identification tool to be used for studying the Strengths, Weaknesses, Opportunities and Threats of a programme. The SWOT analysis technique was recognized as an important participatory assessment tool to be used to gather, synthesize and analyse information for community forestry development (FAO 1989). A number of SWOT analyses have been performed in relation to forest management studies. In the SWOT analysis, the terms 'strengths' and 'weaknesses' refer to attributes that measure internal capabilities whereas 'opportunities' and 'threats' originate from external environments of an project (e.g. forestry programme) being assessed. The 'strengths' apply to current forces associated with a project whereas 'opportunities' refer to what actions could be taken to enhance the project. Likewise, 'weaknesses' refer to current problems whereas 'threats' are problems waiting to happen. What makes the SWOT analysis more complicated is that some of the strengths may constitute weaknesses from another view (Dillan 1988). In other words, sometimes individuals participating in the SWOT group might disagree about whether a current fact or condition is a strength or a weakness, or whether something which might happen will turn out to be an opportunity or a threat (McNutt 1991). Internal attributes are controllable to some extent by project executor. Strengths are to be pursued, and weaknesses strategically eliminated or reduced to ensure the successful application of a project. External attributes (i.e. economic status, cultural, demographic, political or legal trends and events) are mainly beyond the control. Stakeholders involved in a forestry program are urged to take advantage of potential

opportunities, and avoid potential threats that could significantly hamper the objectives of the project from being fulfilled (David 1999). RECOFTC (1999) used this technique to assess the feasibility of potential community forestry extension programs in Asian developing countries. Uychiaoco et al. (2002) highlighted the SWOT of various types of marine protected areas in the Philippines. Jiwan and Kendwang (2004) reported SWOT analysis results linked with agroforestry systems established in Sarawak, Malaysia. Oswald et al. (2004) undertook a comprehensive SWOT analysis to identify strategic plans for forest enterprises in Switzerland. Evaluation Division (2004) identified SWOT of Vana Samrakshana Samithies (VSS, community organisations comprising of families living in and around the forest areas) in Kerala State.

Since a group represents a broad range of perspectives, SWOT analysis should be carried out in the form of a group meeting. Group participation is advantageous in that one person's spontaneous idea can spark a line of thinking from others which leads to a significant part of the analysis (McNutt 1991). Oral discussion in a group is most productive if free-thinking is promoted. All participants are encouraged to voice their ideas without carefully weighing the significance of each observation so that open and frank discussion is facilitated. The rule is nobody's comments are deemed inappropriate as long as he or she thinks that the stated fact is part of the situation. Before group discussion sessions, the project executors should make sure that all the participants are well aware of or informed about the project, the SWOT of which are being discussed. Once the group discussion commences, comments are solicited and recorded as appropriate under the four SWOT headings. It is typical to go through all strengths first, then weaknesses, opportunities and threats in order. Writing on newsprint tablets or a whiteboard prevents losing good ideas which may initially seem inconsequential but later become important. When each item is listed, some space is to be left to insert some other points of discussion that could be raised at a later stage (McNutt 1991).

Methodology

A survey was undertaken during a farmers workshop cum meeting on "Application of Biodrainage for the remediation of water logged sites" to identify the **S**trengths, **W**eaknesses, **O**pportunities and **T**hreats (SWOT) of the application of biodrainage to solve the problem of water logging was studied. A workshop and group meetings were conducted and the issue i.e. the biodrainage and its advantages were well explained to the farmers. An open-ended questionnaire survey was conducted to avoid the disadvantages of verbal discussions as a way of collecting qualitative data, because in some

cases one or a small number of individuals come forward and have a tendency to dominate and affect the discussions, by their personality, status or specialised knowledge. Moreover, another merit of employing the open-ended questionnaire survey method lies in that not only the SWOT items can be identified, but also each SWOT items can be grouped into a few statements so that the frequency of responses for each item can be recorded. Frequency was calculated by calculating the percentage of response in favour of that item. A total fifty farmers participated in the survey. **SWOT details** with their relative frequencies were tabulated in Tables 1, 2, 3 and 4 respectively.

Results and Discussion

Strength of a project comprises factors which have some positive effect and should help in the smooth execution and success of the project. It may be considered as a circumstance working in favour of the activity. The project executor's aim is to take advantage of these strengths. In the above analysis, the strength items of the application of biodrainage were identified as its cost effectiveness, practical viability, and ecological viability, income generation, easy to adopt and team of qualified staff for the execution of project. The frequency of responses were also depicted in Table 1. Cost effectiveness, practical viability and team of qualified staff for the execution of project scored highest frequency. Since the biodrainage system consists of fast growing tree species, as biological drainage system which involves bio-energy for absorption, translocation and transpiration of excess ground water into the atmosphere, the operation and maintenance requirements of biodrainage are less than conventional drainage (horizontal/vertical) methods. Therefore, it was identified as cost effective, easy and practically viable for adopting this technology in their fields. Biodrainage plantations make the water logged /low productive site more productive and enhance economic utilization of problem areas. It involves proper scientific implementation of the project i.e. proper selection of tree species, designs and models of tree plantations, harvesting and marketing of tree products. Hence, the availability of qualified staff for the execution of project was also pointed out as a strength by the farmers. As strategy to maximize the productivity of small land holding, the most accepted model was 'Agroforestry' for biodrainage plantation. Improvement of farmer's water logged site through the plantation of bio drainage species was also accepted by the farmers as a strength item. Some farmers, however, were disagreeing with its ecological suitability, as according to them, the tree plantation will reduce the agricultural crop productivity due to shade and allelopathic effect of leaf litter. In addition to traditional income from agricultural crops, biodrainage plantations may provide extra income and products like fuel wood, fodder, timber and other forestry products; hence, income generation was identified as strength of the

project. Agroforestry model of biodrainage might be a low-cost, socially-acceptable and environment-friendly technique for the reclamation of waterlogged areas.

Table 1. Strengths Identified by the Farmers for the Application of Biodrainage Technology to Solve the Problem of Water Logging

S. No.	Strength Items	Frequency (%)
1	Reclamation of lands suffering from water logging and high water table problem	92
2	Cost effectiveness	96
3	Practical viable	96
4	Ecological viable	70
5	Income generation	80
6	Easy adoption	90
7	Team of qualified staff for the execution of project	100

Weakness is something negative circumstance which may hamper or reduce the success of the project. It is considered as an unfavorable condition which could lead to reduced acceptability. The project executor aim is to avoid or overcome these weaknesses. All weaknesses were depicted in Table 2. Lack of awareness, proper knowledge, motivation and expertise for planning and development of plantations among the farmers was identified as major weaknesses for the execution of the project. These weaknesses can be overcome by regularly visiting the farmers and educating them regarding the advantages of biodrainage regularly. Other weaknesses like disagreement with the selected Biodrainage species for the study and efficacy of biodrainage plantations need to be studied before implementation. Change in land use and lack of availability of land for raising plantations were identified as weakness. Availability of land may affect the adoption of biodrainage by small and marginal farmers and to change its use from agriculture to forestry. However in such cases, agroforestry might be proved as viable option. Legal problem related with tree harvesting and poor acceptability of new technology were also seen as the weaknesses for the successful implementation of the project, however these points may be solved by pursuing the problem and generating awareness regarding the application of technology.

Table 2. Weaknesses Identified by the Farmers for the Application of Biodrainage Technology to Solve the Problem of Water Logging

S. No.	Weaknesses Items	Frequency (%)
1	Lack of awareness	92
2	Disagreement with the selected Biodrainage species for the study	8o
3	Change in land use and land availability	80
4	Legal problem related with tree harvesting	82
5	Poor acceptability of new technology	82

Opportunity is an innovative way to make an activity more successful – to create an environment more favorable for the successful implementation of the project. Opportunity should not be mixed with strengths. The opportunities may be exploited for success of the project. The main observations that were seen as opportunities for bio drainage include the improvement in land quality, bioremediation of poor soil, increase in productivity, employment generation, poverty alleviation, improvement in environment quality, increase in tree cover and maintenance of water table thereby reducing the soil salinization problem (Table 3). It involves social forestry and planting of trees on agricultural land. Roy Chowdhury *et. al.*, 2011 also identified biodrainage plantations as means of resource generation as they may provide economic returns that are at least equivalent to agriculture if not more; besides that it helps to improve environment and solves many problems like water congestion, salinity, wind hazards (shelter belt), etc. Integration of aquaculture with biodrainage agroforestry may be explored as additional opportunity to improve productivity of water logged area. Other opportunities identified by some respondents included carbon sequestration through tree planting and biodiversity conservation. Tree components in agroforestry systems can be significant storage for atmospheric carbon (C) due to their fast growth and high productivity finally depositing the carbon in form of tree biomass. Therefore, apart from lowering the groundwater table, biodrainage plantation provides additional benefits in terms of carbon sequestration (Ram *et al.*,2011). Planting of biodrainage tree species, in due course of succession, may also develop their association and niche with natural invaders, by accommodating varying levels of diversity and productivity status, thus play an important role in biodiversity conservation (Singh and Garg 2007).

Table 3. Opportunities Identified by the Farmers for the Application of Biodrainage Technology to Solve the Problem of Water Logging

S. No.	Opportunity Items	Frequency (%)
1	Improvement in land quality	92
2	Bioremediation of poor soil	86
3	Increase in productivity	90
4	Employment generation	80
5	Poverty alleviation	80
6	Improvement in environment quality	100
7	Increase in tree cover	100
8	Maintenance of water table	90
9	Carbon sequestration through tree planting	96
10	Biodiversity conservation	96

Threat is considered as some event or condition which can harm the activity and reduce the chance of success. Threats are unseen external factors and for successful implementation of the projects these threats should always be taken into consideration and attempted to be minimized. In this present study, the major threats identified were the protection of tree plantations from grazing and illegal felling, disease in tree plantations, failure of the selected tree species for biodrainage, local land disputes and other legal problems. Frequencies of the threat items considered by the respondents were relatively uniform compared to strengths, weaknesses and opportunities (Table 4). Roy Chowdhury *et. al.,* 2011 also discussed the damage of plantations due to natural disasters like cyclones, floods, etc. as major threat in Orissa state. They also stated that the gradual decrease in capacities of trees with age for consuming and transpiring water, thereby reducing the extent of bio-drainage, may also affect the adoption.

Table 4. Threats Identified by the Farmers for the Application of Biodrainage Technology to Solve the Problem of Water Logging

S. No.	Threat Items	Frequency (%)
1	Protection of tree plantation	100
2	Disease in tree plantation	96
3	Failure of the selected tree species for biodrainage	96
4	Local land disputes	96
5	Legal problems	92

Summary and Conclusion

Water logging is a major problem to augment agricultural productivity. The findings of the present SWOT analysis may offer helpful perspectives to implement the use of Biodrainage Technology to solve the problem of water logging**.** They also helped to communicate with stakeholders and to study their perceptions before initiating the project. The results obtained from the above analysis may help in chalking out the perfect strategies for successful implementation of the biodrainage technology in the area, selection of tree species, plantation models etc. Interested farmers who were keen to adopt biodrainage technology to remediate their water logged sites may be identified through the process and may be involved in the selection of species and type of plantation models to ensure the success of the project. Staff should explain to these farmers the strengths, weaknesses, opportunities and threats. The strengths and opportunities of the project may be highlighted for enhancing the success rate of the project, however weaknesses and threat items may be tackled carefully with efforts to minimize such. In the end, this may enhance the adoption of the technology by the farmers after solving their queries.

Since adoption of biodrainage technology may shift pure agricultural farming system to an agroforestry system, its adoption depends on the perceptions of an individual. SWOT analysis may be used as assessment tool to identify the positives and negatives of the project and may help in decision making. Analysis of strengths and opportunities and positive attributes of biodrainage technology may motivate the farmers and widen the scope of its use to reclaim waterlogged areas; while analysis of weaknesses and threats may prepare them to take measures and preplan for tackling the problems.

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