A Review of Approach Pattern of Watershed Management in Agroforestry, Climate Change, Social Aspects and Livelihoods

Sharda Dubey

UBKV, Cooch Behar, West Bengal, India

Abstract: ***Watershed management as the process of guiding and organizing land use and the use of other resources in a watershed in order sustainably to provide desired goods and services to the people without adversely affecting soil and water resources. Watershed management is generally scientifically management of water in the earth.it has evolved and passed through several developmental stages. In the initial stages, it was a subject of forestry and forestry-related hydrology. The involvement of people was not an issue. It was solely an affair of government forest departments. During the second stage, it became land resources management-related, including activities with an eye on economic benefits. At this stage, the focus was on beneficiaries. It is now "participatory and integrated" watershed management, with involvement and contribution from local people.Forests are the biggest users of water worldwide and extensive forested areas have been lost or are undergoing conversion to agriculture, creating concerns about loss of hydrological functions and increasing the competition for scarce water between agriculture, urban centers, industries and wildlife. The challenge is to improve the sustainability and productivity of land and water use, especially for the growing populations of many developing countries. In this chapter we review recent findings on the hydrology of forests and agroforestry systems and indicate how modifications in tree based systems might increase water productivity. In forestry, the focus of research has moved from the hydrological functions of upland forest reserves that are close to settlements to a greater recognition of the roles played by upland communities in the management of water resources. The world's watersheds face a wide variety of stresses that threaten to degrade their biological value and their ability to provide ecosystem services (World Resources Institute, 1998 and Millennium Ecosystem Assessment, 2005). Prominent among the pressures faced by watershed include high population growth, expansion of irrigated cropland, high deforestation and acute water scarcity. The stresses are particularly severe in watersheds that are already substantially modified or degraded by human activity in India, China, and Southeast Asia. Other major watersheds that are less degraded, such as the Amazon and the Congo, are nonetheless beginning to experience rapid transformations that threatens livelihood. The accelerating pace of climate change is an additional challenge to the sustainability of global watersheds. Climate change has the potential to damage irreversibly the natural resource base, on which agriculture depends, in many watersheds, which aggravate the consequences for food security. There is a consensus among climate change scientists that major watersheds in Africa and other tropical regions will be impacted to varying degrees by changes to the frequency, intensity and timing of rainfall within seasons, shifts in seasons with wet seasons becoming shorter, dry seasons longer and more uncertain timing in the transitions between them and warmer temperatures increasing evapo-transpiration and impacting on soil water balance (Dangerfield, 2010). These climate fluctuations necessitate increased attention to addressing human and climatic stresses on watersheds in order to conserve their ecological and economic functions. One of the improvements introduced in recent years is the global approach. Although evaluations of the constraints encountered in and the potential of rural areas revealed the complexity of the situations, they also highlighted the need to take account of the many aspects of the problems to be dealt with. A systemic analysis showed that all human activity may be considered as an element in a complex system; a system where various elements are interrelated and can be exchanged (goods and information) within and outwith the system in accordance with regulatory mechanisms, thereby providing a result while at the same time ensuring that the overall system is sustainable. Under these holistic arrangements, the human factor has a vital role in rural systems.***

Keywords: Watershed management, Agroforestry, Climate change, Social aspects, Livelihoods.

1. A New Approach Pattern to Watershed Management

Watershed management as the process of guiding and organizing land use and the use of other resources in a watershed in order sustainably to provide desired goods and services to the people without adversely affecting soil and water resources. Watershed management is generally scientifically management of water in the earth.it has evolved and passed through several developmental stages. In the initial stages, it was a subject of forestry and forestry-related hydrology. The involvement of people was not an issue. It was solely an affair of government forest departments. During the second stage, it became land resources management-related, including activities with an eye on economic benefits. At this stage, the focus was on beneficiaries. It is now "participatory and integrated" watershed management, with involvement and contribution from local people.

Worldwide environmental, socio-economic and political changes are challenging some of the foundations on which watershed management has been based for the last 25 years. Watershed management is going through a period of experimentation in which old and new practices often coexist and mix. The new generation of watershed management programmes being developed has a different approach, design and implementation strategy.

New Integrated Watershed Management Model for Efficient Management of Natural Resources

A new model for efficient management of natural resources in the SAT has emerged from the lessons learnt from long watershed-based research. The important components of the new integrated watershed management model are:

S.no	Components of the new integrated watershed management model
1.	Farmer participatory approach through cooperation model and not through contractual model.
2.	Continuous monitoring and evaluation by the stakeholders.
3.	Emphasize on individual farmer-based conservation measures for increasing productivity of individual farms along with community-based soil and water conservation measures.
4.	A consortium of institutions for technical backstopping of the on-farm watersheds
5.	A holistic system's approach to improve livelihoods of people and not merely conservation of soil and water.
6.	Link on-station and on-farm watersheds.
7.	Use of new science tools for management and monitoring of watersheds. Empowerment of community individuals and strengthening of village institutions for managing natural watersheds.
8.	Low-cost soil and water conservation measures and structures.
9.	Amalgamation of traditional knowledge and new knowledge for efficient management of natural resources
10.	A micro-watershed within the watershed where farmers conduct strategic research with technical guidance from the scientists. Minimize free supply of inputs for undertaking evaluation of technologies.

2. Role of Agroforestry in Water Shed Management

Forests are the biggest users of water worldwide and extensive forested areas have been lost or are undergoing conversion to agriculture, creating concerns about loss of hydrological functions and increasing the competition for scarce water between agriculture, urban centers, industries and wildlife. The challenge is to improve the sustainability and productivity of land and water use, especially for the growing populations of many developing countries. In this chapter we review recent findings on the hydrology of forests and agroforestry systems and indicate how modifications in tree based systems might increase water productivity. In forestry, the focus of research has moved from the hydrological functions of upland forest reserves that are close to settlements to a greater recognition of the roles played by upland communitiesin the management of water resources. A major source of conflict over water resources is the contrasting perceptions of 'watershed functions' between forest managers and local people, which are often based more on myths of forest functions than on science – for example, the idea that forests increase rainfall. These myths continue to dominate the views of policy makers and institutions and should be revised. The challenge is to gain a better insight into how farmer-developed land-use mosaics have modified watershed-protection functions. Priority must be given to the perceptions, experiences and strategies of local communities.

Trees on farms have the potential for improving productivity in two ways. Trees can increase the amount of water that is used on farm as tree or crop transpiration. Trees can also increase the productivity of the water that is used by increasing biomass of trees or crops produced per unit of water used. Plot-level evidence shows that improvements in water productivity as a consequence of modifications to the microclimate of the crop are likely to be limited. Instead, evidence from semi-arid India and Kenya showed that the greater productivity of agroforestry systems is primarily due to the higher amount of water used. Almost half of the total water use occurred during the dry season, when cropping was impossible, and the rest was extracted from soil reserves. This implies a high temporal complementarity between the crop and tree components of the landscape mosaic. Research is needed to examine the impact of the increased water use on the drainage and base flow at the landscape level. This chapter also describes some of the technical approaches that can be used to improve land and water management, the role of trees and its relation to hydrology and the challenges for rational land-use decision-making.

Agroforestry offers one promising option for efficient and sustainable use of land and water. In simplified terms, agroforestry means combining the management of trees with productive agricultural activities. Agroforestry provides opportunities for forest conversion in the true sense of the term – that is, replacement of natural forests with other tree-based land-use systems. There are also opportunities to use agroforestry for the prevention or reversal of land degradation in the humid tropics (Cooper *et al.*, 1996).

There are numerous potential benefits that agroforestry systems can achieve, ranging from diversification of production to improved natural-resources utilization. The key benefits in terms of natural-resources use are as follows:

S.no.	Benefits in terms of natural-resources
1.	Soil conservation in terms of protection against erosion.
2.	Improvement or maintenance of soil fertility.
3.	Water conservation and more productive use of water.
4.	Providing environmental functions required for sustainability

A recent review by Wallace *et al*. (2003) has described the above benefits of agroforestry

s.no.	Water utilization of agroforestry systems
1.	Trees play an important role in ecosystem in all terrestrials and provide a range of products and services to rural and urban people. As natural vegetation is cut for agriculture and other types of development, the benefits that trees provide are best sustained by integrating trees into agricultural system — a practice known as agroforestry. Farmers have practiced agroforestry since ancient times. Agroforestry focuses on the wide range of trees grown on farms and other rural areas. Among these are fertilizer trees for land regeneration, soil health and food security; fruit trees for nutrition; fodder trees for livestock; timber and energy trees for shelter and fuel wood; medicinal trees to cure diseases and trees for minor products *viz.* gums, resins or latex products. Many of these trees are multipurpose, providing a range of benefits
2.	Agroforestry is the combination of agricultural and forestry technologies to create integrated, diverse and productive land use systems (Garrett et al. 2000). Agroforestry has the ability to provide short-term economic benefits while the farmer waits for

	traditional longer-term forestry products. An example of an agroforestry system is a riparian buffer planting that can attenuate flooding effects and protect water quality, while providing wildlife habitat, recreational opportunities and harvestable products, like edible berries and medicinal herbs. Agroforestry encompasses a very large and diverse set of practices ranging from croplands in which a minimal tree component has been added to complex forest production that has been integrated into an existing forest structure. Differences exist in how agroforestry is defined and perceived between tropical and temperate zones and reflect the wide variation in the climate, soils, pressures on the land and socioeconomic values where agroforestry can be applied. After examining many definitions and examples of agroforestry used globally, Nair (1985) concluded that the "strict scientific definition should stress two characteristics common to all forms of agroforestry:
3.	Scientific evidence is now available to show that the spatial and temporal heterogeneity created by the agroforestry plantings can help enhance resource, increase production, reduce risk of monocultural agricultural and forestry practices, and achieve system stability and sustainability (Sanchez 1995; Ong and Huxley 1996; Lefroy et al. 1999; Nair and Latt 1998; Nair 2001). The biological advantages of agroforestry are 1) increased site utilization, 2) improved soil characteristics, 3) increased productivity, 4) reduced soil erosion, 5) reduced microclimate extremes, 6) positive use of microclimate changes (i.e. shade), 7) enhanced above- and below-ground biodiversity (i.e. natural enemy populations). These advantages in turn provide the economic and/or social values being sought from these systems.
4.	The deliberate growing of woody perennials on the same unit of land as agricultural crops and/or animals, either in some form of spatial mixture or in sequence.
5.	There must be a significant interaction (positive and/or negative) between the woody and non-woody components of the system, either ecologically and/or economically.

A general classification developed by Nair (1985) puts the many agroforestry practices existing world wide into three major types based on the combination of the components:

S. no	Agroforestry practices
1.	Agrisilvicultural: crops and woody plants
2.	Silvopastoral: pasture and/or animals and woody plants
3.	Agrosilvopastoral: crops, pasture and/or animals and woody plants
4.	A fourth category, Other Systems, is also included to catch those practices that don’t quite meet any of the prior three types, such as apiculture with trees.

Agroforestry practiced worldwide (Nair (1989), Nair et al. (1995), and Garrett et al. (2000).

s.no	Agroforestry practiced worldwide (Nair (1989), Nair et al. (1995), and Garrett et al. (2000))
1.	Landcare is a set of appropriate land management practices. It is also an ethic and a principle used to describe the judicious utilization of natural resources viewed in two ways: as a development approach and as a community-led movement. Land care is an approach for rapid and inexpensive method of disseminating soil and water resources managements in the uplands.
2.	There are 5 types of Land care groups that ICRAF had been facilitating such as: 1.) *Landcare in farms* – groups of farmers and landowners working together to address technological andtenurial issues and concerns. 2.) *Landcare in schools* –The Landcare concept is nowintegrated into the school curriculum, specifically in *EdukasyongPangtahanan at Pangkabuhayan*(EPP) and in Technology on Home Economics (THE) of elementary andhigh school students. 3.) *Landcare in forest margins* – deals with indigenous people andmigrants 4.) Landcare in church – integrates Landcare into church activities for both thespiritual and physical needs of the church members. 5.) *Landcare for out-of-school youth* –deals with young people who are out of school due to various reasons and are learning andworking together for effective local resources management.
3.	Most watersheds contain a mixture of land uses, including forestry and agriculture. Protecting water quality requires an integrated multi-sectoral approach to watershed management. Streams that course through agricultural lands are often devoid of vegetation in their riparian zones and runoff containing excess fertilizers, pesticides, animal wastes, and soil sediments enters surface waters unabated. Agroforestry technologies, like riparian forest buffers, have been shown to be effective in reducing water pollution from agricultural activities when they are well designed and properly located in a watershed (Dosskey 2002). These buffers can stabilize stream channels and slow and reduce the transport of runoff to streams. This allows more time for infiltration of water and contaminants into the soil and increases the ability of the environment to degrade pesticides and animal waste products. Linked systems of upland and riparian tree-based buffer systems, designed in regards to other landscape practices and features, can optimize soil and water conservation in the watershed, along with other economic and social services. Agroforestry practices are also being adapted to design best management practices to detain and treat stormwater runoff from communities and restore ecological functions to watersheds.

Role of watershed management for climate change

The world’s watersheds face a wide variety of stresses that threaten to degrade their biological value and their ability to provide ecosystem services (World Resources Institute, 1998 and Millennium Ecosystem Assessment, 2005). Prominent among the pressures faced by watershed include high population growth, expansion of irrigated cropland, high deforestation and acute water scarcity. The stresses are particularly severe in watersheds that are already substantially modified or degraded by human activity in India, China, and Southeast Asia. Other major watersheds that are less degraded, such as the Amazon and the Congo, are nonetheless beginning to experience rapid transformations that threatens livelihood. The accelerating pace of climate change is an additional challenge to the sustainability of global watersheds. Climate change has the potential to damage irreversibly the natural resource base, on which agriculture depends, in many watersheds, which aggravate the consequences for food security. There is a consensus among climate change scientists that major watersheds in Africa and other tropical regions will be impacted to varying degrees by changes to the frequency, intensity and timing of rainfall within seasons, shifts in seasons with wet seasons becoming shorter, dry seasons longer and more uncertain timing in the transitions between them and warmer temperatures increasing evapo-transpiration and impacting on soil water balance (Dangerfield, 2010). These climate fluctuations necessitate increased attention to addressing human and climatic stresses on watersheds in order to conserve their ecological and economic functions.

Working at watershed or landscape level allows to anticipate the impacts of climate change from upstream to downstream. Indeed climate change is expected to intensify extreme weather events such as floods and droughts whose impacts especially depends on land use. This is expected to make communities both from upstream and downstream even more vulnerable. Because of poverty, many local communities live on degraded watersheds placing them at the center of a vicious circle: degraded ecosystems are more sensitive to erosion and further degradation, which are enforced by frequent floods and droughts. Topsoil erosion degrades water quality downstream, decreases agricultural productivity and further impoverishes the rural communities.

Interest in and awareness of the multiple environmental, economic and social benefits provided by watersheds has greatly increased in recent decades. This is particularly true in developing countries where the economy depends predominantly on agriculture. Besides, most of the developing countries are experiencing degradation of land and water resources at an alarming rate, whereas the need for these resources is vastly increasing. Sustainable use and management of land resources can only be achieved by adopting a system of improved land and water management based on an integrated approach to land resources development, and with the direct involvement and participation of the different actors.

Carbon sequestration refers to the capacity of agricultural lands and forests to remove carbon dioxide from the atmosphere in a manner that is not immediately remitted into the atmosphere. Carbon dioxide is absorbed by vegetation through photosynthesis and stored as carbon in biomass and soils. Forests and grasslands are carbon sinks because they can store large amounts of carbon in their vegetation and root systems for a relatively long period of time. However, soils are the largest terrestrial sink for carbon and the ability of agriculture lands to sequester carbon depends on climate, soil type, vegetation cover and land management practices Soil carbon sequestration allows for the replenishment of soil organic matter and, provides several other benefits including improved soil structure and stability that leads to reduced soil erosion, improved soil biodiversity, increased nutrient holding capacity, increased nutrient use efficiency, increased water holding capacity, increased crop yields and profitability and potential marketability of the sequestered carbon. Soil carbon sequestration is good for the soil quality, both at short-term and long-term. It is a cost-effective and environmentally-friendly process that can be achieved through land management practices adapted to specific land uses. Once sequestered, carbon generally remains in the soil as long as the sustainable land management practices are followed.

Carbon sequestration and watershed management

Carbon sequestration at the heart of Climate Smart agricultural policies. Global surface temperatures have increased by 0.8^{oC} since the late 19^{th} Century with an average rate of increase of 0.15^{oC} per decade since 1975. The Earth's mean temperature is projected to increase by 1.5^{oC}– 5.8^{oC} during the 21^{st} Century. Future global warming will exacerbate hydrologic scarcity and variability such that crops will have to grow in warmer and drier conditions. Higher temperatures and shorter growing seasons will reduce the yields of most food crops, and promote the spread of weeds and pests. Changes in precipitation patterns will also increase the likelihood of short-run crop failures and long-run productivity decline. Although there will be productivity gains in some crops in certain regions of the world, the overall impact of climate change on agriculture is expected to be negative, threatening global food security.

3. Watershed Management a Tool to Address Climate Change

Watershed Management

Watershed management is management of land, water and other natural resources on a sustainable basis. Watershed management carries out number of activities with an integrated approach addressing proper land use, protecting lands from all forms of degradation, building and maintaining soil fertility, conserving water for farm use, proper management of water for drainage, erosion control, production, flood protection, sediment reduction and increasing productivity from all land uses. To fulfill the watershed objectives, different Agronomic /Management, Vegetative, and Small Structural Conservation Techniques are packaged into different activities/measures. These measures may be broadly classified as Preventive, Rehabilitative, Conservation education and extension, and Income generating. Following are some rationales of watershed management activities generally implemented to address the water scarcity problems exaggerated by the climate change.

s.no.	Watershed Management a Tool to Address Climate Change	
1.	Vegetative Measures	Vegetative measures such as degraded land rehabilitation mainly through planting grass, tree and fruit sampling, hedgerows, agro-forestry mainly in degraded barren area is one major activity of watershed management. Vegetated watersheds have a "sponge effect". Forest soil, roots and litters act as a giant sponge, soaking up water from rain and runoff and releasing gradually over an extended period
2.	Protection of Water Source from Erosion	Land use beyond its capability and without proper conservation measures enhances erosion in uplands and sedimentation downstream. One of the principles of watershed management is to use the land as per its capability or suitability. So that erosion therefore water pollution from sediment remains low. This helps to protect the water source such as springs, lakes/ ponds, and rivers and enhance their suitability for human use.
3.	Efficient use of Water	Proper use of available water resource is one of the key strategies to address the world water scarcity. Watershed management considers different efficient technologies such as drip irrigation, water efficient conservation farming system such as system of rice intensification, etc

4.	Drip Irrigation	Drip irrigation is a method of watering plants by delivering drops of water in a controlled way to plant root zones of the crop. The system is made up of a water tank and a network of pipes with drippers at predetermined intervals.
5.	Water Harvesting	Water harvesting is a collection and storage of water during excess period and use when required to address the water scarcity problems. Under water harvesting, conservation pond and roof water harvest are most demanded activities.
6.	Conservation Pond	Conservation pond is an indigenous practice to store wastewater and / or run-off water during excess rain to reduce erosion as well as irrigate the crop during critically stressed period. The primary concern of a conservation pond is to manage water wisely for soil conservation and watershed management purposes. However, its use can be extended to serve multiple purposes: (buffalo bathing), irrigation, fisheries, entertainment and so on as required. Conservation pond (non-lined) plays crucial role in recharging ground water improving soil moisture through regulating infiltration, which increases the production. Depression of the conservation pond will have better moisture condition and can be used for growing crops during the dry period.

Role of Watershed Management For Social Aspects

One of the improvements introduced in recent years is the global approach. Although evaluations of the constraints encountered in and the potential of rural areas revealed the complexity of the situations, they also highlighted the need to take account of the many aspects of the problems to be dealt with. A systemic analysis showed that all human activity may be considered as an element in a complex system; a system where various elements are interrelated and can be exchanged (goods and information) within and outwith the system in accordance with regulatory mechanisms, thereby providing a result while at the same time ensuring that the overall system is sustainable. Under these holistic arrangements, the human factor has a vital role in rural systems. If we look at mountain dwellers, we find that they develop survival strategies based on the assets available to them (land, water, inputs, labour and expertise) and are able to obtain results that can be used not only to sustain their system but also, in the best-case scenario, to expand it. Of course, farmers receive funds in the form of aid and subsidies, as well as non-farm income from family members. Understanding the strategies used by small farmers, as well as how small farming systems work or why they fail, could shed light on the constraints they face and the measures to be taken to overcome them. Such measures could include improving the factors of production (e.g. fertility improvement, improved water management, land management, equipment and mechanization, etc.) and the marketing of farm surpluses (labelling, marketing organization, etc.). This requires decisions to be made by the persons in charge, their families and other persons concerned directly or indirectly with these improvements. All these partners are also involved in a number of rural systems all governed by the same rules of operation (e.g. marketing systems, the banking system, the political system, etc.). While each system may be an entity in itself, all the systems are inter-related and may also be interdependent.

The hydrological system is intrinsic to the watershed, a truly complex system. The same may be said of social systems, which may be local, regional, national and even international. They all involve a number of flows and relationships among the various components which, despite the complexity of the task, must be taken into account so that an accurate evaluation of the environmental situation can be made and the most appropriate solutions recommended.

Similarly, the changes in the design and implementation of development programmes in recent years have made it necessary to review the principles and relationships among the players in the rural process, especially the partnership between the people and the outside experts. Indeed, evaluations of the measures taken, often on the initiative of the authorities and outside experts, have highlighted problems concerning the maintenance and sustainability of the measures taken after project completion. The situation is further aggravated by pressure from international donors for government disengagement. The new responsibility-sharing system is part and parcel of a general trend towards decentralization, now taking place in most countries. It also draws on a very strong movement promoting the involvement of grassroots communities in the sustainable management of their resources.

Participation and Local Development

Although people's participation is recognized as a necessity and has been introduced in many programmes and projects as well as in most national and international plans, it is not always evident that it is being implemented. Some of the problems with involving the people in projects lie with the outside experts who have difficulty changing their method of operation – a management-based and top-down approach – and do not fully understand the reality of the situation in which the people find themselves. The people, on the other hand, find it difficult to enter into a new type of relationship as they continue to see themselves as the recipients and the outside experts as the providers of material assistance. However, what slows things down most often is failure to recognize the local people and their associations as true partners.

Social Relations and Partnership

A policy based on local player involvement needs to recognize the demands of local communities and small regions. Conversely, national policies will have to be made more regionfriendly. In other words, they will have to take into account the regions' agro-ecological, social and cultural characteristics. However, these two dimensions can only be implemented if accompanied by strong support measures designed to improve information sharing, strengthen the capabilities of people at all levels and organize the countryside. The major challenge here is how to deal with the contradiction between acknowledging local community initiatives and the need to incorporate these initiatives into a comprehensive approach.

With decentralization, the State becomes the mobilizer and facilitator of local development initiatives proposed by the communities. The basic idea behind economic reforms and decentralization is to give free rein to initiatives so that they can cater to special interests, without the local elites once again using their role as representatives of the people to organize, run and take over decentralization. A contractual and partnership approach would seek to establish new relations among the rural development players rather than vertical relations based on strategies that ignore local and regional processes. Centralized government institutions must be replaced by new institutions capable of creating suitable conditions for dialogue between farmers' organizations and other rural development players. At the same time, these new institutions must work towards the creation, conversion and strengthening of intermediate associations, which will have a central role for the following three reasons: 1) they will provide guidance for the government in drawing up the various policies that must go hand in hand with decentralization; 2) they will collate and regionalize the demands and requests of the rural people; and 3) as they eventually become sufficiently mature consultative partners, they will be able to build partnerships with other rural development players.

Watershed development and its impact on livelihoods

S.no	Watershed development and its impact on livelihoods
1.	Reduction in the threat of drought to crop and livestock production
2.	Recharge of ground water
3.	Improved fodder production
4.	More livestock managed under stall-fed conditions
5.	Diversification of the village economy into artisanal and other activities as people gain the confidence to approach banks for credit
6.	Increase in cropping intensity and yields of both irrigated and dryland crops
7.	Increase in milk production (livestock systems move from open grazing and towards crossbreeds)
8.	Decline in sedimentation downstream
9.	Creation of employment opportunities for landless labour
10.	Year-round availability of drinking water

References

[1] Bass, S., Dubois, O., Moura Costa, P., Pinard, M., Tipper, R., & Wilson, C. (1997). Rural livelihoods and carbon management, IIED Natural Resource Issues paper No. 1. *International Institute for Environment and Development, London. Cover photo: Tzeltal farmer walking home after day's work in the community nursery by Cisco Deitz*, 1605-1017.

[2] Brauman, K. A., Daily, G. C., Duarte, T. K. E., & Mooney, H. A. (2007). The nature and value of ecosystem services: an overview highlighting hydrologic services. *Annu. Rev. Environ. Resour.*, *32*, 67-98.

[3] Caglio, A. (2003). Enterprise resource planning systems and accountants: towards hybridization?. *European Accounting Review*, *12*(1), 123-153.

[4] Cannell, M. G. R., Van Noordwijk, M., &Ong, C. K. (1996). The central agroforestry hypothesis: the trees must acquire resources that the crop would not otherwise acquire. *Agroforestry systems*, *34*(1), 27-31.

[5] De Haas, H. (2010). Migration and development: A theoretical perspective 1. *International migration review*, *44*(1), 227-264.

[6] Harvey, C. A., & Villalobos, J. A. G. (2007). Agroforestry systems conserve species-rich but modified assemblages of tropical birds and bats. *Biodiversity and Conservation*, *16*(8), 2257-2292.

[7] Harvey, C. A., Chacón, M., Donatti, C. I., Garen, E., Hannah, L., Andrade, A., ...& Clement, C. (2014). Climate-smart landscapes: opportunities and challenges for integrating adaptation and mitigation in tropical agriculture. *Conservation Letters*, *7*(2), 77-90.

[8] Ilstedt, U., Malmer, A., Verbeeten, E., &Murdiyarso, D. (2007). The effect of afforestation on water infiltration in the tropics: a systematic review and meta-analysis. *Forest Ecology and Management*, *251*(1-2), 45-51.

[9] Krantz, L. (2001). The sustainable livelihood approach to poverty reduction. *SIDA.Division for Policy and Socio-Economic Analysis*.

[10] Lefroy, E. C., &Stirzaker, R. J. (1999).Agroforestry for water management in the cropping zone of southern Australia. *Agroforestry Systems*, *45*(1-3), 277-302.

[11] Lin, B. B. (2010). The role of agroforestry in reducing water loss through soil evaporation and crop transpiration in coffee agroecosystems. *Agricultural and Forest Meteorology*, *150*(4), 510-518.

[12] Lipper, L., Thornton, P., Campbell, B. M., Baedeker, T., Braimoh, A., Bwalya, M., ...&Hottle, R. (2014). Climate-smart agriculture for food security. *Nature Climate Change*, *4*(12), 1068.

[13] Lott, J. E., Khan, A. A. H., Black, C. R., &Ong, C. K. (2003). Water use in a Grevillearobusta–maize overstorey agroforestry system in semi-arid Kenya. *Forest ecology and management*, *180*(1-3), 45-59.

[14] Montagnini, F., & Nair, P. K. R. (2004). Carbon sequestration: an underexploited environmental benefit of agroforestry systems. In *New vistas in agroforestry* (pp. 281-295).Springer, Dordrecht.

[15] Nair, P. R. (1985). Classification of agroforestry systems. *Agroforestry systems*, *3*(2), 97-128.

[16] Ong, C. K., & Swallow, B. M. (2003).13 Water Productivity in Forestry and Agroforestry. *Water productivity in agriculture: limits and opportunities for improvement*, *1*, 217.

[17] Owen, J. M., & Rogers, P. (1999). *Program evaluation: Forms and approaches*. Sage.

[18] Quisumbing, A. R., &Pandolfelli, L. (2010). Promising approaches to address the needs of poor female farmers: Resources, constraints, and interventions. *World Development*, *38*(4), 581-592.

[19] Rao, M. R., Nair, P. K. R., &Ong, C. K. (1997).Biophysical interactions in tropical agroforestry systems. *Agroforestry systems*, *38*(1-3), 3-50.

[20] Ratna Reddy, V., Gopinath Reddy, M., Galab, S., Soussan, J., &Springate-Baginski, O. (2004). Participatory watershed development in India: Can it sustain rural livelihoods?. *Development and change*, *35*(2), 297-326.

[21] Rodríguez, J. P., Beard Jr, T. D., Bennett, E. M., Cumming, G. S., Cork, S. J., Agard, J., ... & Peterson, G. D. (2006). Trade-offs across space, time, and ecosystem services. *Ecology and society*, *11*(1).

[22] Sanchez, P. A. (1995). Science in agroforestry. *Agroforestry systems*, *30*(1-2), 5-55.

[23] Santiago, J. J., Dangerfield, A. L., Rattan, S. G., Bathe, K. L., Cunnington, R. H., Raizman, J. E., ... & Dixon, I. M. (2010). Cardiac fibroblast to myofibroblast differentiation in vivo and in vitro: expression of focal

adhesion components in neonatal and adult rat ventricular myofibroblasts. *Developmental dynamics*, *239*(6), 1573-1584.

[24] Tscharntke, T., Clough, Y., Wanger, T. C., Jackson, L., Motzke, I., Perfecto, I., ...& Whitbread, A. (2012). Global food security, biodiversity conservation and the future of agricultural intensification. *Biological conservation*, *151*(1), 53-59.

[25] Turton, C. (2000). *Enhancing livelihoods through participatory watershed development in India*. London: Overseas Development Institute.

[26] Vörösmarty, C. J., McIntyre, P. B., Gessner, M. O., Dudgeon, D., Prusevich, A., Green, P., ...& Davies, P. M. (2010). Global threats to human water security and river biodiversity. *Nature*, *467*(7315), 555.

[27] Whitehead, M. (1991).The concepts and principles of equity and health. *Health promotion international*, *6*(3), 217-228.

[28] Young, O. R., Berkhout, F., Gallopin, G. C., Janssen, M. A., Ostrom, E., & Van der Leeuw, S. (2006). The globalization of socio-ecological systems: an agenda for scientific research. *Global Environmental Change*, *16*(3), 304-316.