Review

A Critical Review of Nature-Based Solutions for Enhancing Climate Resilience and Water Security in Mountain Ecosystems

Umal Manjitha [1]

[1] Department of Civil Engineering, University of Moratuwa, Sri Lanka; manjithahhu.20@uom.lk
* Correspondence: manjithahhu.20@uom.lk

Abstract: Mountain ecosystems, functioning as indispensable "water towers," face escalating threats from climate change, land degradation, and water insecurity, jeopardizing the livelihoods of downstream populations. This paper presents a comprehensive critical review of integrated strategies designed to enhance the resilience of these vital socio-ecological systems. It synthesizes the theoretical underpinnings and practical applications of Nature-based Solutions (NbS), Sustainable Land Management (SLM), and Integrated Watershed Management (IWM), arguing that their synergy with Traditional Ecological Knowledge (TEK) offers the most robust pathway toward sustainability. The review meticulously examines a portfolio of proven best practices for critical interventions—including multi-zoned riparian buffers and bio-engineering for streamside protection; green drainage channels and bio-stabilized slopes for road management; and systematic, cascade-level rehabilitation of traditional water storage systems. Through a detailed analysis of design considerations, ecosystem services, and suitability criteria, the paper demonstrates that these are not isolated technical fixes but interconnected components of a holistic strategy. The review concludes that successful implementation is fundamentally contingent on a suite of non-negotiable prerequisites: strong and empowered community institutions, participatory governance, cross-sectoral policy integration, and the adaptation of global scientific principles to unique local ecological and cultural contexts.

Keywords: Mountain ecosystems; Water security; Ecosystem services; Nature-based Solutions

1. Introduction

The global climate crisis is exerting unprecedented pressure on the world's natural systems, with mountainous regions standing at the forefront of this vulnerability. These ecosystems, which serve as critical "water towers," are responsible for capturing, storing, and distributing a significant portion of the world's freshwater, sustaining downstream agriculture, industry, and communities [1]. However, they are now under a compound assault from increasingly erratic rainfall patterns, accelerated land degradation, widespread deforestation, and the decay of essential water management infrastructure. This is acutely evident in regions like Sri Lanka's Knuckles Mountain Range, a UNESCO World Heritage site, where the ecological integrity of the primary watershed is threatened, placing the resilience of subsistence farmers and agricultural communities at critical risk.

In response, a significant paradigm shift is occurring in land and water management, moving away from a historical reliance on single-purpose "grey" infrastructure toward more holistic, adaptive, and multifunctional approaches. This review paper critically synthesizes the conceptual frameworks and practical applications of an integrated strategy that weds modern ecological science with traditional wisdom. The central thesis is that a resilient and

Citation: Manjitha, U. A Critical Review of Nature-Based Solutions for Enhancing Climate Resilience and Water Security in Mountain Ecosystems. *Water* **2025**, *1*, 0.

sustainable future for mountain socio-ecological systems can only be secured through the deliberate integration of three core concepts: Nature-based Solutions (NbS), Sustainable Land Management (SLM), and Integrated Watershed Management (IWM). By conducting an in-depth review of validated best practices and their underlying mechanisms—from the micro-scale of root reinforcement in bio-engineering to the macro-scale of cascade-level water governance.

This paper identifies the non-negotiable prerequisites for successful implementation. The aim is to provide a comprehensive and actionable framework for developing strategies that are not only technically sound but also socially accepted and ecologically sustainable.

2. A Conceptual Framework for Socio-Ecological Resilience

Building resilience in complex mountain landscapes requires a conceptual framework that is multi-faceted and integrative. The synergy of NbS, SLM, and IWM, enriched by TEK, provides such a foundation.

2.1. Nature-based Solutions (NbS)

Defined by the IUCN as actions that protect, manage, and restore ecosystems to address societal challenges while providing human well-being and biodiversity benefits [1], NbS represents a fundamental departure from conventional engineering. Traditional "grey infrastructure" (e.g., concrete retaining walls, piped drainage) is often rigid, expensive, and designed for a limited range of conditions, making it vulnerable to failure when climatic events exceed design thresholds [2]. In contrast, NbS leverages the inherent dynamism and adaptability of natural processes. This includes utilizing wetlands for flood control and water purification, reforesting slopes to prevent landslides, and installing natural water retention measures to absorb flood peaks [3]. The application of NbS can be categorized into a practical typology:

- **Ecosystem Restoration:** The active rehabilitation of degraded systems, such as re-planting native riparian forests (SAoI 1) or restoring the ecological functions of village tanks (SAoI 3) [4].
- **Issue-Specific Ecosystem-Based Management:** The targeted management of ecosystems to deliver specific services, such as agroforestry on slopes to provide both soil stabilization and income [5].
- **Green-Grey Hybrid Infrastructure:** The synergistic combination of natural and engineered systems, such as a concrete culvert (grey) that discharges into a vegetated bioswale (green) to manage water quality and quantity, thereby enhancing overall ecosystem service delivery [6].

2.2. Sustainable Land Management (SLM)

SLM is a holistic approach that views land not merely as a medium for production but as a finite capital asset. The World Bank (2006) defines it as the use of land resources to meet human needs while ensuring the long-term productive potential of those resources and their environmental functions. For fragile mountain environments, the five guiding principles of SLM are particularly salient [7]: ensuring productivity through good practice; providing land tenure security to incentivize long-term conservation investment; active protection of soil and water resources; ensuring interventions are economically viable; and ensuring they are culturally acceptable and aligned with local values.

2.3. Integrated Watershed Management (IWM)

IWM treats the hydrological boundary of a watershed as the fundamental unit for planning, recognizing that physical, biological, and socio-economic systems are inextricably linked [8]. Unlike siloed, sectoral approaches, IWM necessitates systemic thinking about "upstream-downstream" consequences. For example, a village tank rehabilitation project (SAoI 3) is unsustainable if not coupled with upstream measures to control erosion from poorly managed roads (SAoI 2) and agricultural lands [9]. Fundamentally, IWM is a governance challenge that requires moving beyond top-down mandates toward collaborative decision-making among all stakeholders—from forest communities and farmers to various government agencies—to resolve conflicts, build ownership, and ensure equitable outcomes [10].

2.4. Synergy with Traditional Ecological Knowledge (TEK)

The principles of NbS and IWM are often deeply embedded in traditional systems. For millennia, Sri Lanka's cascaded tank-village system has exemplified a sophisticated understanding of hydrology and ecosystem management [11]. These systems, which incorporate elements like protected forest strips (gasgommana) and interconnected irrigation networks (ela), are time-tested models of resilience. Integrating this TEK with modern scientific approaches is not an act of nostalgia but a pragmatic strategy to leverage proven, locally adapted models that have sustained communities for centuries [12].

3. A Critical Review of Best Practices and Proven Models

The application of this integrated framework is best understood through a detailed examination of proven interventions in three strategic areas.

3.1. Intervention Area 1: Streamside Protection

This intervention is critical for enhancing water quality, stabilizing land, and maintaining ecological connectivity.

- **Riparian Buffer Strips (RBS):** As a globally recognized best practice, multi-layered vegetative buffers are highly effective. Studies in similar mountain ecosystems show that buffers of 30-50 meters can significantly reduce sediment and nutrient runoff [13]. Their effectiveness is rooted in several key functions:
  - **Water Quality Improvement:** Buffers act as powerful biofilters. Dense vegetation slows overland flow, causing sediment to settle out [14]. Microbial processes in the buffer's soil facilitate denitrification, removing excess nitrogen from agricultural runoff, while phosphorus is captured along with soil particles [15].
  - **Bank Stabilization:** The dense, interlocking root systems of trees, shrubs, and grasses bind soil particles, increasing shear strength and providing resistance to the scouring forces of floodwaters—a vital function on the steep slopes of mountain regions [16].
  - **Design Considerations:** A "one-size-fits-all" approach is ineffective. Width is the most critical design factor. While narrow buffers (<10m) can trap sediment, wider buffers are required for other functions. A comprehensive literature review suggests widths of 30m or more are often needed to achieve significant temperature control and provide viable wildlife habitat [17]. The most effective designs are multi-zoned:
    1. **Zone 1 (Inner):** Undisturbed native trees and shrubs for deep root reinforcement.
    2. **Zone 2 (Middle):** A managed forest or shrub zone for infiltration and nutrient uptake.
    3. **Zone 3 (Outer):** A dense grass strip to slow and spread runoff from adjacent land uses [18,19].

  - **Bio-engineering for Bank Stabilization:** This technique uses live plant materials and natural structures as a cost-effective and ecologically superior alternative to hard-armoring like concrete. It creates a living, self-repairing structure that adapts over time [20]. Key techniques include:
    * **Live Staking:** The direct insertion of dormant, rootable cuttings (e.g., willow, poplar) into the bank to provide rapid vegetative cover.
    * **Brush Layering:** Placing layers of live branches on terraces cut into a slope. The branches root into the bank, acting like "live nails" that provide deep reinforcement.
    * **Branch Packing:** A hybrid technique where a mix of soil and live cuttings is packed between rows of live stakes, ideal for repairing localized slumps.
    * **Live Cribwalls:** Interlocking log or timber structures filled with soil and live cuttings. The crib provides immediate mechanical support like a retaining wall, while the plants grow through it, creating a reinforced living wall suitable for high-energy environments [21].

3.2. Intervention Area 2: Drainage Management Along Roads

Roads are often primary conduits for erosion in mountain landscapes, altering hydrology and delivering sediment directly to streams [22].

- **Green Infrastructure Approaches:**
  - **Vegetated Swales:** Replacing concrete drains with vegetated channels slows runoff velocity, promotes infiltration, and filters out sediments and pollutants, embodying the "Green Roads" philosophy [23].
  - **Check Dams and Cascades:** Small, permeable structures built from local materials (stone, timber) within drainage lines dissipate the energy of flowing water, induce sediment deposition, and stabilize the channel gradient [24].
  - **Roadside Bio-engineering:** The combined use of vegetation with biodegradable geotextiles (e.g., coir netting) provides immediate surface protection against erosion while native plants establish their root systems for long-term stability. Research in Kerala, India, found coir geotextiles to be a cheaper and effective alternative to terracing for smallholder farmers [25]. Similarly, work in Nepal demonstrated that combining jute netting with grass and shrub planting effectively stabilized highly weathered cut slopes [26].
  - **Infiltration Systems:** Roadside recharge pits and infiltration trenches are engineered structures filled with stone that capture runoff, allowing it to slowly percolate into the ground. This simultaneously reduces flood risk and recharges groundwater aquifers, a dual benefit for water-stressed regions [27].

3.3. Intervention Area 3: Rehabilitation of Village Tanks and Irrigation Networks

This intervention revitalizes traditional water systems that are the lifeblood of many rural communities.

- **A Systematic, Holistic Approach:** Effective rehabilitation goes far beyond simply de-silting. It requires a sequence of actions: 1) restoring the upstream catchment with SLM practices to stop silt at its source; 2) repairing the tank's hydraulic structures (bund, spillway); 3) de-silting the tank bed to restore capacity; and 4) restoring the peripheral ecosystems [28]. The excavated silt can be valorized and reused for bund construction or other applications, creating a circular economy model [29].
- **Cascade System Management:** Since tanks often operate as an interconnected cascade, management must occur at the cascade level. Restoring the overflow channels (keta-

ela) re-establishes the hydraulic connectivity and optimizes water sharing across the entire system, a hallmark of traditional IWM [11].

- **Restoration of Peripheral Ecosystems:** The health of a tank depends on its surrounding ecosystems. This includes the gasgommana (a dense forest strip below the bund that acts as a filter), the iswetiya (a shallow water area), and the thulila (water meadow). Restoring these elements is a classic application of NbS, enhancing water quality, biodiversity, and overall system resilience [30].
- **Participatory Management:** The long-term sustainability of these systems is impossible without the active involvement of farmer organizations. Establishing clear water rights and maintenance responsibilities is paramount [31].

4. Synthesis of Prerequisites for Successful Implementation

The transition from theory to successful on-the-ground implementation is contingent on fulfilling a critical set of prerequisites that can be categorized as institutional, socio-economic, and biophysical.

- Institutional and Governance Prerequisites: This is arguably the most critical category. Strong community institutions, such as empowered Water User Associations or Cascade Management Committees, are essential for sustained management and maintenance. Success requires participatory planning, where communities are engaged from the initial mapping and design phases to ensure ownership. Furthermore, there must be inter-departmental collaboration between government agencies responsible for roads, forestry, agriculture, and irrigation to overcome sectoral silos and enable integrated planning.
- Socio-Economic Prerequisites: Interventions must be economically viable and socially acceptable. This often requires establishing clear land tenure and, where private land is involved, developing incentive mechanisms like Payment for Ecosystem Services (PES) to compensate landowners for dedicating land to conservation purposes like riparian buffers [32]. A focus on using local materials and labor not only reduces costs but also builds local capacity and ensures that maintenance skills remain within the community.
- Biophysical and Technical Prerequisites: Interventions must be based on sound science. This includes conducting hydrological surveys to understand catchment yield and siltation rates before designing tank rehabilitations. The selection of native plant species that are deep-rooted, fast-growing, and adapted to local conditions is crucial for the success of bio-engineering and riparian planting [33]. Finally, a robust monitoring and evaluation framework with clear ecological and socio-economic indicators must be established to measure impact and allow for adaptive management over time.

5. Conclusions

The challenge of building climate resilience and ensuring water security in vulnerable mountain ecosystems cannot be met with piecemeal or purely technical solutions. This critical review establishes that the most effective and durable strategy lies in the holistic integration of Nature-based Solutions, Sustainable Land Management, and Integrated Watershed Management, deeply informed by Traditional Ecological Knowledge. The proven practices for streamside protection, road drainage, and tank rehabilitation are not a menu of options but interconnected parts of a systemic approach to restoring the health of the entire watershed.

The success of such an approach, however, is determined less by the elegance of the engineering design and more by the strength of the underlying socio-ecological foundation. Without participatory governance, empowered local institutions, and cross-sectoral collaboration, even the best-designed interventions are destined to fail. By embracing this integrated, systems-thinking approach and committing to fulfilling its core prerequisites, it is possible to upgrade land and water management infrastructure in a way that secures a resilient and sustainable future for both the unique ecosystems of our mountain regions and the millions of people who depend on them.

Acknowledgments: I am thankful to the faculty and staff of the Department of Civil Engineering at the University of Moratuwa for their assistance and encouragement. Special thanks to my fellow students for their collaboration and feedback, and to the Department of Meteorology and the Department of Irrigation in Sri Lanka for providing the necessary data for this research. Finally, I would like to thank my family and friends for their constant support and motivation throughout my academic journey.

Abbreviations

The following abbreviations are used in this manuscript:

NbS	Nature-based Solutions
SLM	Sustainable Land Management
IWM	Integrated Watershed Management
TEK	Traditional Ecological Knowledge
IUCN	International Union for Conservation of Nature
RBS	Riparian Buffer Strips
PES	Payment for Ecosystem Services
SAoI	Strategic Areas of Intervention

References

1. Cohen-Shacham, E.; Walters, G.; Janzen, C.; Maginnis, S., Eds. *Nature-based solutions to address global societal challenges*; IUCN International Union for Conservation of Nature, 2016. https://doi.org/10.2305/IUCN.CH.2016.13.en.
2. European Commission. Directorate General for Research and Innovation.. *Evaluating the impact of nature-based solutions: a handbook for practitioners.*; Publications Office: LU, 2021.
3. Somarakis, G.; Stagakis, S.; Chrysoulakis, N. ThinkNature / Nature-Based Solutions Handbook **2019**. Publisher: ThinkNature - European Union's Horizon 2020, https://doi.org/10.26225/JERV-W202.
4. Mansourian, S. Governance and forest landscape restoration: A framework to support decision-making. *Journal for Nature Conservation* **2017**, *37*, 21–30. https://doi.org/10.1016/j.jnc.2017.02.010.
5. IUCN, International Union for Conservation of Nature. *IUCN Global Standard for Nature-based Solutions: a user-friendly framework for the verification, design and scaling up of NbS: first edition*, 1 ed.; IUCN, 2020. https://doi.org/10.2305/IUCN.CH.2020.08.en.
6. Browder, G.; Ozment, S.; Rehberger Bescos, I.; Gartner, T.; Lange, G.M. *Integrating Green and Gray: Creating Next Generation Infrastructure*; Washington, DC: World Bank and World Resources Institute, 2019. https://doi.org/10.1596/978-1-56973-955-6.
7. Liniger, H. *Sustainable land management in practice: guidelines and best practices for Sub-Saharan Africa*; Food and Agriculture Organization of the United Nations: Rome, 2011. OCLC: 990265785.
8. Bilalova, S.; Newig, J.; Tremblay-Lévesque, L.C.; Roux, J.; Herron, C.; Crane, S. Pathways to water sustainability? A global study assessing the benefits of integrated water resources management. *Journal of Environmental Management* **2023**, *343*, 118179. https://doi.org/10.1016/j.jenvman.2023.118179.
9. Darghouth, S.; Ward, C.; Gambarelli, G.; Styger, E.; Roux, J. Watershed management approaches, policies, and operations: lessons for scaling up **2008**.
10. Jønch-Clausen, T.; Fugl, J. Firming up the Conceptual Basis of Integrated Water Resources Management. *International Journal of Water Resources Development* **2001**, *17*, 501–510. Publisher: IAHR Website _eprint: https://doi.org/10.1080/07900620120094055, https://doi.org/10.1080/07900620120094055.
11. Madduma Bandara, C.M. Catchment Ecosystems and Village TankCascades in the Dry Zone of Sri Lanka A Time-Tested System of Land and Water Resource Management. In *Strategies for River Basin Management: Environmental Integration of Land and Water in a River Basin*; Lundqvist, J.; Lohm, U.; Falkenmark, M., Eds.; Springer Netherlands: Dordrecht, 1985; pp. 99–113. https://doi.org/10.1007/978-94-009-5458-8_11.
12. Panabokke, C.R.; Sakthivadivel, R.; Weerasinghe, A.D. *Small tanks in Sri Lanka: evolution, present status, and issues*; International Water Management Institute: Colombo, 2002. OCLC: 51264728.

13. Mohan, M.; Saritha, V.N.K.; Rameshan, M.; Chacko, A.; Gopikrishna, V.G. Restoring degraded riparian forest ecosystems of the Western Ghats for ecological sustainability. *Restoration Ecology* **2021**, *29*, e13254. https://doi.org/10.1111/rec.13254.
14. Liu, X.; Zhang, X.; Zhang, M. Major Factors Influencing the Efficacy of Vegetated Buffers on Sediment Trapping: A Review and Analysis. *Journal of Environmental Quality* **2008**, *37*, 1667–1674. https://doi.org/10.2134/jeq2007.0437.
15. Mayer, P.M.; Reynolds, S.K.; McCutchen, M.D.; Canfield, T.J. Meta-Analysis of Nitrogen Removal in Riparian Buffers. *Journal of Environmental Quality* **2007**, *36*, 1172–1180. https://doi.org/10.2134/jeq2006.0462.
16. Wohl, E.; Kramer, N.; Ruiz-Villanueva, V.; Scott, D.N.; Comiti, F.; Gurnell, A.M.; Piegay, H.; Lininger, K.B.; Jaeger, K.L.; Walters, D.M.; et al. The Natural Wood Regime in Rivers. *BioScience* **2019**, *69*, 259–273. https://doi.org/10.1093/biosci/biz013.
17. Sweeney, B.W.; Newbold, J.D. Streamside Forest Buffer Width Needed to Protect Stream Water Quality, Habitat, and Organisms: A Literature Review. *JAWRA Journal of the American Water Resources Association* **2014**, *50*, 560–584. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/jawr.12203, https://doi.org/10.1111/jawr.12203.
18. Welsch, D.J. Riparian Forest Buffers - Function for Protection and Enhancement of Water Resources. *NA-PR-07-91. [Broomall, PA:] U.S. Dept. of Agriculture, Forest Service, Northern Area State & Private Forestry* **1991**, *791*.
19. Dosskey, M.G.; Vidon, P.; Gurwick, N.P.; Allan, C.J.; Duval, T.P.; Lowrance, R. The Role of Riparian Vegetation in Protecting and Improving Chemical Water Quality in Streams. *JAWRA Journal of the American Water Resources Association* **2010**, *46*, 261–277. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1752-1688.2010.00419.x, https://doi.org/10.1111/j.1752-1688.2010.00419.x.
20. Tamrakar, N.K. River bio-engineering solution for protecting banks and rehabilitating stream function; models for Bishnumati River, Kathmandu. *Bulletin of the Department of Geology* **2010**, *13*, 13–22. https://doi.org/10.3126/bdg.v13i0.3962.
21. Lammeranner, W.; Rauch, H.P.; Laaha, G. Implementation and Monitoring of Soil Bioengineering Measures at a Landslide in the Middle Mountains of Nepal. *Plant and Soil* **2005**, *278*, 159–170. https://doi.org/10.1007/s11104-005-7012-8.
22. Yu, Z.; Zhao, Q.; Liu, Y.; Yu, J.; Wang, A.; Ding, S. Soil erosion associated with roads—A global review and statistical analysis. *Land Degradation & Development* **2024**, *35*, 3509–3522. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/ldr.5159, https://doi.org/10.1002/ldr.5159.
23. Joshi, B.; Tiwari, P.C. Land-Use Changes and Their Impact on Water Resources in Himalaya. In *Environmental Deterioration and Human Health: Natural and anthropogenic determinants*; Malik, A.; Grohmann, E.; Akhtar, R., Eds.; Springer Netherlands: Dordrecht, 2014; pp. 389–399. https://doi.org/10.1007/978-94-007-7890-0_18.
24. Li, M.; Shen, Z.; Hui, B.; Lv, X.; Yang, E.; Ma, L.; Ni, Y.; Bao, H. Effect of Check Dams on Sediment Concentration in a Watershed in the Loess Hilly Area During a Heavy Rain Event. *Land Degradation & Development* **2024**, *35*, 5177–5191. https://doi.org/10.1002/ldr.5288.
25. Vishnudas, S.; Savenije, H.H.G.; Van der Zaag, P.; Anil, K.R. Coir geotextile for slope stabilization and cultivation – A case study in a highland region of Kerala, South India. *Physics and Chemistry of the Earth, Parts A/B/C* **2012**, *47-48*, 135–138. https://doi.org/10.1016/j.pce.2012.05.002.
26. Ojha, G.; Shrestha, R. Bioengineering measures for stabilising cut slopes of Dipayal-Mallekh road, Far Western Nepal. *Bulletin of the Department of Geology* **2007**, *10*, 79–88. https://doi.org/10.3126/bdg.v10i0.1423.
27. Van Steenbergen, F.; Arroyo-Arroyo, F.; Rao, K.; Alemayehu Hulluka, T.; Woldearegay, K.; Deligianni, A. *Green Roads for Water: Guidelines for Road Infrastructure in Support of Water Management and Climate Resilience*; The World Bank, 2021. https://doi.org/10.1596/978-1-4648-1677-2.
28. Batuca, D.G.; Jr, J.M.J. *Silting and Desilting of Reservoirs*; CRC Press: London, 2021. https://doi.org/10.1201/9781003210993.
29. Sinha, R.; Mishra, K.; Salunke, P.; Sounderajan, V. Sustainable Silt Management in the Lower Kosi River, North Bihar, India: Demand Assessment, Investment Model and Socio-Economic Development. *Sustainability* **2023**, *15*, 14952. Publisher: Multidisciplinary Digital Publishing Institute, https://doi.org/10.3390/su152014952.
30. Vidanage, S.P.; Kotagama, H.B.; Dunusinghe, P.M. Sri Lanka's Small Tank Cascade Systems: Building Agricultural Resilience in the Dry Zone. In *Climate Change and Community Resilience*; Haque, A.K.E.; Mukhopadhyay, P.; Nepal, M.; Shammin, M.R., Eds.; Springer Nature Singapore: Singapore, 2022; pp. 225–235. https://doi.org/10.1007/978-981-16-0680-9_15.
31. Rastogi, M.; Kolur, S.M.; Burud, A.; Sadineni, T.; Sekhar, M.; Kumar, R.; Rajput, A. Advancing Water Conservation Techniques in Agriculture for Sustainable Resource Management: A review. *Journal of Geography, Environment and Earth Science International* **2024**, *28*, 41–53. https://doi.org/10.9734/jgeesi/2024/v28i3755.
32. Chen, C.; He, G.; Lu, Y. Payments for Watershed Ecosystem Services in the Eyes of the Public, China. *Sustainability* **2022**, *14*, 9550. https://doi.org/10.3390/su14159550.
33. Bambaradeniya, C.N.B.; Ekanayake, S.P. *A guide to the biodiversity of Knuckles Forest Region*; IUCN, Sri Lanka: Colombo, Sri Lanka, 2003. OCLC: 60391919.