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Typical steep slopes, with severe land degradation under the conventional land management practices (centre left), restoration of degraded slopes with vetiver terraces (centre right) and traditional agroforestry system in the background. (Photo: Hanspeter Liniger)

SLM POLICY BRIEF

Productive and protective land management – reducing disastrous floods and saving springs in Haiti

Population pressure, deforestation and unsustainable agricultural practices have led to severe land degradation in Haiti. The combination of degraded land, with poverty and climatic threats (torrential rainfall, tropical cyclones, delayed rainfall onset) results in a vicious cycle of environmental degradation with an ever-increasing risk of disaster-related floods and droughts. Land use and land management practices have a decisive influence on the partitioning of rainfall into surface runoff, evapotranspiration, soil water and groundwater recharge. Sustainable land management practices, for example agroforestry and vetiver grass terraces, can improve the retention and infiltration of rainwater, reduce runoff during heavy rainfall and improve levels of both soil water and groundwater. Thus, there is evidence that these practices enhance the resilience of land, and people, to floods and droughts.

HAITI

Key message

- To mitigate human and environmental disaster in Haiti, the complex cycle connecting exposure to natural hazards of tropical cyclones and droughts, land degradation and poverty must be understood and addressed.
- Onsite and offsite benefits of sustainable land management (SLM) help to ensure land health and productivity, while reducing floods and the drying- up of springs.
- Large-scale implementation of productive, protective, affordable and socially acceptable SLM – especially intensified agroforestry – is the most promising strategy to improve smallholder agricultural production and simultaneously increase climate change resilience, reducing land degradation and disaster risk.
- There is an urgent need to better monitor on- and offsite impacts of land management to support capacity for evidence-based decision-making and action.

Too much water – too little water

Haiti ranks among those countries most affected by extreme weather events[1]. It is severely exposed to tropical cyclones (see definition Box 1) associated with heavy rainfall. On average, a hurricane touches Haiti every five and a half years and fully hits it every 17 years it, triggering disaster[2]. In 2008, Haiti was affected by two hurricanes and two tropical storms within three weeks, which killed more than 800 people, devastated approximately 75% of its agricultural land, destroyed about 60% of the country's harvest and caused $8 billion in damage[3,4]. In October 2016 during the harvesting season, hurricane Matthew hit Haiti as a category 4 storm: over 500 people were killed and more than 1.4 million became food and water insecure[5]. Climate change is aggravating the situation, with the frequency of category 4 and 5 hurricanes predicted to increase[6,7]. With global warming, water vapour levels are rising and intense rainfall associated with tropical cyclones is increasing[8,9]. Additionally, the onset of the seasonal rains has shifted from March to May/June in some locations, prolonging the dry season. This imposes constraints on agriculture and especially the cultivation of rainfed crops[10]. It also endangers springs – the main local water sources. Without interventions, Haiti will continue to be afflicted by the paradigm of "too much" followed by "too little" water availability (floods, then droughts). Both immediate and long-term actions are imperative to mitigate the impacts of these fluctuations, and reduce stress to rural communities, ecosystem services and resource availability.

Land management in Haiti

In rural Haiti, agriculture remains the primary income-generating activity for 70% of the population[11], and provides 25% of the gross domestic product10. Due to the growing population and thus the high demand for fuelwood and arable land, high rates of deforestation have occurred. There has also been a reduction in traditional agroforestry systems that underpin cash and subsistence crops – including coffee, cacao, yams and fruits. The ensuing intensification of agriculture has encouraged a "non-protective" conventional land management (CLM) practice, consisting of continuous cultivation of peanuts, pigeon peas, sweet potatoes, beans and maize. This results in low perennial vegetation cover and accelerates land degradation, especially on steep terrain. 65% of Haiti is dominated by steep slopes exceeding 40%, this is

Figure 1. The overall study area for on- and offsite impact assessment of sustainable land management in Léogâne, Haiti (pink) to reduce floods in the Cormier watershed (blue) and ensure spring recharge in two springs Grand Fond (green) and Cerisier (yellow).[16]

BOX 1: Definitions

Onsite: locations where the land management practices are applied.

Offsite: area where land management applied somewhere else have an impact on land and people.

A **tropical cyclone** "an intense circular storm that originates over warm tropical oceans and is characterized by low atmospheric pressure, high winds, and heavy rain". A **tropical storm** is a tropical cyclone in which the maximum sustained surface wind speed ranges from 34 kt to 63 kt (63 km/hr to 118 km/hr). A **hurricane** or typhoon is a heavy tropical cyclone in which the maximum sustained surface wind reaches 64 kt (119 km/hr) or more.[15]

A **hazard** is a process, phenomenon or human activity that may cause social and economic disruption, property damage, loss of life, injury or other health impacts, or environmental degradation[16]. The origin of a hazard may be natural (earthquake), anthropogenic (technological accident) or socio-natural (environmental degradation).

Resilience is defined as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions".[16]

Vulnerability is refers to the "conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards".[16]

where the majority of smallholders farm. To protect the land from degradation in the Léogâne region in the south-east of Haiti (Fig. 1), progressive bench terraces formed by contour strips of vetiver grass (*Vetiveria zizanioides*) have been promoted by various NGOs. Vetiver has deep roots and forms dense vegetative barriers with the ability to stabilize slopes and prevent erosion, naturally forming terraces over time. This practice also demonstrates the ability to minimize surface runoff[12]. However, despite these benefits, this practice has not yet been widely adopted. While vetiver is useful for mulching, it cannot be fed to livestock, and land users claim that it results in the loss of arable land. Consequently vetiver terraces are mostly used for land restoration, rather than degradation prevention on arable land. (See detailed description of land use practices in Box 2).

Onsite impacts of land management

Water balance. Land use and land management practices impact the partitioning of rainfall into runoff, evapotranspiration, infiltration and groundwater recharge. Degraded bare land results in a 67% loss of annual rainfall to runoff, and therefore groundwater recharge is minimal (Fig. 2). Contrastingly, in dense agroforestry systems, only 7% is lost to runoff and 45% is saved for groundwater recharge. For cropland without good conservation measures, 38-44% is directed to runoff and only 10-15% is conserved as groundwater. On sparse grassland, almost half of the rainfall escapes as runoff while 9% is retained as groundwater. However, during a single tropical cyclone, the percentage of water lost to runoff on bare land is much higher, reaching over 85%. In comparison, dense agroforestry loses less than 10% of runoff under such conditions.

Northern/ southern slope. North-facing and south-facing slopes tend to have different land management and land cover characteristics. Land users adapt their practices to the different microclimates, as the south-facing slopes are more exposed to the sun and the northeastern slopes to the humid trade winds. Typically, sunny and dry south-facing slopes are cleared for in-

BOX 2: Land use practices in Haiti

Conventional land management (CLM): Land is first cleared of trees. When preparing the land, land users loosen the soil with the hoes or the pickaxes and make ridges along the contour lines. After preparing the land – as well as post-harvest – the soil is exposed with no vegetation cover, leaving it very vulnerable to erosion, especially when applied on steep soils, as is the case in the highland of Léogâne. CLM is widespread because the requisite know-how is readily available, it is easy to implement and needs little maintenance. In Léogâne, pigeon peas, sweet potatoes, maize, beans and peanuts are commonly cultivated with this practice. The picture shows that most of the land had to be abandoned due to severe land degradation caused by CLM. (Photo: Hanspeter Liniger 2017)

Progressive bench terracing formed by vetiver grass strips is a SLM practice for crop cultivation on slopes. Vetiver grass (Vetiveria zizanioides) is planted along the contour. Over time, bench terraces are formed by the successive deposit of sediments behind the grass. The resultant reshaping of the slopes reduces soil loss and runoff and improves infiltration. The distance between the grass strips can be as little as 2 m on very steep slopes and can be used for planting crops. Vetiver grass is drought resistant and well suited as anti-erosive structure because of its strong, deep roots. Although it cannot be used as fodder for livestock, cut vetiver is used for mulching. Nevertheless, this practice is not popular among smallholders due to a loss of arable land. Consequently, vetiver terraces are mostly used for land restoration and not for prevention of degradation on cultivated land. (Photos: Hanspeter Liniger 2017)

Agroforestry systems in Haiti are traditional land use practices, characterised by a multi-storey arrangement of tall native trees, fruit species at various heights and a range of perennial and annual crops below. They provide food all year round (e.g. yam, mango, breadfruit, banana, pomelo and papaya) and offer an excellent environment for livestock and to plant the cash crops cacao and coffee. Today, agroforestry is reduced to areas around houses (homegardens) and less sun-exposed and more humid northwest facing slopes, where land users profit from existing forest trees. This practice protects downstream areas from landslides and runoff and is resilient to droughts and also conserves biodiversity. However, the establishment of agroforestry systems can be time-consuming; for some crops/ fruits it may take several months or years before they can be harvested. (Photo: Hanspeter Liniger 2017)

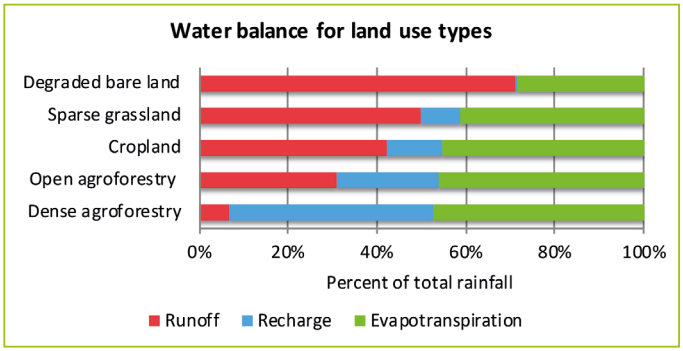

Figure 2. Water balance: the partitioning of rainfall into runoff, groundwater recharge and evapotranspiration for common land use types in the two springsheds Grand Fond and Cormier[16]

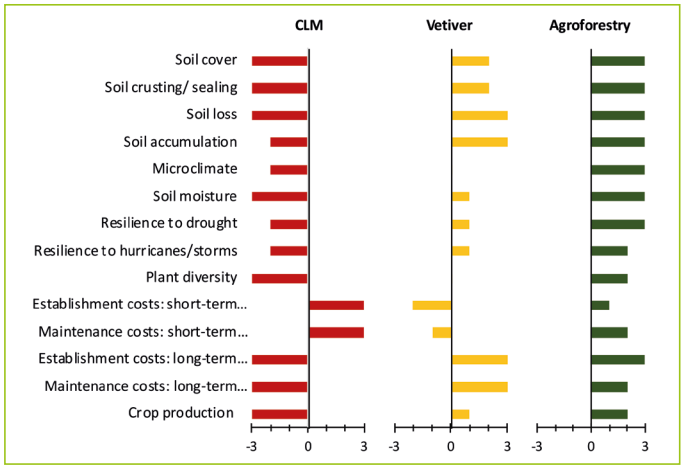

Figure 3. Onsite impacts of conventional land management (CLM), vetiver terracing and agroforestry (-3 = very negative impact, 0 = negligible impact, 3 = very positive impact)[16]

Figure 4: Lower zone of the Cormier watershed with highly degraded mountain slopes and an enlarged riverbed, caused by frequent floods. After high floods, the river has hardly any flow. (Photo: Hanspeter Liniger)

tensive cultivation through CLM, resulting in a high proportion of degraded bare land, sparse grassland and cropland. On the humid north-facing slopes, CLM is less commonly practiced, as land users preserve or establish agroforestry systems. These systems are commonly characterized by multi-storey arrangements of tall, indigenous trees combined with fruit species at different heights, and then an assortment of perennial annual crops below. Such diverse systems confer benefits through a) protection of the soil against sealing and crusting caused by heavy rains, b) high infiltration due to densely rooted topsoils covered with leaf litter mulch, and c) decreased runoff velocity from improved vegetation cover.

Perceived onsite impacts. The comparison of onsite impacts between CLM, vetiver terraces and the traditional agroforestry systems show significant differences (Fig. 3). CLM displays strong negative impacts through all environmental indicators, whereas vetiver terraces indicate soil improvements, stabilization of the slopes and enhanced resilience against both cyclones and droughts. Agroforestry shows the highest score for all environmental indicators, including resilience to hurricanes, droughts and increased plant diversity. Despite these perceived benefits of agroforestry and vetiver terraces, the economic gain of CLM has the highest short-term returns from the land user's perspective. Evidently, poor farmers find this type of land management more attractive and viable, despite it compromising long-term productivity and the health of natural resources.

Offsite impacts of land management

Perceived downstream impacts. Land users in downstream areas (lowlands) and local and international land management experts from implementing projects clearly recognize the negative impacts of CLM (Fig. 4) and acknowledge the benefits that result from SLM practices upstream. Such improvements are evident in terms of water quality and quantity, decreased downstream flooding and siltation, as well as reduced landslides and infrastructure damage (Fig. 5).

Flood reduction (reducing the "too much"). Haiti is exposed to frequent high intensity rainfall: daily events above 20 mm occur about 30 times a year, and events with more than 70 mm about 6 times. Rainfall events during tropical cyclones reaching 150 mm take place every 2 years, and 300mm every 10 years. Under the current land use and land management conditions of the Cormier watershed (Fig. 1), these rainfall events of 20 mm, 70 mm, 150 mm and 300 mm produce runoff of 5%, 22%, 36% and 49%, respectively (Fig. 6). The highest contribution is generated on areas with sparse crop and grass cover or degraded bare land, though their combined area covers only 11% of the watershed. Results from this WOCAT case study indicate that – after a rainfall event of 70 mm – about one-third (35%) of the total contribution to runoff is produced from these land use types. Therefore, by increasing vegetation on areas with poor cover, downstream flooding

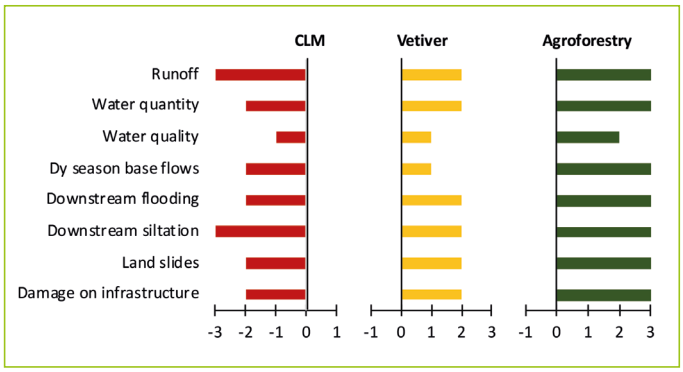

Figure 5. Offsite impacts of conventional land management (CLM), vetiver terracing and agroforestry (-3 = very negative impact, 0 = negligible impact, 3 = very positive impact)[16]

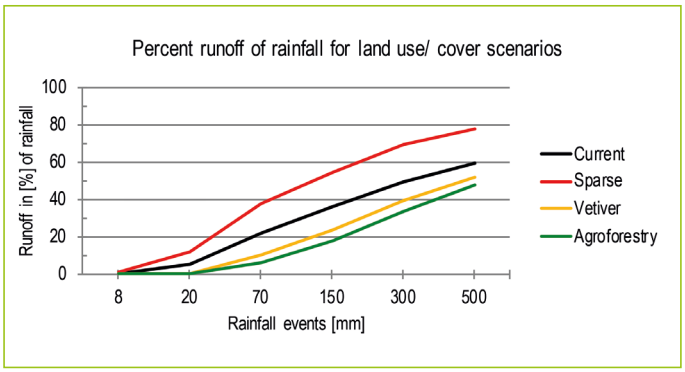

Figure 6. Watershed runoff scenarios for Cormier, Haiti: the current land use/ land cover, a poor (Sparse), and two improved management systems (Vetiver, Agroforestry) during different rainfall events[16]

could be reduced substantially. To assess potential future scenarios for the Cormier watershed, runoff from the current land management was compared with scenarios with poorer (reduced vegetation cover) and improved (increased vetiver terraces and agroforestry) land management. The scenarios with vetiver terraces and agroforestry systems reduced runoff during a high rainfall event of 150 mm by 34% and 50% respectively. Even during extreme events with 500 mm, (e.g. hurricane Matthew), the scenario with agroforestry showed the potential to reduce runoff by 21% (Fig. 7). Along with total runoff, the peak flood and subsequent disaster risk can be reduced due to the deceleration and spread of runoff by dense vegetation cover (agroforestry) and reshaped slopes (vetiver terraces).

Dwindling rivers and springs during the dry season (increasing the "too little"). Due to higher infiltration, improved land use and land management has the potential to increase dry season spring flows and groundwater recharge. The heavily degraded Cerisier springshed (Fig. 1) resulted in a low groundwater recharge, meaning it could only provide an average spring flow of 7.3 l/min/ha over the whole year. However, the current discharge fluctuates widely between the dry and wet season. Local land users reported that the spring discharge is dwindling, and it is completely exhausted at the end of the dry season. In contrast, under the same rainfall conditions, a nearby springshed, known as Grand Fond feeds its spring with almost three times more water, which would allow an average spring flow of 19.3 l/min/ha. The local community confirms that Grand Fond does not dry out – even at the end of the dry season. This can be explained by the predominant cover of agroforestry systems, increasing infiltration and providing year-round spring flow (Fig. 7).

Productive disaster risk reduction

Due to Haiti's highly vulnerable population, sustainable practices need to provide short and long-term benefits that simultaneously increase productivity and protect the land. Progressive terracing with vetiver grass strips has been recommended for stabilizing slopes, reducing runoff, soil erosion, and land degradation for the long term. However, when considering the land users' perspectives this practice does not provide sufficient benefits to people - and animals do not consume vetiver grass. There have been attempts to replace the vetiver with sugar cane or fodder grass species. However, unlike vetiver other species proved less drought resistant, which resulted in desiccation during the dry season and complete washing away of vegetation after subsequent rains. For improving smallholder livelihood in Haiti, productive and protective agroforestry is the most promising practice, inspired by the nature of tropical rainforests. It should be advocated as a nature-based solution for disaster risk reduction and climate change adaptation. Promoting agroforestry systems will help contribute to Haiti meeting a) its food sovereignty, food security and nutrition target for 2023, which aims to improve livelihoods and particularly food security of smallholder farmers and rural communities[13], b) its climate change adaptation plan for 2030, which includes afforestation (137,500 ha) and adding an additional 60,000 hectares of agroforestry systems[14]. However, in order to secure and increase food production, innovative and sustainable crop and grazing land management practices must be implemented to reach these goals.

Data scarcity

In Haiti, data scarcity on basic parameters such as rainfall, river flow, peak floods, spring flow, and the spread and im-pact of land management practices on water, food security and human well-being is a central challenge that needs to be addressed for developing watershed plans, identifying SLM practices, and assessing the on- and offsite impacts of inter-ventions. Lack of these monitoring systems is constraining in-formed implementation and research into the complex inter-actions between land management practices and impacts on productivity, degradation and hydrology. Understanding the hydrological processes related to land use and management in vulnerable watersheds will ensure that future sustainable re-source management strategies can effectively mitigate floods, droughts and enhance the resilience of land and people.

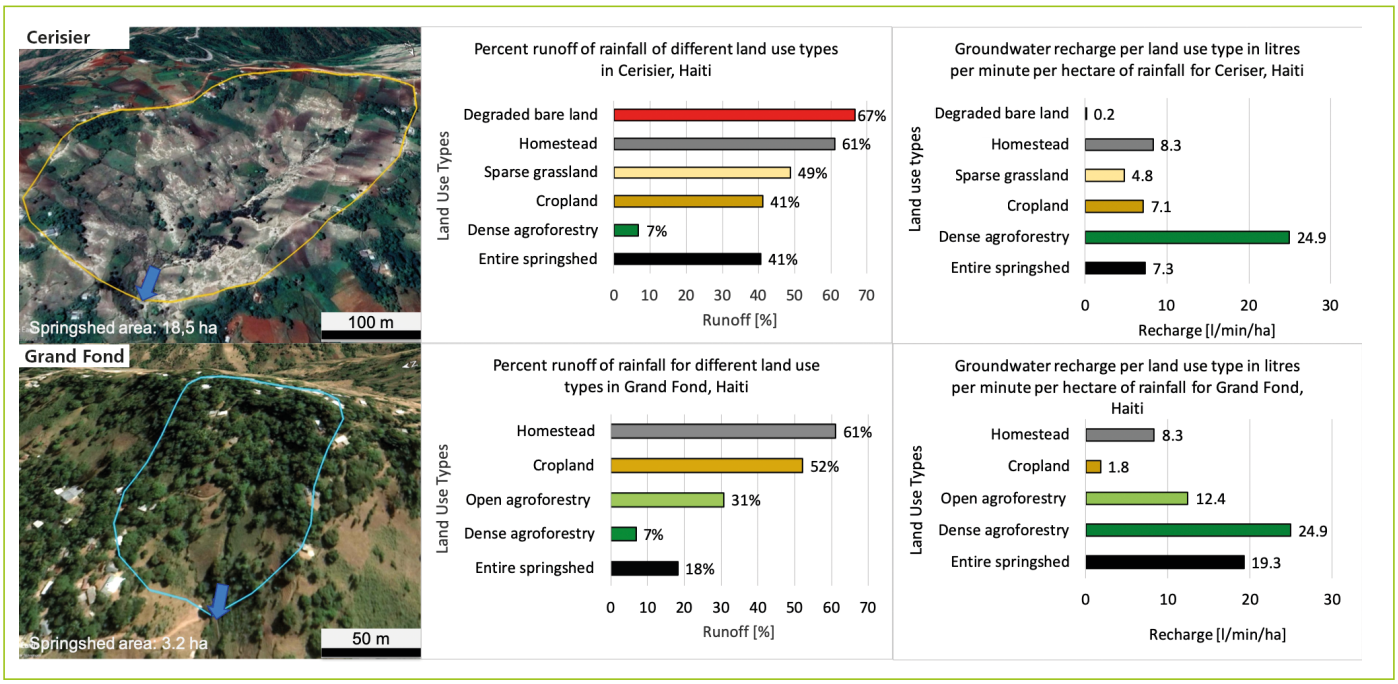

Figure 7. Comparison of land use types in two springsheds, Cerisier (highly degraded) and Grand Fond (high portion of agroforestry systems): percent runoff of rainfall [%] and groundwater recharge [l/min/ha][16]

Joana Eichenberger, MSc
Research assistant
Centre for Development and Environment (CDE)
University of Bern, Switzerland
joana.eichenberger@hotmail.com

Dr Hanspeter Liniger
Senior Research Scientist, WOCAT Director
Centre for Development and Environment (CDE)
University of Bern, Switzerland
hanspeter.liniger@cde.unibe.ch

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Further information

Link to all results from 'on- and offsite benefits of SLM':

- SLM Policy Briefs: www.wocat.net\ …
- Synthesis Report: www.wocat.net\ …
- Videos: www.wocat.net\ …
- Land management practices: WOCAT SLM Technology and Approaches database: www.wocat.net\ …

1 – 16 The list of references is available in the online version of this policy brief: www.wocat.net

Implications for practice, policy and research

Recognize cyclic disaster risks. Haiti ranks among those countries most affected by extreme weather events that trigger floods and droughts. It is essential to recognize that this extreme exposure coupled with severe land degradation and high level of poverty leads to a downward spiral of interconnected environmental and human disaster. Immediate action is required, to solve the tragedy of people and their land being repeatedly threatened by too much (floods) followed by too little (drying springs) water. This situation is aggravated by climate change.

Value sustainable land management (SLM) for its on- and offsite benefits to:

(a) improve land health and productivity (onsite). SLM practices such as vetiver terraces and agroforestry systems improve the health of the land and reduce runoff, resulting in improved productivity and groundwater recharge.

(b) reduce flood disasters and prevent the creeping and often-ignored disaster of drying springs (offsite). The combined onsite benefits of SLM practices reduce runoff and catastrophic floods downstream. Additionally, springsheds with improved vegetation cover have high groundwater recharge rates providing continuous spring flow to water-stressed communities.

Scale-up SLM. The most viable solution to address the cyclic disasters in Haiti requires a transformation of land use through large-scale implementation of productive and protective SLM practices that are affordable and socially accepted by land users. Currently, agroforestry practices demonstrate the highest potential to simultaneously ensure food security and mitigate disasters. Furthermore, additional sustainable crop and grazing land management practices must be identified and promoted.

Combine up-/downstream interventions. Coordinated implementation of SLM practices in the upstream parts of watersheds/ springsheds will yield benefits onsite and offsite. These should be combined with protective measures for people and infrastructure downstream.

Promote monitoring for better decision-making. Vital data is lacking – and thus government agencies, NGOs and research organizations need to be encouraged and supported to initiate and sustain efforts to monitor basic data on rainfall, river flows, spring discharges, and various land management impacts on- and offsite. Furthermore, capacity building is needed to utilize this information for evidence-based planning and decision-making on land management interventions.

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WOCAT SLM Policy Briefs summarise key findings about aspects of sustainable land management. Topics include on- and offsite benefits, disaster risk reduction, biodiversity, climate change adaptation/ mitigation, ecosystem services - and many more. The briefs are based on up-to-date research and implementation experience by specialists and land users. The briefs and other WOCAT resources are available at: www.wocat.net

Centre for Development and Environment (CDE)
University of Bern
Mittelstrasse 43
3012 Bern
Switzerland
www.cde.unibe.ch

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List of references

[1] Eckstein, D., Künzel, V., Schäfer, L., & Winges, M., 2019. Global Climate Risk Index 2020. Bonn: Germanwatch.

[2] Simpson, M., Scott, D., New, M., Sim, R., Smith, D., Harrison, M., Eakin, C., Warrick, R., Strong, A., Kouwenhoven, P., Harrison, S., Wilson, M., Nelson, G., Donner, S., Kay, R., Geldhill, D., Liu, G., Morgan, J., Kleypas, J., Mumby, P., Christensen, T., Baskett, M., Skirving, W., Elrick, C., Taylor, M., Bell, J., Rutty, M., Burnett, J., Overmas, M., Robertson, R., Stager, H., 2009. An overview of modeling climate change impacts in the caribbean region with contribution from the pacific islands. Barbados, West Indies.

[3] Kang, I., 2016. A list of previous disasters in Haiti, a land all too familiar with hardship. The New York Times. https://www.nytimes. com/2016/10/05/world/americas/haiti-hurricane-earthquake.html. [Last Accessed: 25th November 2019].

[4] Jones, S., 2016. Why is Haiti vulnerable to natural hazards and disasters? The Guardian. https://www.theguardian.com/world/2016/oct/04/why-is-haiti-vulnerable-to-natural-hazards-and-disasters. [Last Accessed: 25th November 2019].

[5] Eckstein, D., Künzel, V., Schäfer, L., 2017. Global Climate Risk Index 2018: Who Suffers Most From Extreme Weather Events? Weather-related Loss Events in 2016 and 1997 to 2016, Briefing Paper. Germanwatch e.V., Bonn, Germany.

[6] Murakami, H., Vecchi, G.A., Underwood, S., Delworth, T.L., Wittenberg, A.T., Anderson, W.G., Chen, J.H., Gudgel, R.G., Harris, L.M., Lin, S.J., et al., 2015. Simulation and prediction of category 4 and 5 hurricanes in the high-resolution GFDL HiFLOR coupled climate model. Journal of Climate 28, 9058–9079.

[7] Taylor, M., Douglas, C., Campbell, J., Jones, J.J., Brown, A., Stephenson, T., 2015. Haiti: Historical and future climatic changes. https://www.researchgate.net/publication/309572161_Haiti_Historical_and_Future_Climatic_Changes [Last Accessed: 25th November 2019].

[8] Cardona, O.D., van Aalst, M.K., Birkmann, J., Fordham, M., McGregor, G., Perez, R., Pulwarty, R.S., Schipper, E.L.F., Sinh, B.T., Décamps, H., Keim, M., Davis, I., Ebi, K.L., Lavell, A., Mechler, R., Murray, V., Pelling, M, Pohl, J. Smith, A.O. Thomella, F. 2012. Determinants of risk: Exposure and vulnerability, in: Field, C.B., Barros, V., Stocker, T.F., Dahe, Q. (Eds.), Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, p. 65-108.

[9] Liu, M., Vecchi, G.A., Smith, J.A., Knutson, T.R., 2019. Causes of large projected increases in hurricane precipitation rates with global warming. npj Climate and Atmospheric Science 2, 1–5.

[10] Singh, B. and Cohen, M., 2014. Climate change resilience: the case of Haiti. Canada. https://www-cdn.oxfam.org/s3fs-public/file_attachments/rr-climate-change-resilience-haiti-260314-en_2.pdf

[11] Dolisca, F., McDaniel, J. M., Shannon, D. A., and Jolly, C. M., 2009. Modeling farm households for estimating the efficiency of policy instruments on sustainable land use in Haiti. Land Use Policy, 26(1):130–138.

[12] Liu, H., Yao, L., Lin, C., Wang, X., Xu, W., and Wang, H., 2018. 18-year grass hedge effect on soil water loss and soil productivity on sloping cropland. Soil and Tillage Research, 177:12–18.

[13] World Food Programme, 2019. Haiti country strategic plan (2019–2023). https://docs.wfp.org/api/documents/WFP-0000104702/download/?_ga=2.206430682.872723871.1585233618-2147154982.1585233618 [Last Accessed: 26.03.2020].

[14] Ministère de l'Envionnement, 2015. Contribution prévue déterminée au niveau national. Port-au-Prince, Haiti. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Haiti%20First/CPDN_Republique%20d%27Haiti.pdf [Last Accessed: 12th December 2019].

[15] Zehnder, J.A., 1998. Tropical Cyclone. Encyclopedia Britannica. https://www.britannica.com/science/tropical-cyclone [Last Accessed: 8th April 2020].

[16] UNDRR, 2017. Report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction: Seventy-first session, agenda item 19(c). https://www.preventionweb.net/files/50683_oiewgreportenglish.pdf. [Last Accessed: 10th July 2018].

[17] Eichenberger, J., Liniger, H.P., 2020: Productive and protective land management: reducing disastrous floods and maintaining spring flow in Haiti. Report. WOCAT/CDE, University of Bern, Switzerland.