Drought Disaster Risk in Angola, Tanzania and Zambia

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Key Messages:

- A uniform methodology with an extensive hazard modelling chain, supplemented with national data on exposure and past impacts, can enable national hotspot analysis and the assessment of region-specific drought disaster impacts as well as enable regional comparison regarding historic and future drought risks. In our case studies, the capability of the presented method is showcased for drought-affected population in Angola, drought-induced crop yield losses in UR Tanzania and drought-related hydropower losses in Zambia.
- Local input and cooperation with stakeholders is crucial for proper drought disaster risk analysis and to derive relevant results. Stakeholders of the "Building Disaster Resilience to Natural Hazards in Sub-Saharan Africa Regions, Countries and Communities" program expressed a positive message in relation with the participatory, transdisciplinary DRR approach: "Having realized the importance of a scientific approach for effective risk management, the participants proposed incorporating the academic sector's studies and research of climate change phenomena into the design and budgeting processes for national disaster risk reduction projects and programs."

In the framework of "Building Disaster Resilience to Natural Hazards in Sub-Saharan African Regions, Countries and Communities", probabilistic drought disaster risk assessments were prepared for Angola, Tanzania and Zambia. Given the heterogeneous constellations of livelihood and climate zones, the manifestation of drought impacts in the three countries differs. A flexible modelling chain was developed to highlight location-specific issues while ensuring comparability within and among nations. Linking observed drought disasters with modelled hydro-meteorological drought indices, an AI algorithm was utilized to create a drought hazard map inclusive of local vulnerabilities. Moreover, an FAO-based crop yield model was applied to assess agricultural risks. Initial results were subject to discussion during several stakeholder workshops involving national and regional drought management authorities and scientists. Following a collaborative effort to include local data and expertise, the final risk profiles illustrate drought hazard, exposure and risk under current and projected climate.

Aligned with the Sendai Framework for Disaster Risk Reduction, the profiles assess the current and future drought risk in terms of people affected (B1), agricultural losses (C2), productive assets (C3). It shows that importance of impacts differs among countries. In Angola, almost 1.9 million people are directly affected by drought per year. This is currently focussed in the southern provinces but climate change may expose the centre and east of the country too. In UR Tanzania crop losses are high, currently causing on average an economic loss of 133 million USD each year. The harmful impact of droughts is even clearer when looking into the reduction in available calories,

threatening national food security. For Zambia, it is estimated that drought disasters generate an annual average direct economic loss of 45 million USD through losses in the hydropower production. Distinct spatial variability in hydropower losses exist and will increase towards the future, advocating for a diversification in source areas for hydropower (and overall energy mix) to increase national energy security.

Such national comprehensive drought risk assessment allows governments and decision makers to target investments aimed at disaster risk reduction in the most affected areas with a cost-benefit perspective and thus support a more interventionist and proactive stance with regard to prevention, mitigation and preparation of disasters in countries. For the full risk profiles and technical details of all countries, please see http://riskprofilesundrr.org.

Drought impacts in UR Tanzania:

Drought effects on the agricultural (arable) sector are critical in UR Tanzania, not only because of the direct economic losses but also concerning possible losses in farm labor opportunities and impacts on food security at the (sub-)national level. The East-African 2010/2011 drought, attributed to a strong La Nina and aggravated by human actions, was the worst in 60 years and brought over one million people in food and livelihood insecurity in Tanzania (OCHA 2015).

A recent national disaster risk assessment for Tanzania by Rudari et al (2019) calculated an annual average economic loss of one hundred fourthly million USD due to drought-related yield losses of the main crops (banana, cassava, maize, sweet potato, potato, and beans. Figure 1, left) under current climate conditions. Projected future climate in the same assessment highlights more frequent and intense droughts, which would (with the same harvested area and farming techniques) more than double this economic loss towards an average of three hundred fifty million USD per year. These losses represent respectively 2.4% and 6.1% of the total crop production value under the current and projected climate.

The authors also created Probable Maximum Loss curves (PML, figure 1, right) depicting the return periods of sums of direct economic losses due to crop yield reductions in Tanzania. These PML results indicate, e.g., that under current climate once every ten years, a loss may occur of approximately four hundred fifty million USD, equivalent to almost 10% of the total value of crop production. Under the projected climate, a severe drought event may cause a loss up to five hundred fifty million USD once every 10 years.

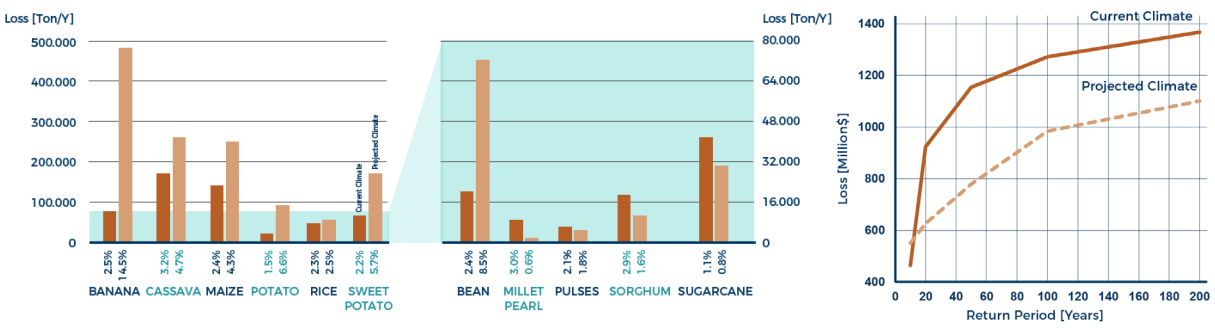


Figure 1: Left: Average crop losses under current and projected climate. Right: PML curves of direct economic crop losses. Source: Rudari et al. 2019 Tanzania Disaster Risk Profile http://riskprofilesundrr.org/documents/2091

Moreover, production losses have been related to domestic food energy supply and expressed in the number of people that could have been fully fed, assuming a minimum diet of 1730 kcal/cap per day and 10% household waste. It is estimated that under the conditions of the projected climate, two million fewer people could potentially be fed due to drought-related crop losses, compared to current climate conditions. This number of potentially fed people does not account for possible adaptations; it is estimated that drought tolerant maize and bean varieties could reduce annual average losses by 85% and 75% respectively, relative to standard varieties.
Finally, the study illustrates that a variety of behaviours among the analysed crops varieties is observed: for some crops the production losses will increase towards the future, while for other crops the opposite is projected. This level of detail is crucial to design proper mitigation measures taking into account climate change.

Key Message:
In UR Tanzania, losses of important food crops may increase significantly under future climate conditions when droughts occur more frequently, causing substantial effects on production value losses, farm labor opportunities and domestic food energy supply. Currently, droughts cause an average economic loss of one hundred thirty-three million USD each year in the food crop sector (Rudari et al. 2019). These would more than double under projected climate conditions, if no adaptation measures were implemented. Under the conditions of the projected climate, two million less people could potentially be fed, compared to current climate conditions. Key action point in the country is the use of more drought tolerant crops as adaptation measure (Rudari et al. 2019). These options are currently adopted in the national DRR strategy on the basis of the study performed.

- *What are people, institutions, etc. doing in managing drought risk in each case study context?*

In this case study, UNDRR and CIMA Research Foundation worked closely together with the Tanzanian governmental institutions, such as the Disaster Management Department of the Prime Minister's Office (DMD-PMO) of the UR of Tanzania and the Water Resources Development Department of the Tanzanian Ministry of Water, as well as national scientific institutions such as the Central Forecasting Office of the Tanzania Meteorological Authority and Ardhi University. Also, the National Bureau of Statistics, the Ministry of Finance and Planning, the Ministry of Agriculture, the Ministry of Water, the Ministry of Energy, the Dar es Salaam Regional Commissioner's Office, the Tanzania Commission for Science and Technology, and the National Emergency Coordination Group provided valuable support. Each entity provided data and expertise and drew lessons learned from the study performed. Specifically, DMD-PMO used the results of the study to derive recommendations for the National DRR Strategy and related action plan in a concerted way with the other involved institutions.

- *How are they accounting for systemic risks?*

With the view to achieve sustainable economic growth, Tanzania has numerous climate change policies, strategies and programs, such as the National climate change strategy (Government of Tanzania 2012) and Vision 2025 (UR Tanzania, 2000), that aim to increase farmers' resilience against risk and upsurge productivity. The National Adaptation Plan of Action (UR Tanzania 2007) prioritizes the improvement of food security in drought-prone areas by promoting drought-tolerant food crops, and the improvement of water availability in drought-stricken communities. The Disaster Management Department of the Prime Minister's Offices and the Ministry of Agriculture created the Agricultural Climate Resilience Plan (2014-2019), followed by the FAO Resilience strategy for Tanzania (2019-2022), to improve agricultural land and water management and accelerate uptake of climate smart agriculture. Besides, the disaster management act (2015), enacted by the parliament, exist to enable the establishment of a disaster management agency, a coordination mechanism for disaster prevention, mitigation, preparedness, response and recovery, and the management of a disaster management fund. All this work has been captured by the newly prepared NDRRS in 2020.

- *What are the barriers to up front actions on preventing or mitigating risk? Including financing?*

To accomplish the sustainable development goals and the targets of the SENDAI framework, a solid national DRR strategy needs to be put in place. Recommendations from multi-sectorial national DRR workshops regarding systemic drought risk, reiterated and reconfirmed the need to mainstream disaster risk, as well as the need to ensure the existence of emergency preparedness and recovery plans. It is also suggested to reinforce the disaster risk awareness and education programs and use the results in the risk profiles for flood and drought as reference material. Moreover, the government should plan, together with the competent public and private institutions, a contingency budget allocation or risk transfer mechanisms.

Disclosing the benefits of a transition to drought-tolerant varieties, it is proposed to improve disaster risk sensitive investment and funding in agriculture to foster climate resilient agricultural practices. The need to invest in climate-resilient seed development and encourage farmers to make the switch through government subsidies, is emphasized. This would reduce economic losses (72 billion shillings per year) and benefit food security: Based on our risk assessment, the country currently faces production losses of up to 140k tons of maize per year when standard varieties are used. If drought-tolerant maize varieties were to be adopted countrywide, 85% of the drought-induced losses in maize production could be avoided (Figure 2).

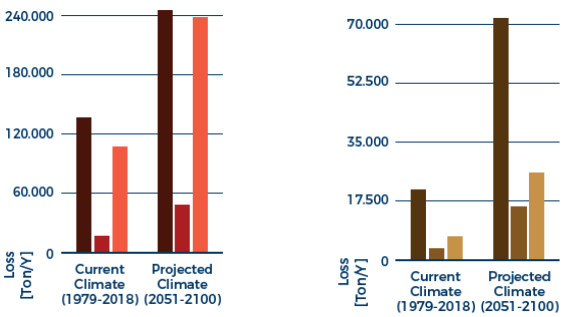


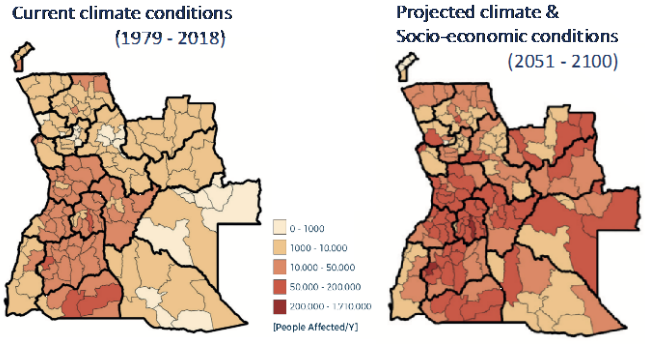
Figure 2: Average physical yield loss of three maize (left) and bean (right) varieties under current and projected climate conditions. Dark hue: standard variety, normal hue: physiological adapted variety, light

hue: shorter cycle variety. *Source: Rudari et al. 2019 Tanzania Disaster Risk Profile* http://riskprofilesundrr.org/documents/2091

Drought impacts in Angola:

About 80% of disasters in Angola are related to water, either due to its excess or its lack. Both the semi-arid and the central plateau suffer frequent droughts and dry spells. Drought-related crop failures or livestock mortality causes families to lose their livelihood hence increasing poverty rates. For example, during the multi-year drought in 2012-2016, fifty thousand families were without livelihoods in the province Benguela (DW 2015). Hunger and lack of water, caused cascading effects and systemic risk, increasing the need for child labor, out-migration, longer transhumance livestock migrations, more considerable difficulties in fetching water for family consumption, and closure of some schools (CNPC-UNDP 2016). Also increase in school dropouts, domestic violence, migrations, and deforestation was recorded (UNDP 2016). Finally, charcoal production, which has significantly increased in the provinces of Huila and Cunene from 2012 to 2014 as an alternative source of revenue (270% and 200% respectively, according to CNPC-UNDP 2016), is becoming a considerable deforestation threat.

In a national disaster risk assessment for Angola, combining and AI-based drought hazard assessment with national population statistics of the National Institute of Angola Statistics, Rudari et al. (2019) estimated that each year on average one million nine hundred thousand people are directly affected by droughts in Angola, under current climate conditions (Figure 3). This is 7.5% of the population and in line with reported affected people, consecutively 0.9, 1.5, 1.3, 1.6, 1.4, and 2.3 million people in the southern droughts of 2012-2016 and 2019 (CNPC, UNDP 2016; Anyadike 2019; UNICEF 2019). Under future climate projections, every year on average three million four hundred thousand people (13% of the population) are projected to be affected by droughts. When also socio-economic projections for 2050 are accounted for, the annual average affected population would increase to seven million nine hundred thousand people.



Rudari et al (2019) also estimated that each year on average almost 50% of livestock is exposed to droughts, and this figure could become close to 70% under projected climate conditions. Hotspots in livestock exposure, which are concentrated in the most water scarce southern region under current climate conditions, would extend to

central and eastern regions in the future due to an increased meteorological (SPEI), hydrological (SFI) and soil moisture (SMI) drought frequency, mainly in the east.

Figure 3: Population directly affected by droughts. Source: Rudari et al. 2019 Angola Disaster Risk Profile http://riskprofilesundrr.org/documents/1851

Secondary cascading effects and systemic risk related to drought should also be considered. An increase in school dropouts, domestic violence, migrations, and deforestation was recorded during drought (UNDP 2016). Given the large share of population depending on agriculture (crop and/or livestock) for income generation, families lose their livelihood during droughts, increasing poverty rates (50 thousand families without livelihoods in Benguela, DW 2015). Besides, droughts often escalate family abandonment, domestic violence and diseases such as Yellow Fever (UNDP 2016). Reports confirmed greater school abandonment and lower school attendance due to the impact of the drought, including hunger and lack of water as a direct cause, increased need for child labor, out-migration, longer transhumance livestock migrations, greater difficulties in fetching water for family consumption, and closure of some schools (CNPC-UNDP 2016). Finally, charcoal production, which has significantly increased in the provinces of Huila and Cunene from 2012 to 2014 as alternative source of revenue (270% and 200% respectively according to CNPC-UNDP 2016) is a becoming considerable deforestation threat.

Key message

In Angola, per year on average almost two million people are estimated to be directly affected by drought events, with the southern provinces, Cunene in specific, being a drought impact hotspot (Rudari et al. 2019). The situation would worsen significantly under projected climate conditions, showing an increasing drought risk also eastward and northward. On a national scale, new estimates of annual average losses and affected people will guide strategic investments budgeting process, while updating National and Provincial Contingency Plans. Enhancing monitoring and forecasting capabilities and Early Warning System is also seen as the way forward to improve timely responsiveness to natural events (Rudari et al. 2019).

- *What are people, institutions, etc. doing in managing drought risk in each case study context? What is working? Does not work?*

In this case study, UNDRR and CIMA Research Foundation worked closely together with the Angolan scientific and governmental institutions, such as the Civil Protection and Fire Service of Angola, the National Institute of Statistics, the Ministry of Agriculture and Forestry, the Ministry of Environment, the Ministry of Education, the Ministry of Health, the Ministry of Energy and Water, the National Institute of Water Resources, the National Institute of Meteorology and Geophysics, the Ministry of Construction and Public Works, the National Road Institute and PRODEL - Public Electricity Company. These institutions are part of the National Commission of Civil Protection, chaired by Minister of Interior, who endorsed the drought risk profile. On the basis of these results, several initiatives were carried out to raise awareness on present and future drought risk conditions, such as the local awareness campaign carried out by the National Service of Civil Protection in full autonomy.

- *How are they accounting for systemic risks?*

In a reaction to the 2012-2016 droughts, the Angolan government, with support of UNDP, has developed a Quadro de Recuperação Pós-Seca (QRS) 2018-2022 for drought recovery and resilience building (ONU Angola 2019). This plan (around 500 million dollars), which strongly rely on donor's contribution, outlines short-term response measures and medium-term proactive risk reducing measures for nine sectors, and includes water-related strategies such as connecting large rivers with canals, building dams to conserve water; agriculture drought adaptation and improved drought prediction. Besides, in 2018, the EU-funded FRESAN program to erase hunger in the southern provinces initiated the "Strengthening of Institutional Structures and Capacities for Disaster Risk Management" project, to promote the establishment and strengthen multi-level inter institutional mechanisms for DRM; and to develop and implement a Risk Information System and a GRD Early Warning System (SAP).

- *What are the barriers to up front actions on preventing or mitigating risk?*

It is suggested by national stakeholders to strengthen the multi-sectoral monitoring and coordination National Platform for risk reduction, to update the National Plans and the Provincial Plans for Preparation, Response, Contingency and Recovery (2015-2017) and to expedite the 2018 – 2022 Drought Disaster Recovery Framework. By considering the estimated annual average losses and affected people, budgeting strategic investments, the expected impacts can be anticipated and minimized in a cost-effective way.
National stakeholders recommend that a permanent National Platform for Disaster Risk Reduction, including the public sector, the private sector, the academic community, traditional authorities, students, UN agencies, NGOs and representatives of civil society could facilitate data sharing between institutions and capacitate exchanges of knowledge, technical skills and technological development for risk management. Besides, it is proposed to support the installation of structural measures, such as mechanisms for diverting, retaining and exploiting rain and river water and promoting diversification of agricultural crops through rural commerce, so as to increase the resilience to droughts under future climate conditions.
National stakeholders say there is a need to strengthen the monitoring and forecasting capacity of Angola, to improve responsiveness to natural events it was suggested to establish an early warning system based on the provincial risk maps and integrating local knowledge. In collaboration with CIMA Foundation, a pilot early warning platform was established. This platform (Dewetra) is based on open-source technologies, meets the international standards of interoperability and would support a continuous analysis of risk and its associated factors and information exchange between various entities and sectors.

Drought impacts in Zambia:

In the last thirty years, Zambia suffered from droughts on average once every two years. Droughts are particularly crucial for the country's hydro-power sector, as hydro-power constitutes eighty five percent of the overall electricity generation in Zambia. By far, most of the hydro- power is generated in the southwest of the country along the Zambezi River and its tributaries, most notably at Kariba dam and Kafue Gorge. During

the 2019-2020 southern Africa droughts, the Kariba hydropower output was cut as the Zambezi River was near its lowest level in half a century, causing elevated electricity prices, blackouts for seventeen million people and impeding national economic growth (Trace, 2019).

A national disaster risk assessment for Zambia by Rudari et al (2019) estimated that drought disasters, causing decreases in hydropower production, generate an annual average direct economic loss of forty-five million USD. The authors also project a drying trend in the southwest and an increase in drought events under climate projections (figure 4, left), which might have a severe impact on hydro-power generation, as most of the hydropower is generated in the southwest of the country along the Zambezi River and its tributaries, most notably at Kariba dam and Kafue Gorge. Their analysis shows that hydropower losses are projected to increase substantially, on average seventy million USD per year. This increase is mainly caused by the intensification of frequent drought events, with an increase of losses up to sixty percent for drought events with a return period of ten years (figure 4, right).

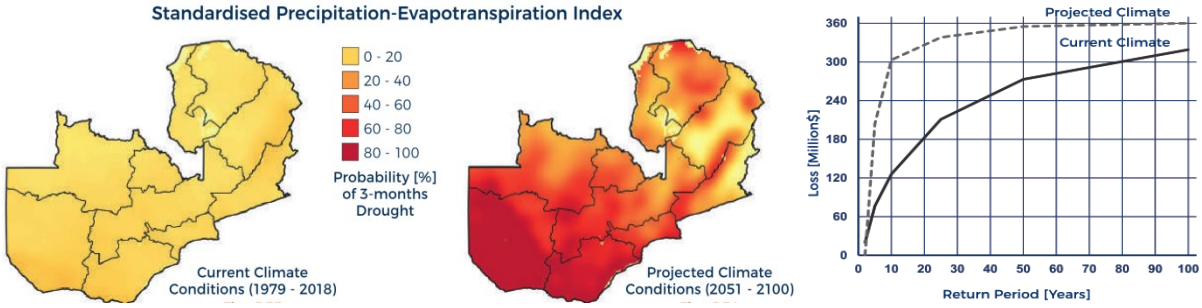


Figure 4: Left: Drought hazard map of Zambia. Right: PML curves of direct economic losses. hydropower Source: Rudari et al. 2019 Zambia Disaster Risk Profile http://riskprofilesundrr.org/documents/1853

However, the study noted distinct spatial differences as most of the increases in losses are caused by the Mulungushi, Itezhi-Tezhi, Kafue Gorge and Kariba dams, while the smaller hydro-power in the centre and north of the country are projected to suffer fewer losses in the future. Hence, differentiation in sources for hydropower could increase energy security. This is especially important because losses in electricity generation are not just limited to reduced revenues, but can have huge implications throughout the economy. For example, Zambia's mining industry (which uses half of all power nationally) is vulnerable to drought-related power losses, showcasing the cascading effects and systemic risk of drought disasters.

Key message:

In Zambia, hydropower is a major source of energy but mainly coming from one river basin (Zambezi), which is not climate resilient. As the negative impacts of energy supply losses are much more impactful than just the revenue loss (impacting further economic activities), there is need to diversify in energy (e.g. supplement with solar) (Rudari et al. 2019). The future climate projection shows there may be spatial differences within Zambia on how streamflow changes (lowering in south, increasing in north), opening opportunities to increase hydropower in other regions of Zambia for a more sustainable supply in the face of drought events (Rudari et al. 2019).

- *What are people, institutions, etc. doing in managing drought risk in each case study context?*

In this case study, UNDRR and CIMA research foundation worked closely together with the Zambian scientific and governmental institutions, such as the Disaster Management and Mitigation Unit, the Ministry of Lands and Natural Resources, Lusaka City Council, the Central Statistics Office, the Ministry of Agriculture and Livestock, the Ministry of Finance, the Ministry of Health, Zambia National Public Health Institute, the Ministry of Labour and Social Security, the Ministry of Education, National Remote Sensing Centre, Zambia Meteorological Department and the Zambezi River Authority. The stakeholders reviewed and validated the risk profile and the Disaster Management and Mitigation Unit have used to inform National development Plan.

- *How are they accounting for systemic risks?*

The National Disaster Management Policy of 2015 represents the transition from a response-oriented system to a more integrated disaster risk management framework, promoting sustainable development among vulnerable communities and improves their resilience, thus making them contribute more to the national development. Plan, strategies, and policies are prepared by National Disaster Management Council and informed by National Disaster Management Technical Committee and Zambia Vulnerability assessment commission.

- *What are the barriers to up front actions on preventing or mitigating risk? Including financing?*

The members of the Zambia Vulnerability Assessment Commission have reviewed and endorsed the results of the Risk Profiles and based on this information have elaborated few recommendations for improving drought management in Zambia. For example, insurance mechanisms should be pursed. Though Zambia is already moving in the direction of drought insurance mechanisms, with the support of Africa Risk Capacity, future discussions should include the adoption of a policy that determines where the line is drawn between an individual and government insurance responsibility.
As the north-east will continue to become wetter and the south-west will continue to become drier, the risk assessment indicates that hydropower losses will increase in the south of the country (Kariba dam) and decrease in the other hydropower stations. It is proposed that the number of dams be increased in areas where productivity is set to rise in the projected future. Besides, to move away from the country's dependence on hydroelectricity, it is proposed that the government could look to diversify its energy sources.
National stakeholders suggest that the country's water policies could be reviewed to ensure more cooperation at the national level around water resources, to increase the focus on recharge areas and to open up the discussion on water transfer infrastructure at the national scale. The regulation of groundwater use, avoiding boreholes to dry up, and the optimizing hydropower dams, turning them into livestock rotary points, can reduce the impact of droughts on livestock and the livelihood of pastoral communities. Also, improved livestock breeds and raising techniques are recommended to increase resilience.

Besides, national stakeholders suggest drought insurance mechanisms should be put in place, starting from probabilistic risk assessments, and it is recommended to ensure the existence of emergency and recovery plans from national toward level.

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