The Coalition of Finance Ministers for Climate Action

The use of climate–economy models in Rwanda's Ministry of Finance and public institutions: the challenges in building analytical capability

International Growth Centre—Rwanda Office

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Introduction

Rwanda is a small landlocked country in East Africa with one of the highest population densities on the continent. It is one of the countries most vulnerable to climate change: the country's economy is based to a large extent on subsistence farming; its main export goods include nature-based tourism as well as commodities such as tea and coffee, while energy supply relies on its water resources.[1] An increasing frequency of natural disasters together with the strong dependence of Rwanda's export sector on roads exemplifies the urgent need to increase resilience. In May 2023, Rwanda experienced one of the most devastating floods in its history, taking 130 lives and causing loss and damage of around US$193 million in one night while reducing economic growth by 0.4 percentage points.[2] The floods destroyed agricultural production capacity, leading to increased food imports and inducing downward pressure on the country's currency. At the same time, Rwanda's Nationally Determined Contributions (NDCs) highlight ambitious goals to mitigate its greenhouse gas emissions, aiming for a reduction of 38% relative to a business-as-usual scenario and to achieve net zero by 2025.

The floods serve as the ultimate proof Rwanda needs to act to strengthen its economy against the increasing impact of natural disasters and rising temperatures. The transformation to zero carbon will require fundamental changes to all its economic sectors. This will crucially rely on the implementation of effective and efficient fiscal and monetary policy at the sectoral and aggregate levels, the identification of public spending priorities, and setting the right incentives for the private sector under a tight public budget constraint. The Ministry of Finance and Economic Planning (MINECOFIN) and stakeholders across all Government actors will rely on the right tools to identify these policies using cost-benefit estimates of alternative actions under different climate scenarios. Structural analytical approaches, and climate economic models in particular, have allowed policymakers globally to structure the inherent uncertainties in the impact of climate change. The integration of climate components into the modeling of economic systems offers a wide range of tools for transparent climate change impact and policy evaluation and has been shown to be key for effective policymaking.

To understand the status quo of Rwanda's integration of climate change into the Government's analytical and model-based analysis, and to highlight persisting gaps, the IGC talked to senior officials, technical analysts, and researchers at MINECOFIN, the Central Bank of Rwanda (BNR), the Ministry of Environment (MoE), and the Rwanda Environmental Management Authority (REMA). Considerations of integrating questions related to climate change into everyday thinking and analytical work are certainly not limited to these institutions. However, concentrated research activities, such as those at BNR, and the straightforward implications of their respective policymaking or action plans, point to their having a leading role in the development of climate analysis.

Existing barriers to a wider use and further exploration of climate-related components in analytical work are elaborated below. The key limiting factor, however, appears to be an insufficient number of staff and, related to this, a lack of the necessary skills. The current status of the use and exploration of analytical climate work, described below, needs to be understood in the context of this constraint.

The integration of climate models in public policymaking

Rwanda has recently started to integrate climate-related data and climate-change modules into various structural analytical approaches as well as existing and new modeling tools. This has been driven by a generally strong understanding of the importance of climate change by the Government as well as by recent events (in particular the 2023 floods). While there is a clear understanding of the importance of climate change impact and policy evaluation, Government officials also internalize the more indirect effects of the benefits of climate models: One official stated that the use of more structural analysis could be key for the interaction with the consumers of climate-related policies. The implementation of a policy will be streamlined not only if the benefits to individuals are communicated

1 According to the ND-GAIN index, in 2023 Rwanda was the 32nd most vulnerable country out of 185 countries. See https://gain.nd.edu/our-work/country-index/rankings/.

2 https://www.minecofin.gov.rw/news-detail/frw-51858-billion-needed-to-recover-from-impact-of-recent-floods-and-landslides.

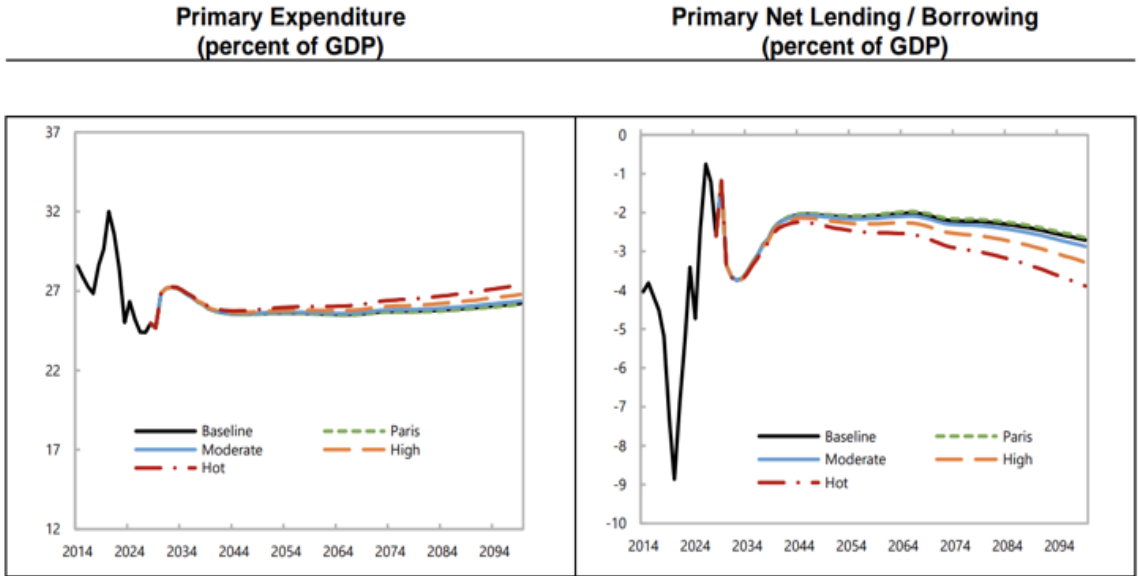
on an abstract level but when tangible numbers can be provided. One example in Rwanda has been the introduction of a ban on single-use plastics, which comes with short-term costs, while quantification of the medium- to long-term benefits relies on estimates. The same argument holds within the Government when, for instance, a suggested policy gains support if other stakeholders can be convinced by concrete numbers relating to costs and benefits.

Models looking at physical climate risk

MINECOFIN and BNR have recently started integrating climate models into their public policymaking processes. MINECOFIN employs the IMF's Quantitative Climate Risk Assessment Fiscal Tool (Q-CRAFT) model to assess the long-term impacts of climate change on GDP, expenditure, interest rates, and other economic indicators. Figure 1 displays the application of Q-CRAFT to estimate the impact of different climate change scenarios on public expenditure and borrowing over time. However, the utility of Q-CRAFT is limited by its long-term focus and lack of sector-specific analysis, rendering it less effective for immediate policy needs. The May 2023 floods and landslides in the northern and western parts of the country highlighted these limitations, as Q-CRAFT could not inform post-disaster spending.

The adoption of Q-CRAFT by MINECOFIN has mainstreamed climate change as a key component of fiscal risk analysis, alongside macroeconomic shocks, specific risks, and contingent liabilities.[3] Each year, MINECOFIN analyses the exposure of the national budget to natural hazards and climate change through direct risks of landslides, extreme weather conditions, and gradual changes to the environment, as well as the transition risks associated with the shift to a carbon-neutral economy. Among the direct risks, MINECOFIN also goes as far as analyzing climate change ramifications for state-owned enterprises (SOEs) and public-private partnerships (PPPs). The prevalence of climate change in the fiscal risk statement proves the extent to which climate change is central to Rwanda's economic policy and its engagement with key development partners such as IMF, World Bank, and the East African Community.

Figure 1. MINECOFIN uses Q-CRAFT to analyze the effects of climate change on fiscal projections



Source: Rwanda Ministry of Finance, personal communication

3 https://www.minecofin.gov.rw/index.php?eID=dumpFile&t=f&f=68625&token=7f1dc492bd86c1a186e9be999c9ef14329fea23a.

Models looking at green growth

With the backing of the IMF to develop short-term models, MINECOFIN and BNR are collaborating with the World Bank to implement and utilize the MANAGE model, a short-term model that offers more granular and dynamic analyses.[4] The model has already been applied by the World Bank in its 2022 Country Climate and Development report (World Bank, 2022). It has also proven instrumental in shaping MINECOFIN's five-year spending plan, especially in areas such as resilient infrastructure investment, through analysis conducted by the World Bank.

The model allows great flexibility and, in its past use, has incorporated Rwanda-specific climate change damage functions that account for the impact on, for instance, yield by aggregate crops, labor productivity, and capital stock. Importantly, it allows the simulation of the impact of different adaptation and mitigation policies on a wide range of disaggregated outcomes (see Box 1 for more details).

At the moment there remains a need to make the model sustainable and fully integrate it into the Ministry's and BNR's tool kit supported by the World Bank. Once implemented, it will offer a more effective tool for policymakers and will benefit not only from central updating and maintenance by the World Bank but also from the ease of use, as it can be accessed via a digital platform and relies less on coding efforts. A consequential downside, arguably, will be less flexibility for further in-house development to address country-specific needs.

In addition, BNR has undertaken measures to integrate climate modules into its financial stability and monetary policy frameworks. These entail incorporating both local and international climate-related data sources to enhance the bank's short-term economic forecasting, as well as collaborating with international actors to better understand and mitigate climate-related financial risks.

Box 1. The impact of different adaptation and mitigation policies on a wide range of disaggregated outcomes

The MANAGE CGE model allows customized modeling of Rwanda's economy and provides key estimates for the World Bank's *Rwanda Climate Change Development Report* (CCDR). The MANAGE model was initially used to model the impact of COVID-19 on Rwanda's economy, showcasing the flexibility of the modeling approach but subsequently extended to incorporate Rwanda-specific climate change damage functions that account for the impact on, for instance, yield by aggregate crops, labor productivity, and capital stock. The model was calibrated to Rwanda's social accounting matrix (SAM) for the year 2019 and includes interactions between 84 sectors and 84 commodities, as well as three types of production—labor at different skill levels, land, and capital—to account for a rural-urban divide. To allow the modeling of policies to be evaluated, the model explicitly accounts for aspects such as energy demand and supply, emission generation, Government debt and public expenditure. Climate change affects the model economy through various channels including production linkages, price and income effects, and a trade channel.

The model allows the simulation of different climate scenarios and climate change actions through various policy scenarios relative to a baseline. The detailed structure of the model allows the impact of different established climate change scenarios to be simulated on the elements incorporated in the model, such as tourism demand. Importantly, this model interacts with the simulation of different policy scenarios coming directly from Rwanda's updated NDCs. These include an increase in private and public investment spending in productive resources (increasing sectoral productivity), sectoral adaptation (reducing expected future climate change damage) such as improvements in crop yields, and non-agricultural capital stock (such as improved urban stormwater management), as well as mitigation to lower Rwanda's emissions path. Expenditures are contrasted with different financing scenarios to evaluate the impact on financing requirements and fiscal sustainability.

[4] MANAGE stands for *Mitigation, Adaptation and New Technologies Applied General Equilibrium.*

Further analytical frameworks in use and exploration

BNR and MINECOFIN, who are the main direct users of analytical model-based frameworks among the four interviewed Government stakeholders, use different models tailored for different purposes. One learning from the interviews carried out by the IGC is that the specifics of climate integration differ by type of model. In particular, econometric models and accounting frameworks have started to benefit from the use of climate-related data such as information about rainfall. The integration of climate components into existing economic models, however, appears to be more complex, such that climate-related aspects mostly enter analytical work through new kinds of models with *initially* integrated climate modules. It remains unclear whether the potential of retrofitting existing models would generally be preferable, as this would avoid the implementation of entirely new modeling approaches.

Apart from MINECOFIN's adoption of Q-CRAFT, there are also ongoing developments in GDP nowcasting and computable general equilibrium (CGE) modeling with support from the International Food Policy Research Institute (IFPRI), though these tools are still in their early stages, are static, and lack a climate component. The Ministry also uses econometric models for fiscal policy simulation and the F-pass model for monetary policy, emphasizing the need for external capacity to enhance these initiatives further. BNR, on the other hand, has built a dynamic stochastic general equilibrium (DSGE) model tailored to the context of climate change in Rwanda for food inflation forecasting. In 2023, BNR started modeling food inflation using qualitative data on food price expectations and the impact of rainfall on different crops, obtained through local surveys. According to BNR, there is also a plan to update short- or near-term forecasting using quantitative meteorological data from satellites and from the Rwanda Meteorology Agency (METEO Rwanda). BNR also employs a Bayesian autoregressive model (BVAL) to analyze shock propagation for forecasting.

There remains room for the integration of climate modeling in other Government institutions such as the MoE. The Ministry, lacking staff capacity and a dedicated environmental research department, relies on the research results from desk reviews of internal best practices and on the analytical work of other Ministries and Agencies, such as Rwanda's Water Resource Board and its Forestry Authority, to inform climate and environmental policies. However, there is ambition to mainstream financial modeling in MoE as the Ministry envisions more analytical work to integrate natural capital into planning and understanding its contribution to economic growth.

Similarly constrained by a lack of staff targeted at analytical work, REMA currently does not conduct comprehensive model-based work. Its work on policy implementation relies largely on stakeholder consultations. Every four to five years, REMA produces larger reports, such as on climate change vulnerability. For this, it relies on external consultants and its infrequent own-data collection. However, more frequent data collection, which would increase its analytical data capacity, is again constrained by REMA's own staff capacity as well as the high costs of data collection both within REMA and through external data collectors.

The use of climate models for current policymaking

BNR has started to use climate data and modules to improve estimates toward its main goals according to the central bank's mandate: fiscal and price stability. The bank has already incorporated climate-related data and its own quantitative surveys to forecast inflation (in particular, food price inflation). There is significant support *within* BNR on this, as the research and the statistics team assist fiscal stability by their ongoing advances in climate modeling. According to the BNR, there is still room for more coordination as, for instance, economists and data scientists, equipped with different skill sets, may lack the integration of the other team's skill set in their work. There is great potential for more coordination within and across Government Agencies.

According to MoE, Rwanda is in the process of revising its existing NDCs. This is another area where robust modeling tools can help assess the implications for fiscal consolidation and other economic indicators, in both the short and long term. Again, analytical support toward the formulation of the NDCs has relied (and will rely) to large extent on external consultants.

The use of climate models at the institutional level

The use of climate modeling for decision-making: a two-way street

The IGC interview asked the agencies how insights developed from analytical work feed into decision-making processes at the level of senior management and boards. All stakeholders unanimously reported a high and proactive interest in the need for decision-makers to learn from analytical work in general and insights from climate-integrated work in particular: there is no policymaking without a robust information basis. MINECOFIN, for instance, has very regular meetings with Departments such as the monetary division, to learn about recent developments and updated forecasts. This analysis feeds into internal processes and is also key for external reporting, such as to the IMF.

Government stakeholders reported that, while analysts report on their findings, the analysis and research agenda is highly influenced by senior management itself, who request specific analysis and tools. Senior management at MINECOFIN, for example, requested the development of more short-term tools, such as the MANAGE model, in addition to existing long term-focused tools. This feedback mechanism ensures the relevance of economic tools and the highest degree of information access for policymaking at the management level.

Barriers, and ways to expand model use

The development and use of economic models is difficult. In addition, the highly complex nature of climate change, which is often nonlinear, highly uncertain, and entails various feedback effects with economic systems, makes the use of integrated models even harder. As initially raised across all interviewed agencies, the main constraint is staff capacity (in terms of number and existing skills). This, in turn, affects additional barriers relating to the development of the necessary technical skills and the exploration of new data sources.

Institutional analytical capacity constraints

As noted above, lack of staff appears to be the most binding constraint to further exploration, implementation, and eventual use of integrated climate-analytical tools across all the interviewed public agencies. Efforts, across the interviewed government stakeholders, to integrate climate change components into analytical work are relatively recent. While staff capacity could be a factor, it will certainly play an important role in the extent to which new aspects and tools are explored, tailored to the Rwandan context, implemented, and used in daily business. In this sense, the lack of staff also creates other challenges, such as building technical capacity and the exploration of data, as discussed further below.

An additional and non-trivial barrier to the development of sustained in-house capacity, as reported by one government stakeholder, is the high value of climate analysis-related skills, stemming from its scarcity in local labor markets: such scarcity raises the market value of these skills. As a consequence, there have been incidences of skills development in the public sector but skilled workers are then enticed to move to the private sector by attractive offers.

An indirect effect of this at MINECOFIN is that in a limited team size, each team member needs to be able to perform each (analytical) task. There is a limited scope for specialization. This, in turn, limits the time and capacity for a more in-depth dedication of some team members to develop a deeper understanding of the integration of climate change in existing and new analytical tools. As discussed above, such a task force exists at the BNR but, importantly, this is in collaboration with international partners from other central banks. This necessity points to the importance of international collaboration not only for direct knowledge transfer but also to develop synergies given limited (human) resources. Collaborative efforts across Government Ministries, such as by MINECOFIN and the BNR, together with external in-country exports (such as the World Bank) are another example of the potential for collaboration to overcome internal barriers.

These partnerships would be complemented by repeated training courses and formalized inter-agency exchange to sustain the lessons learned from existing collaborations. Capacity-building efforts would benefit from expanded collaboration with local partners to build on external expertise and add best-

practice knowledge on agency-internal processes. Another avenue for support could be external assistance to build embedded institutions in Agencies that focus solely on climate-related topics. Such climate units can come in different forms, including general support units, which work as internal advisories for other parts of the Agency, and dedicated climate finance units. The Coalition of Finance Ministers for Climate Action and the NDC Partnership offer technical and financial support to develop such units. MINECOFIN has recently developed a climate unit supported by the UK Foreign, Commonwealth and Development Office, with the goal of making this unit independent and sustainable when initial financial support has stopped.

Technical constraints

Rwanda is a small country. This also limits the pool of available talent with specialized skills, as referred to above. While according to MoE Rwanda's existing NDCs relied on the work of a team of both international and external Rwandan consultants, there are concerns about the availability of the required skills in the country's labor market, as also raised by BNR. Hence, all or most expertise, and tool implementation, needs to be developed internally within public institutions, given the lack of available skills in the local labor market. This in turn requires external experts and international collaborations, as referred to above.

The emphasizes the importance of the above-discussed partnerships such as BNR and MINECOFIN's collaboration with the World Bank and BNR's engagement in the international climate task force led by the French central bank. These, engagements are limited, however. According to MINECOFIN and MoE, it would be very useful to have integrated experts based at the respective public institutions. An expert would act as an agent of change on a daily basis, would explore specific options for more structural analysis in the specific context of Rwanda and the institution, and importantly, could increase staff capacity through training and the integrated practical use of new tools. The MoE reported, however, that while this would be of great use per se, in practice it would not be feasible as, again, limitations in their staff capacity would not allow sustainable engagement of and learning from the expert(s).

Often climate economic models are developed in the context of advanced economies. As reported by the BNR, to ensure relevance to developing countries, these models need to be adjusted to reflect their economic realities, including frictions at the extensive and intensive margins. This appears to be complex, particularly given the often interlinked nature of different frictions, institutional circumstances, and feedback effects between the financial and real sectors. The World Bank's centrally developed and locally calibrated MANAGE model is an example of a deliberate effort to address the developing economies' circumstances from the beginning. The BNR reports that integrated assessment models (IAMs) fail to address this and hence require additional efforts.

Data limitations

How intergovernmental collaboration facilitates data access, such as through an agricultural working group, was discussed above. In general, however, it again appears that staff capacity plays an important role in data limitations. This may be because the model base itself is not yet developed enough to start thinking about the integration of new data sources. Additionally, new data sources can introduce new difficulties: MINECOFIN, for instance, reported that there had been efforts, eventually discontinued, to explore the use of new environment- and climate-related data sources. Granular micro-data such as rainfall or satellite data is often more difficult to work with than conventional (macro) data, which is linked to individuals or economic activity. One reason for this is that spatial data requires linking information to grid cells and eventually to conventional data sources. At the same time, this type of data appears to be of importance moving forward with the implementation of climate modeling. To advance, the Government stakeholders interviewed stated that ongoing intergovernmental collaboration can be a vital means of making use of new data sources. A prime example is the ongoing collaboration with Rwanda's Meteorology Agency.

Ways forward

The impact of climate change is fundamentally cross-cutting in its nature. It will require joint and coordinated efforts by Government stakeholders across Ministries and Agencies. Sharing technical expertise as well as information will speed up the streamlining of better climate economic analysis and can potentially mitigate staff capacity constraints. This argument also holds with respect to international cooperation. Sharing lessons and best practices with similar agencies internationally will allow national practitioners to learn from existing work and past mistakes, reducing the scope for redundant work.

Complementary internal efforts and intergovernmental collaboration

The strong reliance of the MoE on the analytical work of other Ministries and Agencies in the Rwandan Government was discussed above. While the MoE conducts desk reviews to learn from external examples, only its collaboration with other partners allows a contextualization for Rwanda and allows the relevant and up-to-date numbers for Rwanda, key for MoE's policymaking, to be obtained. While BNR and MINECOFIN use similar but different models tailored to their specific needs, they collaborate, share model insights, and plan to cooperate more on CGE modeling. In particular, the MANAGE model is aimed at being used by both Agencies, increasing consistency, and hence comparability, in the Government's analytical work.

In terms of data-sharing, MINECOFIN stated it has streamlined access to public data sources, in particular from Rwanda's national statistics agency (NISR) and its data warehouse. Similar cooperation exists, for instance, between MINECOFIN and BNR for the use of Rwanda's weather and rainfall data. In addition, there is a joint agriculture working group, currently involving MINECOFIN, BNR, the Ministry of Agriculture (MINAGRI), and the Rwanda Agricultural Board (RAB) but soon to be expanded, which meets monthly to exchange insights and data on the agricultural sector. This highlights again the key cross-cutting nature of climate change and the value of cooperation across Government.

The role of international cooperation and support by external experts

In terms of international cooperation, BNR is leading the way by forging partnerships with other central banks and partners to streamline the integration of climate modeling across its departments. In June 2022, BNR joined the Network for Greening the Financial System (NGFS), a global network of central banks and financial supervisors working to enhance the role of the financial system in managing climate-related risks and mobilizing green investments.[5] BNR has been able to receive support from other central banks and international task forces to build climate models, understand the transition mechanisms of climate change impacts, and participate in workshops on sustainable finance. Additionally, the Global Institute for Macroeconomic Modeling (GIMM) is working on linking macroeconomic variables with financial components for stress testing and scenario analysis, supported by the BNR's research team. These initiatives underscore the BNR's commitment to integrating comprehensive modeling techniques to better understand and manage the economic impacts of climate change and other macro-financial risks.

Conclusions

Rwanda's has only recently started efforts to integrate climate aspects into its policy-relevant analysis. However, progress has been substantial, and model-based analysis has already been integrated into implemented policies and strategies. At the same time, these efforts are concentrated: While there has been substantial progress at MINECOFIN and the BNR, a lack of capacity has constrained the exploration and ultimate implementation of climate modeling at MoE and REMA. This, of course, is only a snapshot of Rwanda's public institutions, and other agencies, such as METEO Rwanda and Rwanda's Water Resource Board, inform other Government partners on their analytical work.

5 https://www.ngfs.net/en/about-us/membership.

This highlights the importance of collaboration. There are already existing collaborations, in particular on data-sharing, such as through the agricultural working group. But there is room for more collaboration in the course of advanced development of climate modeling and related data use. This holds in a similar way to the work within individual agencies. At the same time, the agencies interviewed report on the large expected benefits of working with external consultants as well as collaborations with international partners from the same field. BNR's participation in an international climate tasks force of central banks exemplifies this. These findings call for more (and more tailored) collaboration, particularly with regard to the development and local contextualization of specific modeling tools. As reported by the BNR, tailoring existing models, developed for advanced economies, is highly complex. As developing countries face similar market imperfections and institutional barriers, there is great potential to create synergies through collaboration, which could be in the form of focused working groups and/or international conferences.

The importance of collaboration points to the most binding constraint in further expanded and streamlined use of climate models: staff capacity appears to be the limiting factor across all interviewed agencies. Whereas this can be difficult to overcome in the short run, expanded collaborations, such as BNR and MINECOFIN's partnership with the World Bank on the implementation of the MANAGE model, highlight potentially important avenues to mitigate staff constraint. These partnerships, however, will need to be sustained, as climate models will not be static but need to be maintained and updated given new data, new modeling techniques, and developments in the nature of climate change itself. To further reduce the pressure on capacity-constrained practitioners, model developers could facilitate the use of these models as far as possible. The platform-based MANAGE model is an example that facilitates its application, as it is less reliant on (often technically challenging) coding. This argument can be expanded to data migration to facilitate the integration of, for example, granular and spatial temperature and rainfall data.

Reference

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