ASSESSING AND QUANTIFYING SUCCESS AND FAILURES IN POST-DISASTER HOUSING RECOVERY: A COMPREHENSIVE EVALUATION FRAMEWORK

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Abstract: *Over the last three decades the frequency and magnitude of disasters has considerably increased due to urbanization and climate change, thereby causing significant loss of lives, property, and economy. To respond to such catastrophic events, significant financial resources are allocated by a combination of public and private sources for post-disaster housing recovery (PDHR). Housing losses account for over 90% of all damages; it is considered the costliest aspect of recovery in nearly all disaster cases. A report from Global Shelter Cluster also estimated that over 5 million homes were destroyed or damaged due to natural disasters and conflicts between the year 2005 to 2018. Thus, PDHR is perceived critical for disaster management and is taken as an opportunity to 'build back better'. Despite several studies and the growing interest of PDHR to achieve community recovery and future disaster mitigation, there is currently a lack of universally accepted quantifiable metrics to effectively evaluate the success of PDHR programs and approaches. Moreover, with an increasing body of literature focusing on identifying best practices in PDHR, these practices can be translated into critical success factors (CSFs) that offer quantifiable measurements. Based on a thorough literature review and extensive field experience in disaster recovery, an evaluation framework has been developed to assess the effectiveness of PDHR. This research seeks to develop a unified framework where all the CSFs governing the success of PDHR are identified, categorized and evaluated based on the effectiveness of identified factors. The developed framework organizes commonly identified CSFs into five distinct categories: (i) Technical Factors (TF), (ii) Social Factors (SF), (iii) Environmental Factors (ENF), (iv) Economic Factors (ECF), and (v) Project Planning and Management Factors (PPMF). To evaluate and quantify the success rate of PDHR, a quantitative approach (i.e., Analytic Hierarchy Process (AHP) technique) is employed. By utilizing this approach, the evaluation framework provides a systematic means for assessing and measuring the efficacy of different PDHR projects. The comprehensive evaluation framework will serve as a valuable decision-based tool for guiding the selection and design of PDHR programs. Its functions as an evaluation tool will not only enable the assessment & comparison of different PDHR projects in various disaster scenarios but will also help in prioritizing the factors influencing the success of housing recovery post-disaster. Furthermore, the framework has the potential to raise awareness among disaster-affected communities, decision-makers, stakeholders and practitioners regarding the critical aspects necessary for successful PDHR and resilience.*

1. General considerations

The considerable increase in the frequency, magnitude and complexity of disasters are causing significant loss of lives, property and monetary resources (UNISDR, 2015). Housing usually constitutes the largest portion of disaster-related losses, leading to significant projected expenses for recovery. As a result, a substantial amount of financial resources is directed towards rebuilding housing (CERA, 2012). Approximately 50% of the World Bank's post-disaster assistance is allocated for the reconstruction of housing and housing typically consists of approximately 90% of built environment (Lester, 2003). Global estimations also indicate that more than 5 million houses were destroyed or damaged due to natural hazards and conflicts between 2005 and 2018 (Sharma A., 2018). Thus, the increase in frequency and magnitude of disaster events due to urbanization and climate change has prompted a growing interest in post-disaster housing recovery (PDHR) amongst researchers, academicians, practitioners and decision-makers.

Post-disaster recovery has been described in multiple ways. The process of disaster recovery is characterized by the distinct process of restoring, reconstructing, and reconfiguring the physical, social, economic, and natural surroundings through both pre-event preparations and actions taken after the event (Smith and Wenger, 2007). Recovery can be refer to as the restoration of houses, transport and public services, recommencement of economic activities, the promotion of long-term community rehabilitation and developments (Schwab et al., 2014). On the other hand, housing reconstruction is considered as the backbone of disaster recovery since losing a house is more about losing identity, privacy and dignity (Barakat, 2003). Further, housing must satisfy multiple needs including physical and structural quality, location, socio-economic, cultural, psychological and neighbourhood requirements (Aluko, 2012). In the aftermath of any catastrophe or calamity, PDHR plays a crucial role in reducing the impact and bringing back the normalcy. Nonetheless, if not carried out properly, it can heighten the susceptibility of the impacted community, resulting in significant financial losses and time setbacks.

2. Comprehensive Review of PDHR

PDHR is a complex phenomenon as it requires multi-sectoral involvement, very significant resources, and a wide range of skills (Silva, 2010). Since disasters are a result of interactions between the physical, built, and human environments, it is important that recovery efforts incorporate all these systems (Smith and Wenger, 2007). Some studies suggested framework (Patel and Hastak, 2013; Bilau and Witt, 2016), some directed ways to alleviate from the consequences of disasters and to optimize the procedures of post-disaster housing recovery (Nejat et al., 2012; Eid and El-adaway, 2017; Pamidimukkala, 2020; Ahmed I., 2011) while some discussed the challenges/barriers and shortcomings in achieving a successful PDHR (AFP, 2009; Ahmed, 2011; Charlesworth & Ahmed, 2015; Steinberg, 2007; Tsunami Evaluation Coalition, 2006; Hayles, 2010; Rouhanizadeh B. et al., 2020; Safapour, E., et al., 2021). Literature identified relates to case studies and experiences from specific post-disaster housing recovery programs: Gujarat earthquake in 2001 (Vahanvati & Mulligan, 2017), Kosi floods of Bihar in 2008 (Vahanvati & Mulligan, 2017), past experiences and challenges in post-disaster housing reconstruction after earthquakes in Aceh (2004), Yogyakarta (2006), West Java (2009) and West Sumatera (2009) (Pribadi K.S. et al., 2014), progress of reconstruction five years after the 2015 Gorkha earthquake, Nepal (Acharya et al., 2022), comparative review of cases of post-disaster temporary housing strategies in Japan and Indonesia (Biswas, 2019), references from Marmara earthquake in Turkey (1999), and Bam earthquake in Iran (2003) (Bilau and Witt, 2016). From this comprehensive literature review, it has been found that very little literature & guidelines are available with respect to evaluating the efficacy of PDHR. As of now, no globally accepted list of variables/ influencing factors exists that contribute to achieve a successful post-disaster housing reconstruction, thereby highlighting the absence of unified methodology for implementing PDHR.

2.1 Characteristics of the PDHR

Researchers and scholars working in the field of PDHR has long argued that PDHR outcomes in communities are influenced by a combination of various factors. These elements include the resources within a community, its organizational capabilities, its socio-economic status and cultural diversity, as well as its access to public or private financial aid programs (Siembieda, 2002; Vatsa, 2004). Nevertheless, developing suitable indicators for determining long-term project results is a critical step in designing a recovery evaluation (Hales, 2010). Moreover, the indicators should be SMART (specific, measurable, adequate, relevant, and timely) (Caldwell, 2002). Several influencing factors have also been discussed in the studies of Moe and Pathranarakul (2006), Silva (2010), Hidayat and Egbu (2011), Pribadi et al. (2014), Ophiyandri et al. (2013).

3. Proposed Conceptual Framework for PDHR

3.1 Research Methodology

Based on a thorough literature review and extensive field experience in disaster recovery, an evaluation framework has been developed to assess the effectiveness of PDHR. This paper seeks to develop a unified framework where all the critical success factors (CSFs) governing the success of PDHR are identified, categorized and evaluated based on the effectiveness of identified factors. The developed framework organizes commonly identified CSFs into distinct categories. To evaluate and quantify the success rate of PDHR, a quantitative approach (i.e., Analytic Hierarchy Process (AHP) technique) is employed. By utilizing this approach, the evaluation framework provides a systematic means for assessing and measuring the efficacy of different PDHR projects. AHP is a structured decision-making method developed by Thomas L. Saaty in the 1970s. The basic premise of AHP is that decision-makers can make more rational and consistent judgments by systematically evaluating and comparing different criteria and alternatives (Saaty, 1980). The effectiveness of post-disaster housing recovery (PDHR) programs can be assessed through four fundamental steps, as depicted in Figure 1.

Figure 1. Methodological steps for achieving PDHR

3.2 Identification of Critical Success Factor (CSFs)

The concept of 'critical success factors' was originally introduced by Rockart (Nguyen et al., 2004). In Rockart's (1979) definition, critical success factors (CSFs) refer to the key areas of activity where achieving satisfactory results ensures a competitive advantage for an organization. Boynton and Zmud (1984) also described CSFs as the essential elements that must be successful to ensure managerial and organizational success. Therefore, they represent the specific managerial or enterprise areas that require ongoing attention to achieve high performance. In context to business, success factors can be described as fundamental elements of knowledge, expertise, qualities, motivations, attitudes, values, or other individual attributes that are vital for excelling in a position or role, setting apart outstanding performance from the typical (PEPDS, 2010).

Based on the existing literature five critical success factors (CSFs) have been identified in order to achieve effective (or successful) PDHR, namely: (i) Technical Factors (TF), (ii) Social Factors (SF), (iii) Environmental Factors (ENF), (iv) Economic Factors (ECF), and (v) Project Planning & Management Factors (PPMF). Further these five CSFs are governed by various key performance indicator (KPI). KPIs are measurable benchmarks used to evaluate performance over time, specific to a given objective. They provide valuable insights and an analytical foundation to support informed and effective decision-making for strategic and operational priorities and enhancements (Asih I., 2020).

3.3 Selection of Key Performance Indicators (KPIs) for each CSF

Drawing on the existing disaster recovery literature, best practices, challenges and shortcomings in PDHR a list of the most influential KPIs were identified. Table 1 provide a summarized list of selected KPIs for each of the five CSF categories including references.

3.4 Development of PDHR Evaluation Framework

The proposed PDHR evaluation framework which consists of the five key CSFs covering technical, social, environmental, economic and project planning and management factors, and the KPIs under each of these categories that govern the success of a PDHR program. A short description of all the selected KPIs is provided in Table 2.

3.5 Quantification Efficacy of PDHR

Since housing recovery after a disaster is for the people of the affected communities, there satisfaction with the reconstructed/repaired houses after a disaster plays a key role in deciding the success of the project. Thus, their satisfaction will be dependent upon on all the five CSFs. In this study, satisfaction of the people is evaluated by using a widely used empirical equation used in marketing sector. In this study, the customer satisfaction score will quantify the success of the project. The customer satisfaction score (CCS) can be calculated using Eq. (1).

$$\boldsymbol{Customer\ Satisfaction\ Score\ (CSS)} = \frac{\boldsymbol{Total\ point\ scored\ from\ survey\ sheet}}{\boldsymbol{Number\ of\ Questions}}\ \boldsymbol{x\ 100} \quad (1)$$

Where, total points are assigned via Analytic Hierarchy Process (AHP) technique by using Satty's scale to each to the KPIs under each of the five CSFs. The CSS score is expressed as a percentage, typically multiplied by 100, to give a score out of 100%. Higher scores indicate higher levels of customer satisfaction.

4. Concluding Remarks

To restore the normalcy of the livelihood after a disaster, a significant amount of funding is invested by private or public sectors in post disaster housing program. Post-disaster housing recovery processes are progressively becoming the paramount focus of disaster management stakeholders and decision-makers. Existing literature also shows that there is lack of globally accepted methodology to evaluate the efficacy of housing recovery post-disasters and despite adoption of several post-disaster recovery activities, there remains a lack of attention to effective post-disaster recovery tending to greater losses of financial resources. To achieve an integrated approach for effective post-disaster recovery, the primary critical focus needs to be on identifying the factors that influences its effectiveness. The aim of this paper is to quantify and evaluate the success of PDHR programs by first identifying the factors contributing towards its efficacy and then evaluating it with a quantitative technique. While studies have been conducted in this area, it has been observed that there is lack of unified framework that considers various aspect of a project ranging from technical, social, environmental, economic to project planning and management. This study is set out to create a framework that is simple and easy to use irrespective of geology, topography or climatic condition of a country.

The novelty of this study lies with the fact that the developed framework is flexible, as other indicators may be added/modified or removed depending upon the availability of data and other prevailing conditions of the region. It will support the concerned organizations to develop better understanding of the recovery programs, identify the key influencing indicators and to formalize the lessons learnt.

The next stage of the research is focused on the implementation of the framework in an appropriate region where the reconstruction/repair & retrofitting has been undertaken as recovery initiatives post-disaster event. It is intended that the developed framework will contribute to the challenges and shortcomings of PDHR programmes after implementation, thereby leading to a more effective framework.

5. References

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Table 1. Selected Key Performance Indicators (KPIs) for the PDHR Conceptual Framework

CSF	KPI	Supporting Literature
Technical Factors (TF)	(a) Quality of Construction, including Construction Materials and Workmanship; (b) Usage of Locally Available Construction Materials and Practices; (c) Availability of Skilled Engineering and Construction Labour; or Provision of Skills Training to Strengthen Capacity; (d) Effectiveness of Quality Assurance and Quality Control (QA/QC) Mechanisms; (e) Adherence to Building Codes, and/or Guidelines that meet appropriate standard; (f) Incorporation of Site-Specific DRR Measures in the Engineering Design	UN-Habitat (2009) ; Barenstein and Pittet (2007); Silva (2010); Pribadi et al. (2014)
Social Factors (SF)	(a) Effective Communication campaigns that inform community about risks and recovery approaches; (b) Extent of Local Leadership and Community Participation in Design and Implementation; (c) Cultural Appropriate Housing Design; (d) Occupant/Homeowner Acceptance and Usage/Adoption of the Housing Unit; (e) Occupant/Homeowner Ability to Cost-Effectively Maintain and/or Repair the Housing Unit; (f) Access to Jobs and Markets; (g) Access to Basic Services and Facilities Required to Carry on Daily Life; (h) Community Relocation; (i) Occupant/Homeowner Perception of the Structural Safety of the Housing Unit; (j) Occupant/Homeowner Satisfaction	Biswas (2019); Ophiyandri et al. (2013); Silva (2010); Vahanvati & Mulligan (2017); Bilau (2016)
Environmental Factors (ENF)	(a) Exposure to Environmental and Public Health Risks at Site; (b) Overexploitation of natural resources for construction; (c) Excessive Removal of Vegetation and Trees at Site and/or Disaster Affected Area; (d) Climatically appropriate housing	Ophiyandri et al. (2013); Silva (2010)
Economic Factors (ECF)	(a) Affordability of Construction; (b) Ability of Local Community to Replicate Construction Methods; (c) Extent of Local Job Creation, and/or Usage of Local Labor	Vahanvati & Mulligan (2017)
Project Planning and Management Factor (PPMF)	(a) Adherence to Local Laws, Reconstruction Strategies and Policy Directives; (b) Existence of Supportive Laws, Policies and Regulations; (c) Sufficient Coordination with Relevant Government Authorities or Official Coordination Mechanisms; (d) Appropriate Beneficiary Identification and Selection; (e) Effective and Regular Program Monitoring and Evaluation; (f) Sufficient Transparency and Accountability	Vahanvati & Mulligan (2017); Jha et al. (2012); Moe and Pathranarakul (2006)

Table 2. Proposed PDHR Evaluation Framework

CSF	KPI	Category	Reason for Selection of KPI
TF	Quality of Construction, including Construction Materials and Workmanship	• Good • Acceptable • Poor	To achieve a safe, durable, and functional building or structure. It can be determined by the applicable codes, regulations, and industry standards.
	Usage of Locally Available Construction Materials	• High • Medium • Low	To ensure reduced costs, improved resource efficiency and environmental sustainability, cultural appropriateness, and to support to the local economy; facilitating recovery as well as future DRR if build back better measures were integrated into design/construction.
	Availability of Skilled and Construction Labor; or Provision of Skills Training to Strengthen Capacity	• High • Medium • Low	Adequately trained construction workers, including foremen and masons, are crucial for ensuring adherence to engineering/construction plans, industry standards of care, and any applicable building code standards or guidelines. If not professionally trained, comprehensive skills training of construction workers is critical to enhance the safety and quality of any rebuilt structures, promotes efficiency a culture of professionalism in the industry.
	Effectiveness of Quality Assurance and Quality Control (QA/QC) Mechanisms	• High • Medium • Low	Proper QA/QC such as regular site supervision and assistance helps to ensure quality of construction work.
	Adherence to Building Codes, and/or Guidelines that meet appropriate standards	• High • Medium • Low	Building codes and guidelines can ensure construction meets legal requirements and minimum structural safety standards; this should include local jurisdiction building permits/approval.
	Incorporation of Site-Specific DRR Measures in the Engineering Design	• Yes • Partly • No	Ensures that newly built, or rebuilt structures are better able to withstand disasters and that build back better has been achieved.
SF	Effective Communication campaigns that inform community about risks and recovery approaches	• Yes • Somewhat • No	Effective community awareness-raising activities are important as they equip the disaster affected populations with accurate information. Effective community awareness campaigns provide context specific communication strategies with accurate and informed messaging. These activities ensure education, information dissemination and lay the foundation for effective community engagement and

		participation in PDHR programs. This in turn supports effective and inclusive recovery.
Extent of Local Leadership and Community Participation in Design and Implementation	• Strong • Partial • Little/None	Engaging community members in decision-making processes fosters a sense of ownership and empowerment, leading to increased satisfaction and long-term commitment to recovery efforts. Community participation in housing recovery processes enhances the inclusivity and effectiveness of PDHR, as it facilitates the identification of local needs and preferences, ensuring that recovery efforts align with the community's priorities, as well as the exchange of knowledge between residents and professionals, resulting in more effective and contextually appropriate recovery strategies and approaches. Community members' involvement in decision-making also enhances the sustainability of the recovery efforts, as the community is more likely to take ownership of the rebuilding process.
Cultural Appropriate Housing Design	• Yes • Partial • No	The cultural appropriateness of reconstructed housing is crucial for community acceptance and long-term sustainability. It creates a sense of belonging and normalcy as a result improves psychological well-being and improves cultural identity among affected communities assisting them on their path to recovery. Community participation in the design and PDHR decision-making processes can ensure integration of culturally appropriate spatial arrangements and traditional building materials and architectural styles that reflect local cultural norms and preferences and avoid insensitive or inappropriate design decisions.
Adequate Considerations of Gender Equality and Inclusion	• Yes • Partial • No	PDHR programs need to ensure that the needs of woman and vulnerable or marginalized populations, such as persons with disability or refugees, are considered, and are accessible to these groups.
Occupant/Homeowner Acceptance and Usage/Adoption of the Housing Unit	• Yes • Partial • No	The acceptance of a reconstructed house by the occupant or homeowner is a significant indication of whether the PDHR program and investment therein has been a success. The adoption of reconstructed housing unit is also critical for community well-being and cohesion, and economic and disaster recovery.
Occupant/Homeowner Ability to Cost-Effectively Maintain and/or Repair the Housing Unit	• Yes • Partial/ Same as pre-disaster • No	The ability of the occupant or homeowner to maintain homes, and repair these using available and cost-effective labor and materials is essential for the sustainability of the PDHR program, as well as the overall financial safety and environmental well-being of the occupant/homeowner.

	Access to Jobs and Markets	• Yes • Same as pre-disaster • No	Proximity and access to employment opportunities and accessible transportation networks ensure residents' livelihoods and contributes to overall community enhance economic recovery and long-term sustainability; whereby a lack thereof greatly hamper recovery processes and the wellbeing and economic prospects of the community. Access to job opportunities and markets is therefore critical for successful housing recovery.
	Access to Basic Services and Facilities Required to Carry on Daily Life	• Yes • Same as pre-disaster • No	Access to basic services such as water, sanitation, electricity, healthcare, and education in the design and implementation of post-disaster housing recovery efforts are critical considerations to ensure overall community well-being, recovery, and long-term sustainability.
	Community Relocation	• No relocation • Yes, with extreme hazard justification • Yes, with insufficient justification	Factors such as community preference, cultural identify and heritage, and social capital and support networks are all key considerations in decision-making processes that support the case for non-relocation of community's post-disaster. Disaster researchers and practitioners commonly emphasize the importance of avoiding community relocation whenever possible during post-disaster reconstruction. Disaster experience has shown that relocation of marginalized communities can exacerbate existing inequalities. Relocation might be necessary in exceptional cases such as due to extreme hazards, such as volcanic eruptions or toxic waste contamination.
	Occupant/Homeowner Perception of the Structural Safety of the Housing Unit	• Safe • Somewhat Safe • Unsafe	The safety of reconstructed houses after a disaster is crucial for the physical and mental well-being of residents and for the long-term resilience of communities. Governments, aid organizations, and other stakeholders involved in post-disaster reconstruction must prioritize safety and ensure that residents feel secure and protected in their homes.
	Occupant/Homeowner Satisfaction	• Satisfied • Partially Satisfied • Unsatisfied	Overall occupant satisfaction refers to the degree to which occupants or homeowners are satisfied with the PDHR program. Given that occupants/homeowners are the primary beneficiary of these programs, and the end-user, their satisfaction is critical for evaluating overall program success.
ENF	Exposure to Environmental Public Health Risks at Site	• Yes	Potential risks associated with the contamination of water and/or soil and land, or exposure to hazardous waste at the housing/program sites need to be understood, addressed and monitored, if in existence. These risks have developed in housing

		• Somewhat/ same as pre-disaster • No	sites after a major disaster, and have potential far-reaching impacts on human health, the environment and local economy. Environmental and Social Impact studies that assist in identifying potential public health risks are critical to ensure that these are properly assessed and inform the PDHR programs.
	Over-Exploitation of Natural Resources for construction	• Yes • Somewhat • No	In the haste to rebuild, there may be a tendency to overlook the long-term impacts of resource extraction and use. Over-exploitation of natural resources may include excessive removal of mineral and water resources. This in turn can lead to significant negative long-term environmental and social consequences.
	Excessive Removal of Vegetation and Trees at Site and/or Disaster Affected Area	• Yes • Somewhat/ same as pre-disaster • No	While it may be necessary to clear some areas to make way for new homes and infrastructure, it is important to minimize the damage to the natural environment as much as possible.
	Climatically appropriate housing	• Yes • Somewhat/ same as pre-disaster • No	Climatically appropriate housing builds resilience, reduces vulnerability to future disasters, and contributes to the overall sustainability of affected communities.
ECF	Affordability of Construction	• Yes • Somewhat • No	The use of cost-effective construction improves the economics of the PDHR program reducing the overall cost of reconstruction
	Ability of Local Community to Replicate Construction Methods	• Yes • Somewhat • No	The ability of the local community to replicate the construction methods used as part of the PDHR program can ensure uptake of more disaster resilient building practices ensuring improved disaster resilience and sustainability of the program; therefore, also, increasing the economic benefits of the PDHR program.
	Extent of Local Job Creation, and/or Usage of Local Labor	• High • Medium • Low	Local job creation with fair financial compensation can support improving the economic prospects of the affected community and overall economic recovery of the disaster impacted areas.

PPMF	Adherence to Local Laws, Reconstruction Strategies and Policy Directives	• Yes • Somewhat • No	PDHR programs are impacted by a lack of supportive laws and an enabling policy environment which provides a framework for decision-making, resource allocation and maximization, government coordination, transparency, and accountability.
	Existence of Supportive Laws, Policies and Regulations	• Yes • Somewhat • No	Coordination with relevant public authorities is critical for success of recovery programs, as it ensures government approval/buy-in, government procedures are followed, resources are mobilized and leveraged more effectively, information is shared, and the duplication of efforts is minimized or avoided. Similarly, coordination with official coordination mechanisms, such as UN/OCHA cluster systems, is critical for coordinated humanitarian action, information, and knowledge sharing, minimize duplication of efforts, while leveraging available resources and partnerships.
	Sufficient Coordination with Relevant Government Authorities or Official Coordination Mechanisms	• Yes • Somewhat • No	It ensures that assistance reaches those most in need, promotes community involvement, and contributes to long-term resilience. Further, it prioritizes people's well-being and help communities rebuild stronger after a disaster.
	Appropriate Beneficiary Identification and Selection	• Yes • Somewhat • No	It helps to prioritize individuals and communities that have been most severely affected by the disaster, ensuring that limited resources are allocated efficiently. This process minimizes the risk of aid being misappropriated or ineffectively distributed, ultimately contributing to a more rapid and equitable recovery for those impacted by the disaster.
	Effective and Regular Program Monitoring and Evaluation	• Yes • Somewhat • No	Effective and regular program monitoring and evaluation are indispensable in construction projects for quality control, compliance with regulations, cost and schedule management, risk mitigation, stakeholder communication, continuous improvement, and documentation. Hence, essential for the successful implementation and improvement of any project.
	Sufficient Transparency and Accountability	• Yes • Somewhat • No	Regardless of its nature or scale, sufficient transparency and accuracy are crucial factors for the success of any project, as it forms the foundation for successful project delivery and helps to achieve project objectives efficiently. It also promotes trust, effective communication, risk management, resource allocation, accountability, stakeholder involvement, and continuous improvement.

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