COMMUNICATION AND PREPAREDNESS CHALLENGES DURING RAPID INTENSIFICATION OF TROPICAL CYCLONES IN THE RIO GRANDE VALLEY

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1. INTRODUCTION

Since the landfall of the 1933 Cuba–Brownsville Hurricane, the Rio Grande Valley has undergone profound demographic, economic, and infrastructure changes that have significantly altered the region's vulnerability to tropical cyclones. Over the past nine decades, continued expansion in housing, transportation networks, and emerging industries has increased the number of residents and critical infrastructure exposed to hurricane hazards, creating a regional risk profile in which future storms may produce greater societal and economic consequences than those experienced historically.

Despite significant advancements in tropical cyclone forecasting, rapidly intensifying (RI) hurricanes near landfall continue to present operational challenges for both meteorologists and emergency management officials. In the Gulf region, storms may strengthen quickly over short time periods, reducing warning lead time and compressing the window available for effective public response. These shortened timelines may complicate evacuation decision-making and increase uncertainty in public risk perception during high-impact events.

In the Rio Grande Valley, these challenges are further amplified by flood-prone terrain, limited evacuation infrastructure, and diverse population needs, including bilingual communication requirements and varying levels of access to emergency information. As a result, effective hurricane communication is critical in ensuring that rapidly evolving storm threats are clearly understood and acted upon in a timely manner.

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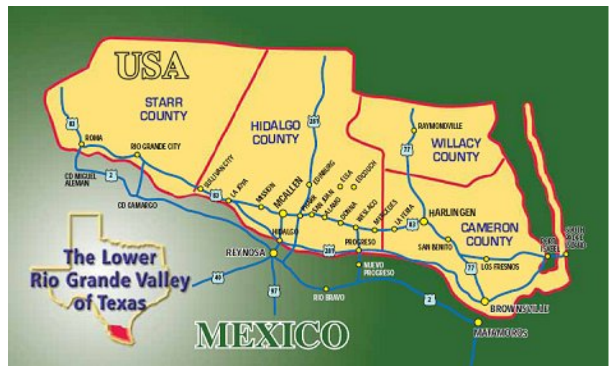

Figure 1. Map of the Rio Grande Valley showing major cities and counties in South Texas. Source: @SenatorLucio(2017), X.

This study examines communication and preparedness challenges associated with rapidly intensifying tropical cyclones in the Rio Grande Valley. Using historical storm analysis, operational meteorological review, and broadcast communication assessment, this work evaluates how compressed warning timelines may influence public preparedness and resilience, evacuation behavior, and the effectiveness of risk communication strategies during rapidly evolving tropical events.

2. REGIONAL VULNERABILITY IN THE RIO GRANDE VALLEY

The Rio Grande Valley presents a unique set of challenges when preparing for tropical cyclone hazards due to its geographic location, rapid population growth, flood vulnerability, and evolving infrastructure. Since Hurricane Dolly (2008), continued residential and economic expansion across Cameron, Hidalgo, Starr, and Willacy Counties has increased the number of residents and critical infrastructure exposed to hurricane-related hazards. At the same time, the region faces several preparedness concerns, including limited evacuation corridors, vulnerable housing in some communities, and communication challenges associated with rapidly changing tropical forecasts.

Rapidly intensifying hurricanes near landfall may further complicate preparedness efforts by reducing warning lead time and increasing uncertainty in protective decision-making. These concerns are especially important in the Rio Grande Valley, where flood- and wind-prone areas, bilingual communication needs, and varying levels of community resilience may influence public response to hurricane threats. This section provides a regional preparedness context to better understand the vulnerabilities that may shape outcomes during future rapidly intensifying tropical cyclone events.

2.1 Population Growth and Development

The Rio Grande Valley has experienced continued population growth and regional development, increasing the number of residents, homes, and infrastructure exposed to tropical hazards since Hurricane Dolly (2008). In 2008, the Rio Grande Valley population was estimated at approximately 1.2 million residents, while recent estimates place the regional population above 1.45 million in 2026. Continued growth has contributed to increased housing development, roadway congestion, and urban expansion throughout Cameron, Hidalgo, Starr, and portions of Willacy Counties. As regional growth continues, a larger population may increase evacuation complexity and elevate the number of residents vulnerable to hurricane impacts.

Beyond population growth, the Rio Grande Valley has also experienced notable industrial and economic expansion. Major facilities, including operations at the Port of Brownsville and the development of Starbase in eastern Cameron County, have altered portions of the regional infrastructure landscape. Energy-related development and maritime activity near the coast, together with expanding industrial investment throughout the region, may introduce additional preparedness considerations during tropical cyclone events, particularly in areas vulnerable to storm surge, high winds, and flooding.

2.2 Flood Vulnerability and Geographic Risk

Flooding represents one of the most significant hazards associated with tropical cyclones in the Rio Grande Valley due to low-lying terrain, poor drainage capacity in some areas, and the potential for extreme rainfall associated with slow-moving or rapidly intensifying storms. Although flood hazard maps produced by the Federal Emergency Management Agency (FEMA) identify areas of elevated flood risk throughout the region, recent heavy rainfall events have demonstrated that damaging flooding may also occur outside traditionally mapped flood zones. Hurricanes such as Beulah (1967), Dolly (2008), and Hanna (2020) produced widespread rainfall-related impacts across much of Deep South Texas, which includes the Rio Grande Valley. In addition, recent heavy rainfall events unrelated to tropical cyclones, including October 2015, June 2018, June 2019, and March 2025, have further highlighted the region's susceptibility to flash flooding, roadway inundation, and prolonged standing water. These impacts may become increasingly problematic during rapidly intensifying hurricanes if warning timelines are shortened and rainfall expectations change quickly near landfall.

In addition to inland flooding, geographic risk along the Lower Texas Coast contributes to regional vulnerability during tropical cyclone events. South Padre Island remains particularly susceptible to storm surge due to its low elevation and narrow barrier island structure, while surrounding communities such as Port Isabel and portions of coastal Cameron County may also experience surge-related flooding during major hurricanes. Historical storms, including the 1933 Labor Day Hurricane (Cuba–Brownsville Hurricane), Hurricane Beulah (1967), Hurricane Allen (1980), and Hurricane Dolly (2008), demonstrated the potential for coastal inundation, erosion, and infrastructure impacts associated with elevated water levels and strong onshore winds. The combination of inland flooding and coastal storm surge hazards creates a unique preparedness challenge for emergency management officials and residents throughout the Rio Grande Valley

2.3 Evacuation and Transportation Constraints

Evacuation planning remains an important component of hurricane preparedness within the Rio Grande Valley due to the region's geographic location, population growth, and limited transportation corridors. Major evacuation routes primarily include Interstate 69E/US 281 northward and U.S. 83 toward Laredo, which are designated to support inland movement during tropical threats. However, portions of the transportation network, including heavily traveled corridors through rapidly developing communities, may become congested during large-scale evacuations, particularly under shortened warning timelines associated with rapidly intensifying hurricanes. While contraflow operations remain a potential emergency option, large-scale regional evacuation procedures have never been fully tested under a major hurricane scenario in the Rio Grande Valley. Additional logistical considerations, including transportation access, vulnerable housing areas, and delays associated with inland travel corridors, may complicate protective actions during high-impact tropical events.

2.4 Communication and Vulnerable Populations

Effective hurricane communication within the Rio Grande Valley presents unique challenges due to the region's demographic composition and vulnerable communities. The Rio Grande Valley has a predominantly Hispanic and Latino population, with many households relying on both English and Spanish communication for weather information. During rapidly evolving hurricane scenarios, timely and accessible bilingual messaging becomes increasingly important, particularly for residents who may rely primarily on Spanish-language broadcasts or translated National Weather Service products.

Beyond language accessibility, socioeconomic and housing vulnerabilities may further complicate preparedness and protective decision-making. Numerous *colonias* (underdeveloped communities) throughout the Rio Grande Valley contain communities with varying levels of infrastructure resilience, including mobile homes, manufactured housing, and structures potentially more susceptible to high winds and prolonged flooding. During rapidly intensifying hurricane events, shortened warning timelines may limit preparation time for these vulnerable populations, emphasizing the importance of clear, consistent, and accessible communication strategies.

3. HISTORICAL TROPICAL CYCLONE ANALYSIS

Historical tropical cyclone events provide valuable context for understanding how rapidly evolving hurricane threats may challenge preparedness, communication, and resilience within the Rio Grande Valley. While forecast skill and operational hurricane prediction have improved substantially in recent decades, storms impacting South Texas continue to present unique challenges due to changing intensity, flooding potential, and uncertainty near landfall. Previous tropical cyclones affecting the region offer important insight into how meteorological conditions, warning timelines, and community vulnerability may influence public response during high-impact events (Lawrence and Pelissier 1981; Trepanier et al. 2014). To better understand these risks, selected case studies including the 1933 Cuba-Brownsville Hurricane, Hurricane Beulah (1967), Hurricane Allen (1980), Hurricane Dolly (2008), and Hurricane Hanna (2020) were chosen based on their regional impacts, varying storm characteristics, and relevance to preparedness and communication challenges within the Rio Grande Valley.

3.1 The 1933 Cuba-Brownsville Hurricane: An Early Benchmark for Regional Hurricane Preparedness

The 1933 Cuba–Brownsville Hurricane represents one of the earliest documented major hurricanes to directly impact the Rio Grande Valley and serves as an important historical benchmark for understanding the region's long-standing vulnerability to tropical cyclone threats. The hurricane originated from a tropical disturbance off the west coast of Africa during late August 1933 before steadily intensifying across the Atlantic Ocean. After passing north of the Lesser Antilles, the cyclone rapidly strengthened into a Category 5 hurricane with maximum sustained winds estimated near 160 mph before making landfall in northern Cuba on September 1. Upon entering the Gulf of Mexico, the hurricane restrengthened to Category 4 intensity before weakening slightly and making its final landfall on South Padre Island during the early morning hours of September 5 with estimated winds near 125 mph (National Hurricane Center).

As the hurricane approached Texas, forecast guidance initially suggested a greater threat to Corpus Christi, prompting hurricane warnings, mandatory evacuations, and even martial law in portions of the Coastal Bend during the busy Labor Day weekend. However, the hurricane gradually shifted farther west before ultimately striking the Lower Rio Grande Valley. Although forecasting technology was extremely limited compared to modern standards, early warnings issued by the United States Weather Bureau are widely credited with preventing a much greater loss of life by encouraging residents and visitors to leave vulnerable coastal areas before landfall.

The hurricane produced devastating impacts throughout Cameron County and the surrounding Rio Grande Valley. Sustained winds exceeding 90 mph were recorded in Brownsville before the anemometer failed, with gusts estimated near 125 mph. Storm surge reached approximately 13 feet along portions of the Lower Texas Coast, while heavy rainfall exceeding 15 inches was recorded near Mercedes. Across the Valley, powerful winds destroyed approximately 90 percent of the citrus crop, severely damaged homes and businesses, downed nearly all communication and electrical infrastructure, and left thousands of residents without power or shelter. Brownsville, Harlingen, San Benito, and numerous smaller communities experienced widespread structural damage, with many frame buildings either heavily damaged or completely destroyed. Overall, the hurricane caused approximately $16.9 million in damages and claimed 40 lives across South Texas, most of which occurred within Cameron County.

Beyond its historical significance, the 1933 Cuba–Brownsville Hurricane provides an important preparedness lesson that remains relevant today. The storm demonstrated how changes in hurricane track during the final stages before landfall can dramatically alter which communities experience the greatest impacts. It also highlighted the value of timely warning dissemination and coordinated emergency response, even when forecast uncertainty exists. Many of the hazards observed during the 1933 hurricane, including destructive winds, storm surge, flooding, agricultural losses, and widespread infrastructure disruption, remain among the primary threats facing the Rio Grande Valley today. Consequently, this storm serves as an important historical foundation for evaluating modern hurricane preparedness, communication strategies, and community resilience throughout the region.

3.2 Hurricane Beulah (1967): Extreme Rainfall, Stalling, and Regional Flood Vulnerability.

Hurricane Beulah (1967) serves as one of the most significant historical tropical cyclone events for evaluating preparedness challenges in the Rio Grande Valley, particularly regarding extreme rainfall, prolonged flooding, and changing storm behavior near landfall. Beulah remains one of the strongest hurricanes to directly impact Deep South Texas, making landfall near the mouth of the Rio Grande River on September 20, 1967, as a Category 3 hurricane after previously reaching Category 5 intensity over the western Gulf of Mexico (Sugg and Pelissier 1968). The storm developed from a tropical disturbance emerging from the west coast of Africa in late August before steadily intensifying across the Caribbean Sea and entering the Gulf of Mexico, where exceptionally warm waters supported renewed strengthening before landfall (Sugg and Pelissier 1968).

Figure 2. Track and intensity of Hurricane Beulah (1967), illustrating the storm's path across the Gulf of Mexico and inland stalling over South Texas following landfall near Brownsville. *Source: National Hurricane Center/Wikipedia Commons.*

While Beulah's destructive winds and storm surge produced severe impacts along the Lower Texas Coast, one of the storm's defining characteristics was its slowing and eventual stall over South Texas following landfall. After moving inland near Brownsville, the storm tracked northward before stalling near Alice, Texas, and later curving southwestward into Mexico (National Weather Service Corpus Christi 2017). This prolonged inland motion significantly amplified rainfall totals and flooding impacts across the region. Rainfall amounts commonly ranged between 10 and 20 inches across South Texas, with localized accumulations exceeding 30 inches. Within the Rio Grande Valley, Brownsville recorded more than 13 inches of rainfall, while nearby communities observed widespread totals exceeding one foot of rain, contributing to record river flooding and widespread inundation across low-lying communities (Sugg and Pelissier 1968; NWS Corpus Christi 2017). Previous rainfall during August and early September further worsened flooding conditions, leaving many areas vulnerable to prolonged standing water and infrastructure disruption.

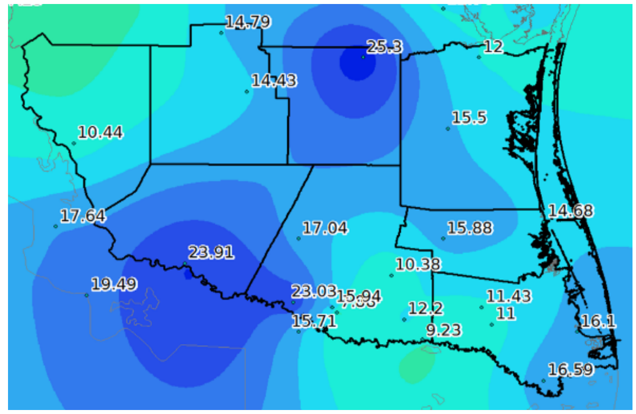

Figure 3. Estimated rainfall distribution associated with Hurricane Beulah (1967) across South Texas and the Rio Grande Valley. Shading represents approximate 4-inch rainfall intervals, ranging from 4–8 inches to greater than 24 inches. Source: National Weather Service Brownsville/Rio Grande Valley

Storm surge and wind impacts across the Rio Grande Valley were also substantial. Surge heights between 15 and 20 feet were estimated along portions of Deep South Texas, resulting in significant coastal flooding and the formation of 31 cuts across South Padre Island (National Weather Service Corpus Christi 2017). In Brownsville, wind gusts exceeded 100 mph, while observations from the S.S. *Shirley Lykes* reported winds near 136 mph in the Port of Brownsville (Sugg and Pelissier 1968). The hurricane also generated widespread infrastructure and agricultural damage throughout the Valley, including severe impacts to citrus crops and transportation networks (Roth 2010).

Beyond direct impacts, Beulah highlights an important preparedness concern relevant to this study: the consequences of a high-impact storm that slows or stalls near the region. Prolonged rainfall and repeated flooding may create significant challenges for evacuation, emergency response, and communication, particularly in flood-prone and vulnerable communities. Although forecasting capabilities have substantially improved since 1967, Beulah demonstrates how changing storm motion and prolonged impacts can complicate preparedness and recovery efforts throughout the Rio Grande Valley.

3.3 Hurricane Allen (1980): High-Intensity Wind and Major Hurricane Vulnerability

Hurricane Allen (1980) is one of the strongest hurricanes to threaten the Rio Grande Valley and serves as an important benchmark for evaluating the region's vulnerability to a major hurricane. Allen formed in the tropical Atlantic on August 1, 1980, and intensified rapidly while traversing the Caribbean Sea, reaching peak sustained winds of approximately 190 mph and a minimum central pressure of 899 mb, making it one of the most intense Atlantic hurricanes on record (Lawrence and Pelissier 1981). After weakening slightly due to environmental changes over the Gulf of Mexico, Allen regained and maintained Category 5 intensity approximately 120 miles east-southeast of South Padre Island before eventually weakening prior to landfall. The hurricane ultimately made landfall near Port Mansfield as a Category 3 hurricane on August 10, 1980.

Despite weakening before landfall, Allen produced widespread impacts across the Rio Grande Valley, highlighting the region's vulnerability to major hurricane threats. Wind gusts approaching 138 mph were reported in Port Mansfield, while storm surge reached approximately 8 to 14 feet along portions of the Lower Texas Coast, with the highest values occurring north of Port Mansfield and lower values near Boca Chica Beach. Extensive coastal damage occurred along South Padre Island and Port Isabel, where numerous structures sustained major impacts and portions of barrier island infrastructure were heavily damaged. Padre Island experienced severe geographic changes, including flattened dunes and multiple breaches through the barrier island. Inland communities also experienced tornadoes, flooding, and widespread wind damage.

Allen further demonstrated the importance of evacuation planning and preparedness during high-end hurricane events. Approximately 300,000 residents evacuated before landfall, representing one of the largest hurricane evacuations in South Texas history. However, the storm also highlighted challenges associated with forecasting uncertainty and preparedness decision-making, as the strongest impacts shifted northward before landfall. While the Rio Grande Valley avoided a direct strike from Allen's most intense core, the storm nevertheless produced substantial regional impacts, suggesting that even near-miss scenarios may result in considerable societal disruption.

For this study, Hurricane Allen serves as a valuable comparison storm for understanding how a stronger hurricane could impact the modern Rio Grande Valley. Since 1980, the region has experienced substantial population growth, expanded housing development, and increased critical infrastructure, including industrial facilities, transportation networks, and energy infrastructure. A hurricane following Allen's track under present-day conditions would expose significantly more residents and infrastructure to extreme winds, storm surge, and flooding than was the case over four decades ago. Consequently, Allen provides an important historical benchmark for evaluating regional wind resilience, evacuation feasibility, and preparedness under a high-impact hurricane scenario.

3.4 Hurricane Dolly (2008): Regional Preparedness and Forecast Challenges

Hurricane Dolly serves as a modern reference point for hurricane preparedness and vulnerability in the Rio Grande Valley due to its relatively recent impacts, changing forecast conditions, and widespread societal effects across region. Dolly was the first United States landfalling hurricane of the 2008 Atlantic hurricane season and the first hurricane to make landfall in Deep South Texas since Hurricane Bret (1999). Initially developing from a tropical wave that moved westward from Africa, Dolly encountered periods of environmental resistance, including dry air intrusion and increased vertical wind shear, which delayed strengthening (Fang and Zhang 2010). However, after July 21, environmental conditions became increasingly favorable as wind shear weakened and moisture increased across the lower and middle troposphere, allowing Dolly to strengthen into a Category 2 hurricane prior to landfall near the Texas-Mexico border on July 23.

Dolly provides an important case study in how changing forecast conditions and late-stage storm evolution may complicate preparedness decisions in the Rio Grande Valley. Although the storm strengthened gradually rather than undergoing rapid intensification, its continued intensification near landfall compressed preparation timelines for some residents and emergency managers. According to the National Weather Service Brownsville/Rio Grande Valley office, Dolly reorganized after interacting with the Yucatán Peninsula and strengthened further as environmental conditions improved over the western Gulf of Mexico. Changes in storm structure and intensity forecasting contributed to uncertainty regarding expected impacts across the region, particularly with respect to wind, flooding, and storm surge threats.

The impacts of Hurricane Dolly exposed several preparedness vulnerabilities that remain relevant today. Widespread power outages affected hundreds of thousands of residents across Cameron, Hidalgo, and Willacy Counties, while extensive wind damage impacted homes, businesses, and public infrastructure. Heavy rainfall overwhelmed drainage systems, inundated roadways, and required numerous water rescues. According to estimates from the Insurance Services Office and the National Hurricane Center, property losses associated with Hurricane Dolly were approximately $1.05 billion (NHC 2009). However, the overall economic impact was likely considerably higher because of widespread uninsured flood-related damage; estimates indicate that approximately 90% of flood losses occurred to uninsured properties. Post-storm surveys conducted following Dolly further highlighted challenges in public perception of hurricane threats, evacuation decision-making, and communication effectiveness (Ruin et al. 2009). These findings demonstrate that effective preparedness depends not only on accurate forecasts but also on how risk information is communicated, understood, and acted upon by the public.

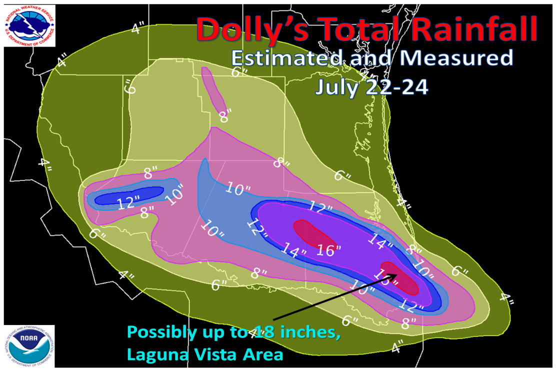

Figure 4. Rainfall totals and approximate track associated with Hurricane Dolly (2008) across the Rio Grande Valley and Deep South Texas. Source: National Weather Service Brownsville/Rio Grande Valley.

Since Dolly, the Rio Grande Valley has experienced substantial population growth, housing expansion, and infrastructure development, increasing the number of residents potentially exposed to tropical threats. As a result, Hurricane Dolly serves as an important modern baseline for evaluating how preparedness, communication, and resilience strategies may need to evolve in response to future hurricanes approaching the Lower Texas Coast. Lessons from Dolly suggest that even hurricanes below major hurricane intensity may produce substantial societal disruption when forecast conditions evolve shortly before landfall.

3.5 Hurricane Hanna (2020): Modern Communication Challenges and Flood Impacts

Hurricane Hanna (2020) serves as the most recent tropical cyclone to directly impact the Rio Grande Valley and provides an important modern case study for evaluating preparedness, communication, and evolving hurricane threats. Similar to the 1933 Labor Day Hurricane, Hanna followed a somewhat unusual west-southwest trajectory across the Gulf of Mexico before making landfall near Padre Island on July 25, 2020. The storm intensified into the first hurricane of the 2020 Atlantic season and ultimately produced widespread flooding, damaging winds, and disruptions across Deep South Texas.

While Hanna did not undergo explosive rapid intensification immediately prior to landfall, the storm demonstrated how evolving forecast conditions and strengthening intensity can still complicate preparedness and operational response in the Rio Grande Valley. Forecast adjustments in storm track and intensity required continuous coordination between the National Weather Service, emergency managers, local officials, and broadcast meteorologists to ensure residents understood changing storm threats associated with rainfall, wind, and coastal flooding.

Heavy rainfall represented one of Hanna's greatest regional impacts, particularly across low-lying and flood-prone areas of the Rio Grande Valley. Portions of Cameron, Hidalgo, and Willacy Counties experienced flash flooding, roadway inundation, and prolonged standing water, illustrating continued vulnerability to tropical rainfall despite improvements in forecasting capabilities since Hurricane Dolly (2008). The storm also produced widespread power outages, wind damage to structures with substandard construction, vegetation damage, and coastal impacts near South Padre Island and Port Isabel.

Hanna further highlighted the importance of localized and accessible hurricane messaging in a region characterized by rapid population growth, socioeconomic vulnerability, and a large bilingual population. The need to communicate changing storm threats clearly and promptly remains critical when forecast confidence evolves near landfall. As the most recent hurricane to directly affect the Rio Grande Valley, Hanna provides a contemporary example of both progress in operational forecasting and the continued preparedness challenges associated with tropical cyclone impacts in the region.

Overall, Hurricane Hanna reinforces the importance of preparedness strategies that account for changing forecast conditions, rainfall vulnerability, and public response during tropical cyclone threats. Lessons learned from Hanna, together with historical storms such as the 1933 Labor Day Hurricane, Beulah, Allen, and Dolly, provide valuable context for evaluating current communication practices and resilience strategies in the Rio Grande Valley.

4. COMMUNICATION, PREPAREDNESS, AND RESILIENCE ASSESSMENT

The historical hurricane case studies examined in this paper reveal several recurring themes that continue to influence hurricane risk in the Rio Grande Valley. While each storm occurred under different meteorological conditions, common challenges emerged regarding communication, preparedness, housing vulnerability, evacuation planning, and public response. Advances in forecasting technology and emergency management have improved the region's ability to respond to tropical cyclone threats; however, population growth, continued development, and vulnerable communities present new challenges. This section evaluates the current state of hurricane communication and regional preparedness in the Rio Grande Valley while identifying areas where resilience can be further strengthened before future high-impact storms.

4.1 Communication Challenges During Rapidly Changing Storms

The effectiveness of hurricane preparedness in the Rio Grande Valley is heavily dependent on the ability of emergency managers, meteorologists, and media organizations to communicate evolving threats to the public. Rapidly intensifying hurricanes present a unique challenge because forecast conditions may change significantly within a short period of time, reducing the time available for protective action. As a result, communication systems must be capable of providing frequent updates while ensuring information remains understandable to the general public.

At the national level, the National Hurricane Center (NHC) serves as the primary source of tropical cyclone forecasts for the United States. The NHC routinely issues forecast advisories, discussions, and track updates every six hours, with intermediate advisories often released every three hours when watches and warnings are in effect. As landfall approaches, public advisories may be issued as frequently as every hour. This rapid update cycle allows emergency managers, local National Weather Service offices, and broadcast meteorologists to continuously adjust messaging as storm conditions evolve. During rapidly intensifying events, this communication framework becomes especially important because changes in intensity and track can significantly alter local impacts within a matter of hours.

The National Weather Service Brownsville/Rio Grande Valley office serves as the local forecast authority for the Rio Grande Valley and adjacent ranchlands of Deep South Texas and maintains continuous coordination with the National Hurricane Center during tropical events. The office provides forecasts, watches, warnings, and decision-support services to county emergency management agencies throughout Cameron, Hidalgo, Willacy, and Starr Counties. Communication efforts are particularly important within the Rio Grande Valley because of its large bilingual population. To improve accessibility, the National Weather Service provides Spanish-language NOAA Weather Radio resources and regularly distributes bilingual graphics and warning information through social media platforms. The office in Brownsville maintains dedicated online resources explaining how residents can obtain and use Spanish-language NOAA Weather Radios, providing an additional method for receiving warnings when internet, television, or cellular services may become unavailable. During significant weather events, warning information is often communicated in both English and Spanish to ensure critical safety information reaches as much of the population as possible. These efforts help address one of the region's unique communication challenges and improve warning accessibility for Spanish-speaking communities.

Despite advances in forecasting technology, one of the greatest challenges remains forecast uncertainty. Numerical weather prediction models can improve understanding of future storm behavior, but they are not always accurate. The March 26–28, 2025, flood event demonstrated this limitation. During that event, high-resolution forecast models significantly underestimated both the location and magnitude of the heaviest rainfall. Areas along the Interstate 2 corridor from McAllen to Harlingen received catastrophic flooding despite many model solutions indicating much lower rainfall totals. The event highlighted the difficulty of translating uncertain forecasts into actionable public messaging when impacts may differ substantially from model guidance.

Broadcast meteorologists represent another critical component of the communication network. Local television stations, including KGBT-CBS-4, KVEO-NBC-23, and KRGV-ABC-5, provide continuous weather coverage during high-impact events and often serve as the primary information source for many residents. Broadcast meteorologists face the challenge of translating complex meteorological information into language that can be understood by the general public. Interviews and discussions with local meteorologists reveal a common emphasis on visual communication, impact-based graphics, and simplified messaging designed to quickly convey threat. Rather than focusing solely on technical terminology, broadcasters frequently emphasize expected impacts and protective actions. Modern social media platforms have further expanded communication capabilities by allowing stations to livestream updates and distribute graphics directly to the public.

Overall, communication in the Rio Grande Valley benefits from strong coordination between the National Hurricane Center, National Weather Service, emergency management officials, and local media outlets. However, rapidly changing storm conditions, forecast uncertainty, and the need to communicate across diverse populations continue to present significant challenges. Effective hurricane communication, therefore, depends not only on forecast accuracy but also on the ability of forecasters and broadcasters to deliver clear, timely, and actionable information before conditions deteriorate.

4.2 Regional Preparedness

While forecasting and communication capabilities have improved substantially over the past several decades, physical and social vulnerabilities remain important concerns throughout the Rio Grande Valley. One of the most significant preparedness challenges involves housing quality within colonias and other underserved communities. According to Kyne (2023), approximately 190,000 to 200,000 residents live within more than 1,200 colonias located throughout the region. Many of these communities contain mobile homes, repurposed structures, or housing constructed before modern wind-resistance standards became common. In addition to structural concerns, many colonias are located in naturally flood-prone areas, increasing vulnerability during tropical cyclone events.

Recognizing these risks, numerous organizations have partnered to improve community resilience through housing improvements and public outreach initiatives. Programs involving Proyecto Azteca, the Institute for a Disaster Resilient Texas, the Texas Advanced Computing Center, the Lower Rio Grande Valley Development Council, and the National Weather Service have emphasized both physical and educational preparedness. One notable initiative is the "60 to 90" campaign, which seeks to improve housing resilience by upgrading structures capable of withstanding approximately 60 mph winds to standards closer to 90 mph. This effort promotes the "ABCs of Smart Construction," emphasizing Anchors, Braces, and Connections to strengthen roofs, walls, and foundations against high-wind events. These efforts are particularly important because many colonia residents face financial barriers that limit their ability to make structural improvements independently.

Building standards across portions of the Lower Texas Coast vary depending on location and are intended to reduce wind damage during tropical cyclones. Within the Texas Windstorm Insurance Association (TWIA) designated catastrophe areas, structures are designed according to three wind zones: Seaward (130 mph 3-second gust), Inland I (120 mph 3-second gust), and Inland II (110 mph 3-second gust). These standards primarily apply to eligible coastal areas within Cameron and Willacy Counties and other designated catastrophe areas along the Texas coast. Structures located on South Padre Island are generally required to meet the highest wind-resistance standards, while areas farther inland within the designated catastrophe zone are subject to lower design wind speeds. Although these standards reflect historical assessments of wind risk, historical hurricanes such as the 1933 Cuba–Brownsville Hurricane, Beulah (1967), Allen (1980), Dolly (2008), and Hanna (2020) demonstrate that damaging hurricane-force winds can extend well inland beyond the immediate coastline, including into Hidalgo County. As population growth and development continue throughout the Rio Grande Valley, ensuring that vulnerable structures are constructed or retrofitted to withstand future hurricane threats will remain an important component of regional resilience.

Another preparedness concern involves evacuation planning. Although official evacuation routes exist through Interstate Highway 2/U.S Highway 83 and U.S. Highway 281, the Rio Grande Valley has never experienced a modern full-scale evacuation associated with a major hurricane. Consequently, significant uncertainty exists regarding how transportation systems would perform during a large evacuation event. Historical examples such as Hurricane Allen (1980) demonstrate how roadway closures and storm impacts can restrict movement throughout South Texas. Modern challenges include potential traffic congestion along major highways and delays associated with Border Patrol checkpoints near Sarita and Falfurrias. While these routes generally function well under normal conditions, their effectiveness during a mass evacuation remains largely untested.

Preparedness concerns are not limited to hurricanes alone. The March 26–28, 2025 flood event demonstrated how vulnerable the region remains to extreme rainfall. Multiple rounds of storms produced widespread flooding across the Rio Grande Valley, with some locations receiving more than 20 inches of rainfall. Hundreds of roads were closed, thousands of vehicles and structures were damaged, several hundred water rescues were conducted, at least four flood-related fatalities were reported, while two additional fatalities were associated with lightning strikes during the event. Even communities with relatively developed drainage systems experienced significant flooding. The event demonstrated that vulnerability extends beyond coastal storm surge and hurricane winds to include inland flooding hazards that can impact large portions of the region simultaneously.

Public response to rapidly evolving hurricane threats also remains an important area of concern. While the Rio Grande Valley has experienced major hurricanes, it has not experienced a textbook rapid-intensification event immediately before landfall. However, Hurricane Dolly (2008) and Hurricane Hanna (2020) demonstrated how relatively small changes in track and intensity can significantly alter local impacts and preparedness requirements. These storms serve as reminders that warning timelines may shorten quickly, requiring residents and emergency managers to make decisions under increasingly uncertain conditions.

Overall, preparedness within the Rio Grande Valley has improved through stronger partnerships, increased public outreach, resilience initiatives, and improved forecasting capabilities. However, continued investments in housing resilience, drainage infrastructure, evacuation planning, and community preparedness remain necessary as population growth and regional development continue to increase both exposure and vulnerability to hurricane hazards.

4.3 Recommendation for Future Resilience

The historical hurricanes and modern flood events discussed throughout this study demonstrate that continued investment in both communication and infrastructure will be necessary as the Rio Grande Valley continues to grow. One area that deserves additional attention is public communication, particularly among younger populations who increasingly rely on social media platforms such as Instagram, TikTok, and other digital sources for information. While weather agencies and local broadcasters already maintain active social media presences, future messaging should focus not only on communicating the hazard itself, but also on clearly explaining the actions residents should take in response to that hazard. Impact-based messaging that connects forecast information with specific preparedness actions may improve public response during rapidly evolving events.

Infrastructure improvements also remain critical, particularly in areas vulnerable to flooding. The March 2025 flood event demonstrated that even locations not traditionally viewed as high-risk flood zones can experience significant impacts when extreme rainfall occurs. Continued investments in drainage systems, stormwater management projects, and flood mitigation infrastructure will be important, especially throughout Hidalgo County and other rapidly growing portions of the Upper Rio Grande Valley. In addition, continued efforts to strengthen colonia housing through resilience initiatives such as the "60 to 90" campaign may reduce future wind-related damage and improve community recovery following major hurricanes. Together, these efforts can help increase the overall resilience of the Rio Grande Valley to future tropical cyclone threats.

5. CONCLUSIONS

The Rio Grande Valley has experienced numerous high-impact tropical cyclones throughout its history, ranging from the 1933 Cuba–Brownsville Hurricane to more recent events such as Hurricanes Dolly (2008) and Hanna (2020). Although forecasting technology, emergency management, and public communication have improved substantially over the past several decades, continued population growth, expanding infrastructure, and persistent social vulnerabilities present new challenges for hurricane preparedness. Historical events demonstrate that no two storms produce identical impacts, emphasizing the importance of maintaining flexibility in forecast messaging and emergency response.

As research continues to improve understanding of rapidly intensifying tropical cyclones, strengthening regional resilience remains equally important. Investments in effective communication, wind- and flood-resilient housing, drainage infrastructure, evacuation planning, and public preparedness can reduce vulnerability before future storms occur. By combining advances in meteorological science with continued community resilience efforts, the Rio Grande Valley will be better positioned to respond to future hurricanes similar to those that have impacted other locations along the Gulf Coast, including Hurricane Harvey (2017), which affected the Texas Coastal Bend through Houston, Galveston, and Beaumont; Hurricane Michael (2018), which impacted the Florida Panhandle and extended into southwest Georgia; and Hurricane Ian (2022), which impacted Florida's Suncoast.

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