# Judges' Commentary: The Place I Called Home...

Heather Bloemhard
Assistant Director of Federal Relations
Division of Government and Community Relations
Vanderbilt University
Washington, DC

Tiffany Chu
International Studies & Political Science
Virginia Military Institute
Lexington, VA

Christa Cochran
Foreign Policy Analyst
Department of Defense
Alexandria, VA

Keith Erickson
Mathematics
Georgia Gwinnett College
Lawrenceville, GA

Eleanor Ollhoff
Bonn, Germany

Troy Siemers
and
Jessica Libertini
Applied Mathematics
Virginia Military Institute
Lexington, VA
libertinijm@vmi.edu

## Introduction

A reality of climate change is that sea levels are rising, putting entire island nations at risk. This year's ICM® Policy Problem asked students to explore this issue—from measuring the scope and scale of the problem to developing policies designed to protect both the people and their culture as they resettle in a new homeland.

This problem is challenging and nuanced, and the ICM problem statement (reproduced in the director's report on the contest [Beecher 2020]) includes an issue paper that highlights several important considerations, such as cultural value, human rights issues, the legal status of environmentally displaced persons (EDPs), the responsibilities of host nations, the obligations of nations that contributed more to climate change, the value of personal choice, and the role of the international community.

We outline some of the criteria that the final judges used in assessing the submissions. We also offer a brief overview of each Outstanding paper.

*The UMAP Journal* 41 (3) (2020) 321–336. 

# Judges' Criteria

The judges wanted to see papers that cohesively looked at the problem in its entirety rather than tackling each element of the problem separately, with models that seemed disconnected. Most importantly, the models needed to inform the proposed policies, not be stand-alone solutions to mathematical problems.

Because of the complexity of the problem, proposing models and policy solutions required making a certain number of assumptions. The best papers explained the reasoning behind the stated assumptions and explained why each one was necessary in order to address the problem.

The prose, including the sections used to describe mathematical models, needed to be clear and demonstrate logical thought processes.

Additionally, successful papers did not have any extraneous information, graphics, or models, but tied into a coherent whole each model used, to determine the scale of the problem and the policies proposed to address the EDP challenge. These papers discussed the strengths and weaknesses of their modeling approaches and provided comprehensive summaries of the final proposals.

Successful papers used different methods for calculating the number of EDPs. The judges were looking for papers that contained clear explanations for why the authors proposed the model(s) that they included and then evidence that the authors evaluated the proposed model(s) with actual data. Also, the judges favored papers that tested constructed models against proposed policy prescriptions as a means of demonstrating consideration of the problem as a whole, rather than separate elements to be solved individually.

The submissions also contained a wide variety of proposals for determining where EDPs could resettle. The best papers contained unique policy ideas that took into account the challenge of preserving EDP culture and ensuring EDP human rights in their new homes. Making policies aimed at preserving culture from an EDP country required defining the culture and considering which elements of culture can be transported and which cannot. The judges were excited to see papers that understood culture had tangible and intangible facets—some of which would be easier to preserve than others—and that defined and examined cultural value indicators. Papers that considered the problem of preserving culture over time after EDPs settled in a new home were viewed favorably by the judges. For example, EDPs settling as a group into a new home could preserve their language and religion for a generation or two, but some aspects of culture are likely to be lost over time as the EDPs assimilated into their new home.

This issue of assimilation presented a particularly difficult challenge in this year's problem. The judges were pleased to see that some papers considered the nuances of an EDP assimilating into a new homeland instead of assigning normative judgments to EDP and host country concerns about

assimilation. Assimilation could be beneficial as EDPs tried to make new lives in a new home, but it could also result in the loss of the culture that the proposed policies were trying to preserve.

The judges were impressed by the wide variety of proposals for determining where EDPs should resettle. Many submissions assigned industrialized countries scores based on their $CO_2$ emissions to determine "responsibility" for resettling the EDPs from their disappearing homelands. In some papers, teams coupled high $CO_2$ emissions with a strong economy as a way to include capability of a country to take in EDPs. In these cases, the assumptions that the authors made became important.

The most successful solutions considered how well EDPs could settle in the new homes based on proximity, job options, population density, and availability of health care, education, and other social goods necessary for a refugee to start a new life. The judges were less swayed by solutions that used simple numerical formulas for dictating new homelands for the EDPs. Some of these proposed solutions did not consider an EDP preference, host country ability to support new residents, or ability of the EDPs to succeed in their new lives. The judges were most impressed by those entries that contained unique ideas for leveraging existing international institutions or creating new ones to serve as mediators between the EDPs and their new homelands. Unique suggestions for using institutions to address the EPD challenge included proposing that countries with high $CO_2$ emissions contribute to a fund for initiatives aimed at preserving EDP culture, allowing teams to optimize financial responsibility and community integration separately.

As always, the judges were looking for clarity in problem definition, convincing arguments about model construction, and meaningful interpretations of the results in the context of policies and the real world. All in all, the judges were really looking for papers from teams that had embraced and wrestled with the challenging multifaceted nature of this problem, as had been illustrated through the issue paper included in the problem prompt.

# Discussion of Outstanding Papers

There were some very creative papers this year; and as the judges debated the final few, they were looking to select a set of Outstanding papers that could serve as examples showcasing diversely powerful work. However, given the limited time in the competition, no paper is ever perfect. For each Outstanding paper, we offer below a brief discussion that highlights the strengths that moved it into the Outstanding bracket but also point out ways in which the paper, although largely excellent, was not perfect.

## Xi'an Jiaotong University: "Models for EDPs Relocation and Relative Policies" (Vilfredo Pareto Award and COMAP Scholarship Award)

This paper stood out to the panel especially for the unique way it addressed the human element and the challenge of modeling the policy issues of this global predicament. The evidence and application of thorough research into how this issue is or isn't being addressed and the existing international policies in place really set this paper apart from its peers. It is for these reasons that this paper was chosen as the recipient of the Pareto Award.

The human aspect of this paper is what the panel found to be extraordinary. This was one of the only papers to take into account the self-interest motivations of the refugees, instead of assuming that they will willingly go along with any policy for relocation. This is a much more realistic approach and stands a better chance of creating effective policy than ignoring the fact that people will make decisions based on what they deem to be best for themselves and their families. This team also made an important distinction between internally vs. externally displaced persons, based on the fact that many refugees would choose to relocate in their own country, if possible, instead of undertaking the expensive and complicated process of moving to another country. The paper defines this population as IDPs, or Internally Displaced Persons, so as to distinguish them from EDPs, or Externally Displaced Persons, as shown in **Figure 1**.


**Figure 1.** Organization and distinctions of displaced persons in the Outstanding paper from Xi'an Jiaotong University.

Another consideration that set this paper apart was that it distinguished between tangible and intangible heritage in creating a Cultural Evaluation System (**Figure 2**). In fact, all of the criteria for their cultural loss evaluation were well-thought-out and researched.

We see more evidence of thorough research and literature review through the policies proposed in this paper. These policies are well-rounded and build on an existing policy architecture at the international level, which shows this team's understanding of the importance and benefit of work-

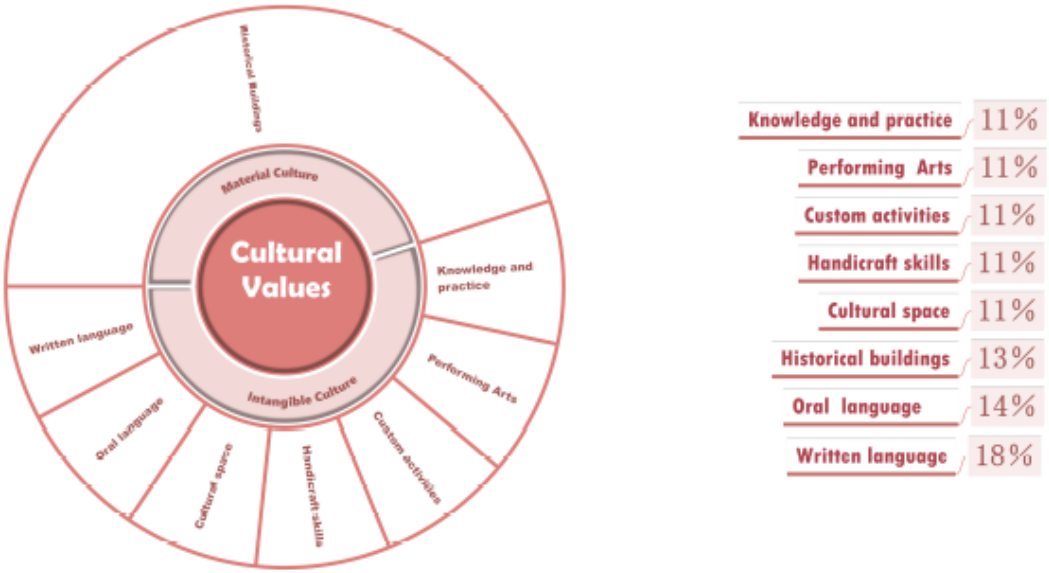


**Figure 2.** Stratified evaluation index.

ing with a foundation already in place. When considering where to place these EDPs, another unique aspect of this paper was that they looked at not only the GDP of the potential host countries (which was the standard approach of many papers), but also at the Gross National Happiness Index, the Social Security Index, and the Cultural and Environmental Pull Indices. This was the most comprehensive set of criteria for evaluating suitability of the host countries that the judging panel saw.

The paper does a great job of tying the policies back into their model, as shown in **Figure 3**. It is very important to demonstrate how the proposed policies impact the model and how the model reflects these effects.

Another highlight of the paper is the application of the models to the example of the Maldives. This case study gave the panel an opportunity to see how the authors intend their models to be used and how they anticipate them being applied to facilitate solutions to the crisis of these displaced peoples.

The models used were simple, well-used, and well-justified. What makes the models in this paper so good are that the assumptions and criteria are well-rounded, clearly researched, and take human nature and motivation into account. This paper did have some organizational issues that, if corrected, would have made their work clearer. A more concerning detail of the paper that the panel mentioned was the attention the authors paid to illegal activity on the refugees' part. It was felt that this was unnecessary and that the assumption that this behavior is inevitable without intervention by the host country does not accurately reflect the cultures or people being discussed.

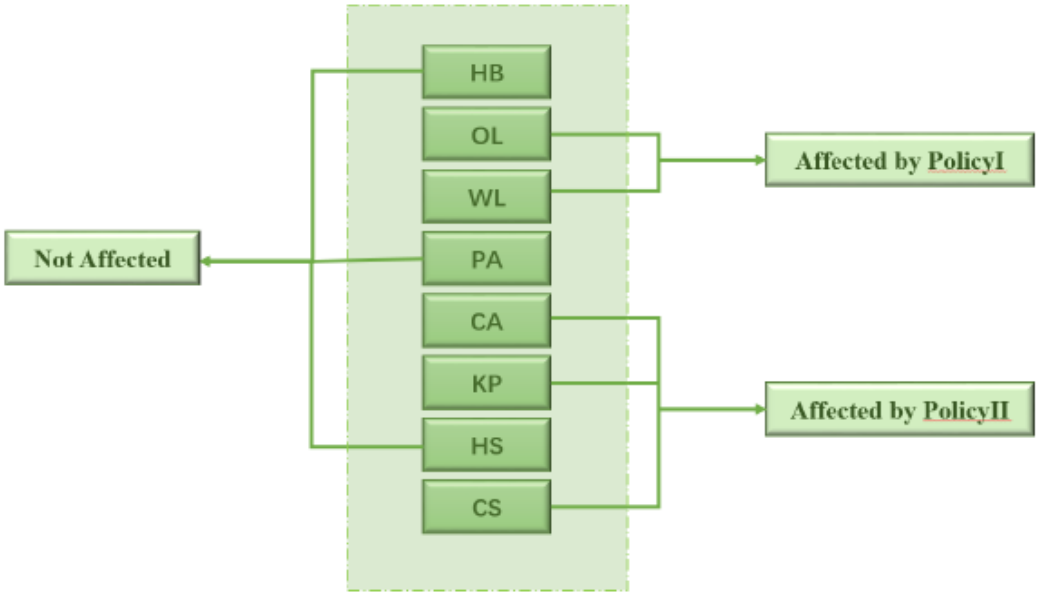


**Figure 3.** The policy-affected indicators of cultural value

## Beijing Normal University: "The Wandering Homeland"

This paper stood out for its clear organization and exposition, and for its creative use of the Lotka-Volterra model to examine the survival of EDP culture in competition with the culture of the host country.

The authors used the executive summary to state the problem, define important terms, and outline their approach. They included a brief description of major results and used bold font to highlight key details, providing a clear scope that linked the pieces together and was easy to follow. The paper stayed within this scope throughout, without getting distracted by excessive detail or overly-complex models.

After reviewing the literature, including key references, and restating the tasks, a complete and concise analysis of the issue paper was presented. The assumptions were well-justified and provided a reasonable scope for the solution space. The policy recommendations were then stated in eight points that clearly connect the different pieces and fill in some detail around implementation.

To estimate the number of EDPs over time, the authors used a linear regression on sea level, with a cone model to represent an island (**Figure 4**) and exponential growth of the island population. This approach was fairly typical among entries; but the modeling pieces in this paper were focused and fit together clearly, and the results were supported with appropriate references.

The 50 countries with the highest greenhouse gas emissions were scored using the entropy weight method based on a small set of variables: greenhouse gas emissions, GDP per capita, arable land, and freshwater resources.

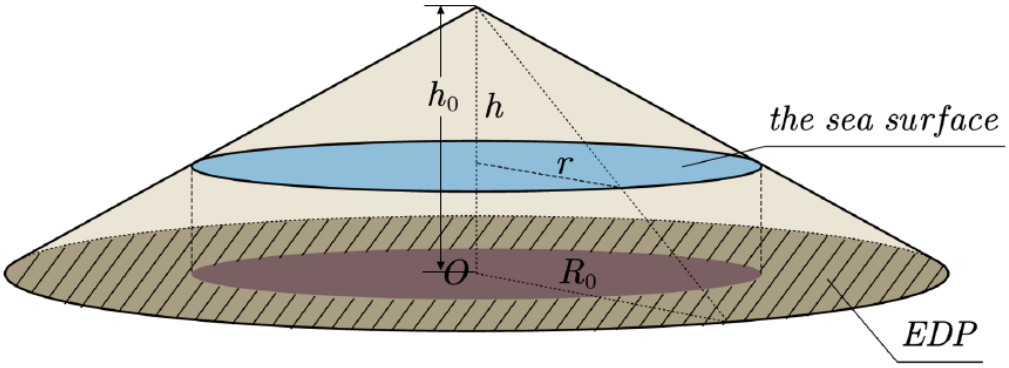


**Figure 4.** A cone island model.

Variable values and results for the top 20 countries were presented in a table with appropriate references. The distribution of EDPs among the countries should have been explicitly stated, but it was reasonably assumed to follow the distribution of scores.

A highlight of this paper, and one of the main reasons that it stood out, was its creative use of the Lotka-Volterra model to examine the survival and stability of competing cultures. The model was clearly adapted to the context with variables quantified by values from previous sections. Results were presented for two different sets of parameter values that indicated either cultural loss or gain. The paper would have benefited from a more-thorough analysis of long-term stability and some insight into how to resolve the parameters, but there is a foundation for a deeper analysis that could show multiple stable states among the cultures.

The economic impact of EDPs on the 20 receiving countries previously mentioned was modeled in terms of resettlement costs, the cost of living, and the value that EDPs would create after a transitionary period. The results predicted which countries will have long term revenue decline or growth after reaching a break-even point.

The authors then analyzed the strengths and weaknesses of their models, noting important components that they left out, including religion and nationalism, with suggestions for how to adjust the results to improve the policies.

While the judges noted that there were some missing pieces that would have strengthened the paper, including a deeper analysis of the Lotka-Volterra model, the clarity in the organization and exposition made it easy and enjoyable to follow. The models focused on critical details that were reasonably limited in scope. Complications were mentioned but did not distract from the overall quality. These features combined to make this an Outstanding paper.

## South China University of Technology: "NOT ME, US!"

What impressed many judges about this paper was its clarity and illustration of their model to the case of the Maldives. The executive summary provided a clear outline of the paper, bolding important aspects of their paper, such as their various models and parameters. They describe how each of their models improves upon the preceding model, to address more of the problem, as illustrated in **Figure 5**.

The paper did a good job framing the environmental risk of rising sea levels on the potential for an increasing number of individuals becoming EDPs. Moreover, they account for potential unexpected disasters, such as tsunamis, to illustrate that the issue is not slow-moving, but can have unexpected mass movements of people due to environmental shocks.

The paper's policy proposals took into account unique parameters that were not discussed in other papers. For example, the paper took into account the timing of emigration, variable costs of hosting of different countries, and the political implications of refugees in host states, to ensure minimal domestic unrest. They also explained why these parameters mattered, which put it above some of the other papers in quality.

One way that this team set their paper apart from others was choosing the Maldives as a case study to walk through the process of their models. This exercise helped judges understand the model and how it applies to actual cases where EDPs are expected.

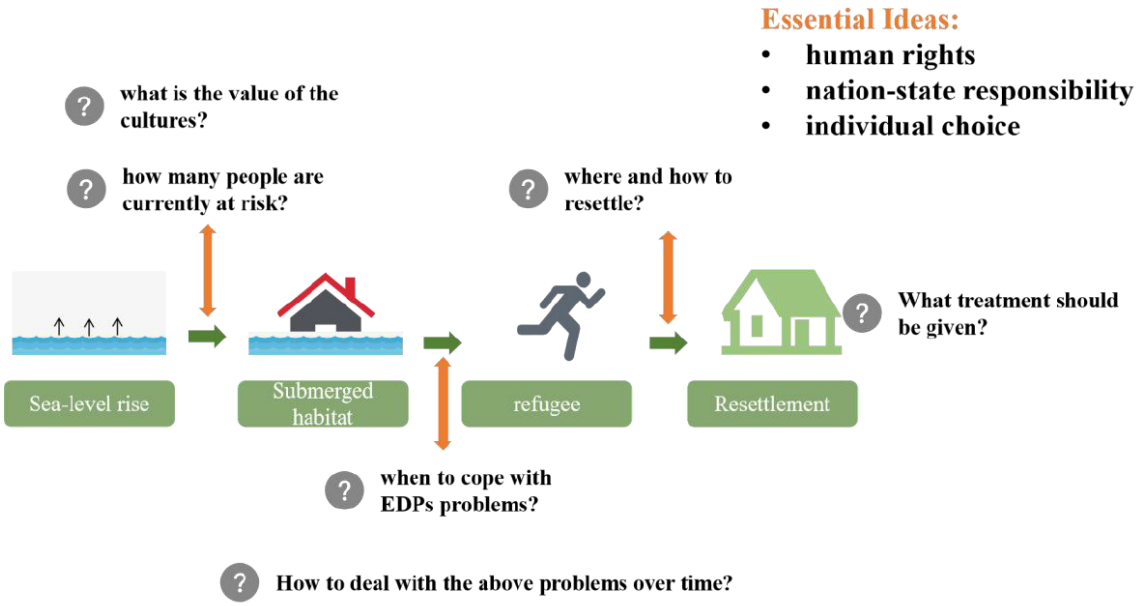


**Figure 5.** Problem overview.

The paper could have been improved in several ways. Some of the models lacked a full explanation, including of variables in the model. Some of the proposed polices were extremely broad, which ended up being a double-edged sword: While judges liked that the authors took into account

all of these issues (human rights, culture, unexpected natural disasters and sea level rise, host country dynamics), the discussion lacked depth in terms of how it would translate into application. This limitation was somewhat offset by walking through the case with the Maldives, resulting in an Outstanding paper.

## Beijing Forestry University: "The Place I Called Home"

This team shined in overall organization and thought. They carefully covered many aspects of the problem, allocating a large portion of their paper to all parts of policy development, implementation, and the importance of such policies, instead of just seeing how many models they could shove in. Their executive summary was excellent, succinctly reviewing their work, and most importantly, giving specific answers to the questions instead of generalities; it was a true exemplar of a summary. After reading the executive summary, it was clear not only what models they used but also all of the main takeaways. It made the judges want to read more.

Key numbers required in the problem were the number of refugees and when that number would be reached. Some teams gave estimates in the millions or tens of millions, way overestimating the numbers of EDPs that would need to emigrate, at least in the typical time frame provided. This team was much more nuanced in their approach both in the overall estimates and in the types of refugees there would be. They estimated the number of climate refugees in the low hundreds of thousands, a very reasonable estimate of true refugees in the sense of the problem. The team clearly identified the difference between EDPs able move to another location in their home country vs. those who would have to go to another country and therefore would need help from UN policies. The team set the time frame at the year 2080 for their analysis, which was approximately in the middle of the estimates given in many papers (often 2050 to 2100) and is certainly reasonable given the uncertainty in sea level rise models.

The models that the team used, including the Analytic Hierarchy Process and the Kuhn-Munkres algorithm (also known as the Hungarian algorithm) for optimal destination matching, as well as principal component analysis for cultural loss importance, were also used by many other teams in the competition; but this team did a good job in the clarity of the presentation. (It would have been desirable for the team to cite sources for the techniques used.)

In the ICM policy problem, policy development is an important consideration; and this team gave a lot of thought and discussion to policy. They broke the policy discussion down into Human Rights Protection and Cultural Protection; they developed a long, clear list of important factors to consider, including the delicate issues surrounding forced assimilation versus preservation of culture. They first talked about initial stages of refugee influx. This included positive approaches to cultural preservation by cre-

ating museums, in using video, sound, and text recordings, and in understanding the need to protect cultural awareness and pride. Naturally, there can be negative results of immigration, including financial damage in reduction per capita share of resources, which can often be followed with potential backlashes from the host country in the form of a decrease in human rights protection capabilities and maybe even riots or wars. But then secondly they followed it forward in time to show how some of the characteristics of assimilation interact with one another, providing long-term positive impacts (e.g., employment trends and economic impact over time). They pointed out that the impact of the new culture can both strengthen the economics of the home country with new jobs and products, but at the same time doubly serve to increase cultural pride and harmony between the refugees and the native residents.

In the end, the team realized that no set of policies is perfect. Even with the best policies implemented, there will be challenges; but as the team points out, no one wants to re-create the refugee crises of the past. These plans at least set the directions. This crisis is coming and all stakeholders cannot ignore it.

## Xi'an Jiaotong University
## "Disaster for Island Country but Games of Big Power: Find New Home for EDPs and Their Culture"

The team built a model based on game theory to simulate the negotiations among possible host nations. The model, as depicted in **Figure 6**, allowed the team to consider the complexity of the political dynamics that exist between nations. Nations were selected as players of the game based on the cumulative greenhouse gas emissions since the 18th century, total gross domestic product (GDP), and population density. The resulting responsibility index allowed the team to select nations that would be candidates for accepting EDPs and which would provide economic support.

The simulation focused on identifying which of the candidate nations would accept EDPs from each nation. The team used "international pressure" as their simulation index. Nations with higher levels of responsibility were assumed to experience more international pressure; nations with more external influence—through their military strength and GDP—were assumed to exert more international pressure. These and other assumptions mean that the model is not entirely realistic; however, the judges concluded that these simplifying assumptions were reasonable.

One area where the judges felt the paper was lacking was the team's approach to cultural heritage, which seemed heavily based on some arguably outdated ideas of what defines culture, such as limiting the scope to things such as literature and books. The team was careful to consider that individuals would have a choice of completely assimilating into the

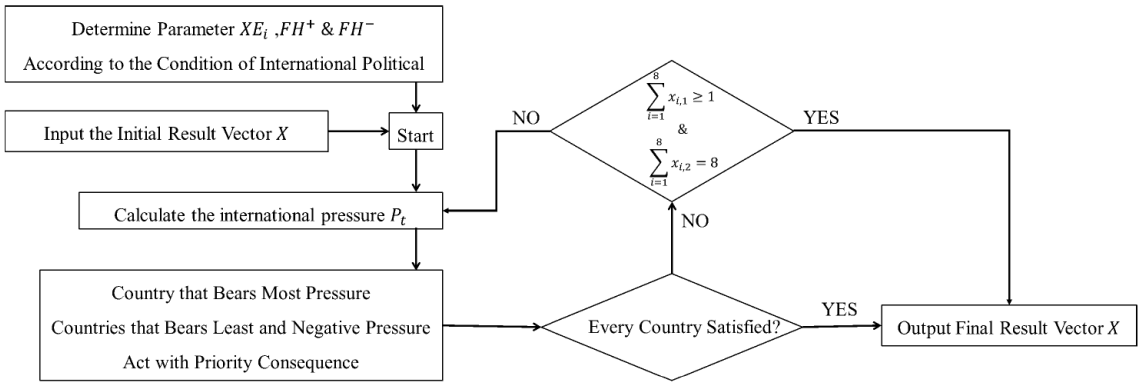


**Figure 6.** The game theory simulation constructed by team from Xi'an Jiaotong University.

host nation, remaining culturally isolated, or achieving a mix; but several of the terms used to describe these populations were inaccurate.

One feature that the judges greatly appreciated was the clear, concise summary of the model results. The logical flow was generally good. However, there were places where the language made the work less clear.

## Shanghai University of Finance and Economics: "Comprehensive policy models developed for EDPs"

This team opened their paper with a graphic that provided a clear overview of their approach (**Figure 7**).

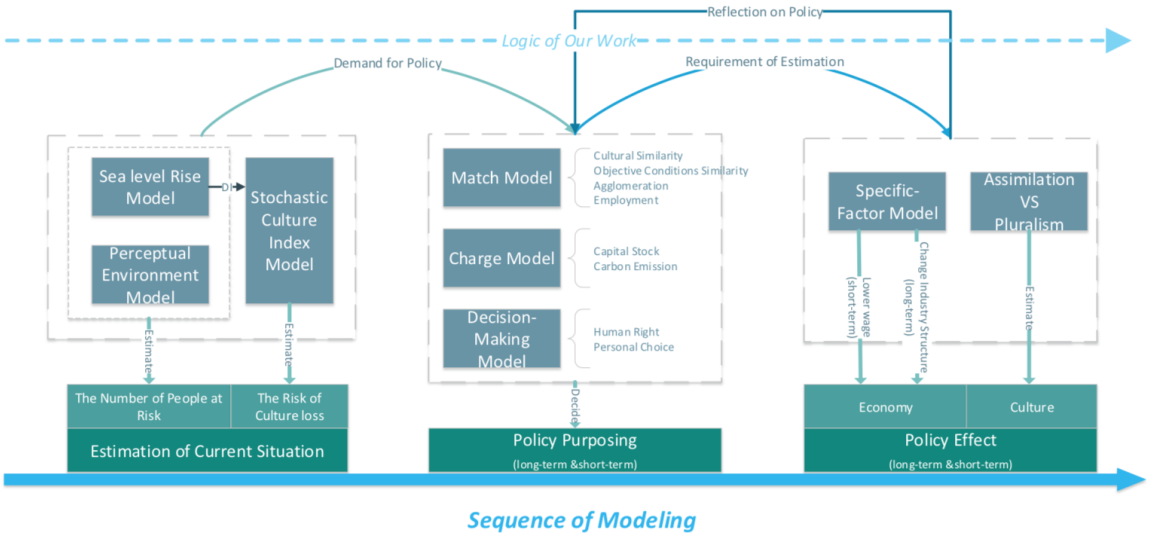


**Figure 7.** Overview of the team's methodology.

They presented a model that started with a simplified island shape and then overlaid a complex index that leveraged the environment, living conditions, and national efforts to develop a probability of needing to migrate.

The team then proposed a stochastic cultural index model that took education, GDP, land loss, and tourism into consideration. The model also assumed that, over time, assimilation is inevitable. The team then ran the cultural model to illustrate how perturbations in sea-level rise would impact the longevity of the culture. In these models, the judges noted the simplicity of the island's geographic model, but recognized that this simplification allowed additional explorations in other areas of the problem. A concerning aspect of the paper was the team's treatment of culture, which seemed outdated and limiting.

The second half of the paper is what really impressed the judges. The judges were pleased to see this team's resettlement decision model, which accounted not only for the best-fits based on the model but also for personal choice. The team also had a match model that helped country's find their closest cultural match from among possible host nations (**Figure 8**), as well as a charging model that used environmental indicators to explore responsibility offsets by nations that contributed more to climate change. The team then pulled all of their work together by exploring policy impact. Throughout the paper, the team made great use of graphics to help readers understand their complex ideas; in fact, the strengths of their visualizations help solidify this team's selection as an Outstanding paper.

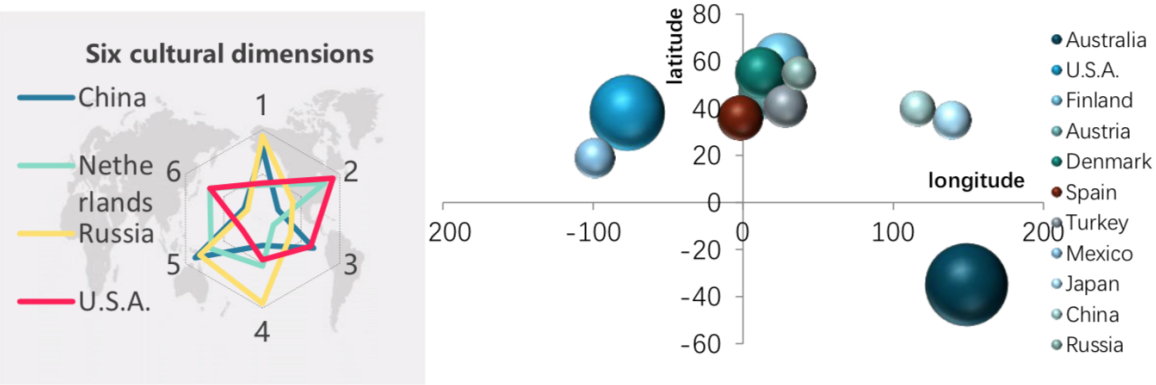


**Figure 8.** Radar plot of the six cultural domains as well as a visual comparison of cultural similarity across multiple possible host nations.

# Conclusion and Recommendations for Future Participants

As in every year, the judges were excited to see how teams interpreted and tackled the problem posed. Within the span of approximately 100 hours, successful teams defined the problem, performed background research, determined the severity and size of the issue of EDPs, explored issues of cultural preservation, created and used models to explore the relo-

cation and resettlement of EDPs, proposed policies based on their findings, and prepared their 20-page report. The strongest papers clearly communicated their efforts and made convincing cases for their modeling decisions, and also demonstrated how the policies connect with their models.

As we look forward to future competitions, here are some suggestions from our panel of final judges about how to prepare a strong submission, particularly in Problem F, the policy problem.

- **Plan your time.** Each year, there are papers that showed potential but suffered from inadequate time management. Sometimes a paper starts strong, with lots of in-depth background research; but then the model is incomplete. Other times you can tell that the team focused so much on creating the model, that they didn't get a chance to use their model to explore the problem. And some papers include a lot of findings, but the team did not take the necessary time to convey their work clearly in their report.
- **Go back and forth between the modeling and the policy.** Since Problem F focuses on policy, it is important that teams develop models that allow them to explore the impacts of their proposed policies, and this work spirals. Successful teams might propose a policy first, then develop a model to analyze it, and then perform a sensitivity analysis to inform and update their policies. Another viable approach is to construct the model first, and then develop the policies based on the findings that result from trade studies or optimizations using their model(s). Regardless of the approach, it is very important that there is a clear connection between the modeling work and the policy work.
- **Leverage individual strengths.** Given that the competition is only 100 hours long, it is important for teams to know each member's strengths, which could include performing background research, finding reliable data, designing the model, coding the model, analyzing model outputs, using the model to understand the issue, developing policies, testing policies, writing clearly, editing, and making sure that all sources have proper citations.
- **Communicate clearly for a broad scientific audience.** The panel of judges for the ICM policy problem is comprised of diverse disciplinary experts including policy experts, social scientists, and applied mathematicians. Therefore, it is important that teams write convincingly about the techniques they use. The judges are not looking for the paper with the most sophisticated mathematics—they are looking for papers that clearly explain and make a strong case for the methods that are applied.
- **Find sources and cite them properly.** When teams make a claim, their argument is even stronger when they point to a credible source that backs that claim. While teams should not spend all of their time looking

backwards, a good paper typically supports their framing of the problem and their modeling decisions with good references that are properly cited.

# Reference

Beecher, Amanda. 2020. Results of the 2020 Interdisciplinary Contest in Modeling. *The UMAP Journal* 41 (3): 187–216.

# About the Authors

Heather Bloemhard earned a Ph.D. in physics from the New Mexico Institute of Mining and Technology and a B.S. in physics and astronomy from George Mason University. She is currently the assistant director of federal relations for Vanderbilt University; she has served as a Science & Technology Policy Fellow at the Department of Defense and the American Astronomical Society's John N. Bahcall Public Policy Fellow. She became involved with MCM/ICM in 2018 as a triage judge; in 2020, she served on the final judging panel.

Tiffany S. Chu is an Assistant Professor at Virginia Military Institute in the Department of International Studies and Political Science. Her research focuses on decisions taken by forced migrants and conflict processes. She received her Ph.D. and M.A. from the University of Arizona and her B.A. from the University of California, Berkeley. Given her background in forced migration, Dr. Chu served as one of several problem-specific experts on the final judging panel.

Christa Cochran has a Master's of Public Policy from the University of Maryland, with a specialization in International Security Policy. She has worked in several different offices within the Department of Defense, currently as a Foreign Affairs Analyst. This was her first year serving as a judge for the MCM/ICM. (Disclaimer: Her work with the MCM/ICM is in a personal capacity and not as a representative of the Department of Defense.)

Keith Erickson earned his B.S. in Chemical Engineering from the University of Washington in 1999 and his Ph.D. in Bioengineering from the University of California, San Francisco and Berkeley, in 2006. He served as a Davies Fellow at the US Military Academy at West Point 2007–2008 before joining the faculty at Georgia Gwinnett College, where he helped start and build the Mathematics major and continues teaching all levels of mathematics. He has been a triage judge for MCM and ICM since his time at West Point.

Jessica M. Libertini holds advanced degrees in both engineering and applied mathematics. She has served as Senior Engineer at General Dynamics, National Research Council Fellow at the US Military Academy at West Point, and Science & Technology Policy Fellow in the Office of the Secretary of Defense. She is currently an Associate Professor at Virginia Military Institute. She became involved with the MCM/ICM in 2008, and she has been a final head judge since 2014.


Eleanor Ollhoff studied at the University of Tennessee and has a background in undergraduate mathematics instruction and pedagogy and also in pure mathematics (low-dimensional topology and differential geometry). She has taught in the mathematics departments at Appalachian State University, the University of Tennessee, and the US Military Academy at West Point. Eleanor has been a triage judge for the ICM since 2014, and she has been on the final judging panel for three of the past four years.

Troy Siemers has his Ph.D. in Mathematics from the University of Virginia. He has worked at the Virginia Military Institute in the Dept. of Applied Mathematics since 1999 and since 2010 as department head. He has been a triage judge for ICM for several years and a finals judge for two years, and has taught the VMI senior capstone course, which is based on preparing for the ICM. He has broad interests, having conducted research with faculty in the Economics & Business, Physics, Psychology, Chemistry, and Applied Mathematics.