Mesoamerican Reef Alliance - ICRAN-MAR

Workshop on Watershed Management, Land Cover Change Analysis, and Modeling of Land-based Sources of Pollution and Sediment Discharge to the MAR

Proceedings

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List of Acronyms

BMP	Better Management Practices
CATHALAC	Water Center for the Humid Tropics of Latin America & the Caribbean
CLUE-S	The Conversion of Land Use and its Effects
DEM	Digital Elevation Model
GIS	Geographic Information System
IABIN	Inter-American Biodiversity Information Network
ICRAN-MAR	Mesoamerican Reef Alliance
INEGI	Instituto Nacional de Estadística, Geografía e Informática, México
JICA	Japan International Cooperation Agency
LAC	Latin America and the Caribbean
LU/LC	Land use/Land cover
MAR	Mesoamerican Reef
MBRS	Mesoamerican Barrier Reef System
N-SPECT	Nonpoint Source Polution and Erosion Comparison Tool
SeaWifs	Sea-viewing Wide Field-of-view Sensor (SeaWiFS)
SERVIR	Mesoamerican Regional Visualization and Monitoring System
SIDA	Swedish International Development Cooperation Agency
SRTM	Shuttle Radar Topography Mission
UNEP	United Nations Environment Programme
UNF	United Nations Foundation
UNFCCC	United Nations Framework Convention on Climate Change
USAID	U.S. Agency for International Development
USGS	U.S. Geological Survey
WCMC	UNEP World Conservation Monitoring Centre
WRI	World Resources Institute
WWF	World Wildlife Fund
WRIScS	Watershed-Reef Interconectivity Scientific Study

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INTRODUCTION

ICRAN-Mesoamerican Reef Alliance (ICRAN-MAR)

The International Coral Reef Action Network (ICRAN), was established in the year 2000 as an innovative and dynamic global partnership of many of the world's leading coral reef science and conservation organizations. It is a collaborative effort that operates at different levels to help to stop and reverse the decline in health of the world's coral reefs. ICRAN partners create alliances around the world to facilitate inter-linked and complementary actions in reef monitoring and management, at local, national, and global scales.

In the ICRAN Mesoamerican Reef Alliance (ICRAN-MAR), several partners have come together in a three-year initiative to support regional efforts in response to the Tulum Declaration of 1997 for the conservation of the Mesoamerican Barrier Reef (Mexico, Belize, Guatemala, and Honduras). With the kind contribution of the United States Agency for International Development (USAID), and the United Nations Foundation (UNF), and under the overall supervision of the United Nations Environment program (UNEP), the ICRAN-MAR Alliance seeks to develop and facilitate innovative tools that promote the voluntary adoption of best management practices in the areas of Tourism, Fisheries and Watershed Management. The project therefore, offers a holistic approach that recognizes the strong relationship between these three components and their potential impact on the health of the Mesoamerican reef, and promotes and seeks cooperation with other institutions and initiatives in the region.

The Watershed Management component of the ICRAN-MAR project was designed recognizing that appropriate land use practices are critical for proper management of watersheds in the Mesoamerican region, and to ensure that transport of sediment, nutrients and other pollutants to the coral reef system is minimized. Developing appropriate land use strategies requires gathering information on the potential impact of different land use and development options in the region, as well raising awareness and coordination with the different stakeholders.

ICRAN-MAR partners in the Watershed Management component contribute to these regional efforts by forming alliances with the private sector to reduce the impact of agricultural activities on the reef, and by developing innovative Geographic Information Systems tools that can be used to simulate watershed dynamics and inform decision makers in the Mesoamerican region.

With respect to the GIS tools, the work of the ICRAN-MAR project is complementary to the ongoing and past work of other regional initiatives such as the MBRS, SERVIR and IABIN-DGF projects. It is the first to engage a regional-scale analysis and spatial modeling of the environmental impacts of watersheds on the Mesoamerican Reef. This work also builds on the World Resources Institute's *Reefs at Risk of the Caribbean* initiative.

The current proceedings summarize the dynamics and outcomes of a successful workshop held in San Ignacio, Belize in August 2006, in which project partners presented the results of two years of project implementation and requested feedback from regional experts.

Watershed Management Workshop

The objectives of the meeting were twofold: inform regional participants of the land use modeling results and the initial findings for the region, and train regional GIS technical experts who could in turn become trainers of other experts in their particular countries.

The workshop was divided in two sessions: a Policy Session and a Technical Session. The policy session was geared towards senior managers and decision makers of participating institutions; its main objective was to help them understand the usefulness and applicability of the data products and models developed by ICRAN-MAR for watershed management. This session lasted for one and a half days and took place on August 15th and the morning of August 16th.

The technical session's objective was to allow specialists from participating countries to become familiar with and get hands-on training in the use of the data products and models aforementioned. This session lasted for two and a half days and took place on the afternoon of August 16th, and on August 17 th and 18th.

Both sessions provided a great opportunity for national specialists to acquire new technological knowledge, coordinate activities, plan their modeling efforts, exchange experiences with colleagues from other countries, and acquire geospatial information developed or collated by ICRAN-MAR.

The following sections provide an overview of the contents, results, discussions and resolutions attained in the course of the two sessions of the workshop.

POLICY SESSION

The Policy Session was held on August 15 and the morning of August 16, 2003, at Galen University in San Ignacio, Belize (see workshop agenda in Appendix 1).

Senior staff and specialists from national and regional institutions that deal with marine and coastal issues attended the meeting (see list of participants to policy session in Appendix 2).

The objectives of the policy session were the following:

1) Inform policy makers and other potential information users of the information outputs and tools that have been developed under this project.

2) Learn about the ICRAN MAR watershed project and the analytical components on land cover change analysis, watershed delineation, hydrologic modeling and circulation modeling.

3) Review scenarios of land cover change and provide feedback on these scenarios.

4) Review results of predictive modeling of land-based sources of pollution and sediment discharge to the Mesoamerican Reef

5) Raise awareness of the linkages between human activities on the land and threats to the Mesoamerican Reef.

6) Identify policy questions/applications for the analytic tools, as well as future users of the analytic tools.

During the morning of August 15 an introduction to the ICRAN-MAR project and the role of its partners in the watershed component was offered, together with the following keynote presentations:

Health of Corals and threats to the Mesoamerican Reef (by Melanie McField)

Dr. McField gave a thorough presentation on the most pressing threats (dredging, tourism, aquaculture-overfishing, poor port management and shipping, climate change, and natural disasters) to the Mesoamerican Reef (MAR). She discussed the concept of a "healthy" reef and the different reef attributes (structure and function) and human dimensions (drivers of change, social well being, and governance) that must be taken into account when defining the level of disturbance (i.e. health). Eventually we need to make use of the reef resources and we need to identify the best ways to do so.

Conceptual evolution of watershed management in the Mesoamerican Region (by Carlos Rivas)

Dr. Rivas presented the evolution of the watershed management efforts in the region during the last 20-30 years. He began by introducing the topographic characteristics of the region and the socio-economic drivers that have defined regional development models, and the traditional agricultural uses of the land. Extractive economy, poverty and expansion of the urban and agricultural frontiers have caused changes in the landscape and the watershed dynamics over the past decades. The need to control flooding and guarantee the provision of water resources to cover the increasing needs of the population and industry led to the early watershed management efforts imported from developed countries to the region. With time, there has been a shift from anthropocentric ('rational/economic') to more biocentric ('sustainable') rationales when developing strategies to manage watersheds. With this shift in mentality, the social component is included and participatory planning is encouraged; however, the strategies are not always economically attractive and very often conflicts arise. There is a generalized need for more government support and development of coherent policies for the sustainable use of the water resources.

Following the keynote presentations, Joep Luijten (UNEP-WCMC) and Lauretta Burke (WRI) respectively offered an overview of the different methodologies and results in land use change and hydrologic modeling[1]; immediately afterwards, Jose Vasquez (WWF) presented results of the on-the-ground work with agricultural companies for the adoption of better agricultural practices.

Overview of scenario development (by Joep Luijten)

Joep Luijten began his presentation by explaining the concept and descriptive nature of the scenarios, and how they can inform policies. Scenarios are not predictions of the future, but rather present "different assumptions about how current trends will unfold, how critical uncertainties will play out and what new factors will come into play" (UNEP, 2002). The 3 scenarios developed for this project were adapted from the Global Environment Outlook 4 scenarios for LAC that will be released in 2007. These scenarios looked at the current regional situation of the natural resources and

[1] Please refer to the Workshop Data CD for detailed documentation on the development of the scenarios, land use change modeling, and hydrologic and circulation modeling.

the potential situations by 2025 under three hypothetical world-wide and regional situations (Markets First, Policy First, and Sustainability First). These scenarios would have different impacts on the socio-economic and natural dimensions of the region and could serve to influence decision makers.

Overview land use change modeling (by Joep Luijten)

Once the descriptive scenarios were developed, a multi-scale modeling approach was applied to quantify the potential changes in land cover in the MAR. Three models were utilized (International Futures, IMAGE, and CLUE-S) to explain the dynamics of the different variables involved in land cover change processes. Thus, the *International Futures* model estimates the proportion of regional land use change that occurs in each country, and provides socio-economic drivers to the *IMAGE* model. *IMAGE* in turn, is a global integrated assessment model that simulates the rate of change in the region, and the proportion of change that occurs in each land use type.

CLUE-S is the land use change (allocation) model and adds a spatial dimension that simulates where land cover change occurs within the MAR region.

For quantification of the changes in land demand under each scenario the year 2000 was used as the base year because that was the year for which the latest land cover data were available for most countries.

Overview of Hydrologic and Circulation Modeling for the MAR (by Lauretta Burke)

Lauretta Burke began her presentation highlighting that the purpose of this analytical modeling exercise of the ICRAN-MAR was to model present and future impact of land cover change and agricultural activities on coral reefs and identify land most vulnerable to erosion. The outcomes of the modeling exercises could eventually guide stewardship of vulnerable areas in the region. Likewise, the project sought to identify tools and a methodology that could be easily be transferred to analysts and land stewards in the MAR region for more detailed local application.

The first step in this exercise was to delineate the watershed for the region. Basins were delineated from 90m resolution NASA SRTM data and 300 basins (of 5 km^2 minimum size) were identified within the MAR region. This exercise took several months and was especially difficult for the Yucatan peninsula due to the geological characteristics of the terrain and the presence of underground rivers. She invited participants to provide inputs to improve the accuracy of the delineation.

The following step was to run the "Nonpoint-Source Pollution & Erosion Comparison Tool" (N-SPECT) to evaluate sediment and pollutant delivery into coastal waters. The N-SPECT model, developed by NOAA, is in the public domain and is easy to run in ArcMAP. N-SPECT provides estimates of erosion across the landscape as well as sediment and pollutant (N and P) delivery and concentrations at the river mouths.

Using the land cover scenarios from CLUE-S, coupled with the N-SPECT hydrologic model, sediment and pollutant delivery at 300 river mouths can be estimated. The University of Miami is implementing a high resolution 4-dimensional model to examine sediments and pollutants transport within the region's lagoonal system. The sediment and nutrient transport predictions will be calibrated using the SeaWifs sensor.

Lauretta commented that the hydrologic results need to be calibrated (and validated) using data from several sources. Project collaborators from Texas A&M University are taking sediment samples; WWF is taking sediment samples and is looking at

bioaccumulation of toxics in reef organisms. AGRRA reef assessments will be used to examine the location of sediment impacts on coral reefs. She discussed the limitations of the analysis and invited workshop participants to make recommendations for data to calibrate the model.

Results of Hydrologic and Circulation Modeling (by Lauretta Burke)

Keeping all inputs but land cover equal, WRI produced estimates for the present day and future scenarios of accumulated runoff, as well as accumulation and concentration of sediment, nitrogen, phosphorous, and total suspended solids. Annual model runs were implemented for current land cover, hypothetical natural land cover, and the three 2025 scenarios for the MAR region. Analysis of results allowed the identification of those areas with the highest sediment and nutrient delivery, and of how much sediment and nutrient delivery has increased due to human activities. It was also possible to see the influence that future land cover might have on sediment and nutrient delivery, as well as the areas that are the most vulnerable to erosion, and which parts of the MAR are affected by sediment and nutrients. Maps and summary tables were presented, and later discussed with workshop participants.

Activities with Agribusiness for the adoption of Better Management Practices (BMPs) (by José Vasquez).

José Vasquez presented the efforts WWF is leading in the region to raise awareness and persuade agricultural companies into the adoption of BMPs. He began by highlighting that agrochemicals (fertilizers and pesticides) are known for their effect on global reef health. In 2004 WWF conducted a preliminary monitoring analysis to identify the levels of toxic substances in marine organisms and identified the need to reduce the presence of particular 'priority' pesticides in the MAR. To accomplish this, and to control soil erosion, they have engaged in conversations with some of the major agricultural companies in the region, and are currently developing partnerships for the adoption of BMPs in banana, citrus, palm oil, pineapple and sugar cane crops. Based on the preliminary results presented by WRI and WCMC, WWF will select a pilot watershed to collect specific data to validate the models, and to pursue the implementation of BMPs.

In the afternoon participants broke into four national groups (Honduras, Belize, Mexico, and Guatemala) to review the modeling results by country Each group presented a summary of their observations and suggestions at the plenary session in the morning of August 16 (see summaries in the following section).

Data dissemination through the Mesostor portal (by Emil Cherrington)

During the morning policy session on August 16, the representative from the Water Center for the Humid Tropics of Latin America & the Caribbean (CATHALAC) presented briefly on how the ICRAN-MAR Project's data and information products will be disseminated through the USAID-supported Regional Visualization & Monitoring System (SERVIR) at: http://servir.nasa.cathalac.org or http://servir.nsstc.nasa.gov. Mr. Cherrignton mentioned that the MAR data will be added to the variety of public domain spatial datasets and satellite imagery already available through SERVIR for the Mesoamerican region. As such, long after project completion, researchers and decision-makers will continue to have access to the rich database developed by the ICRAN-MAR Project regarding land-based impacts on the Mesoamerican Reef

ecosystem. With regard to synergies between these two USAID-supported initiatives, SERVIR and the ICRAN-MAR Project have collaborated on data development, and SERVIR representatives provided technical support during the August 2006 Regional Watershed Modeling workshop in Belize.

During the discussion session, Dr. Barbara Best – Coastal Resources and Policy Advisor for the Office of Natural Resources Management with USAID, and Cognizant Technical Officer for the ICRAN-MAR Alliance – presented on opportunities for partnerships within the region and on a broader spatial scale. In particular she described the USAID Global Development Alliance, which works through public-private partnerships, and the Central America Free Trade Agreement (CAFTA), through which Central American countries could access financial support for follow-up activities in the region. She highlighted the emphasis these initiatives give to capacity building efforts, water issues, and tourism, and encouraged participants to communicate the results of this workshop's discussions to their governments and seek additional funding for capacity building. As another opportunity for capacity building Dr. Best recommended linking US Universities with local Universities.

SUMMARY OF BREAKOUT GROUP REVIEWS

BELIZE

1. The watershed boundaries look good, but must be re-drawn to reflect the 18 major watersheds of Belize. Small coastal watersheds must be merged with larger ones rather than leaving them out.

   Note: In response to this, Lauretta Burke mentioned that N-SPECT calculates using much larger watersheds, with the smaller coastal watersheds being merged, though she emphasized that these larger watersheds are incorrect because they reflect the combined catchments of multiple rivers that drain into the sea.
2. N-SPECT outputs need to be explored further / validated.
3. Land Use scenarios – the group would like to know more about how the scenario narratives were translated to IMAGE 2 outputs.
4. Numerous possible applications of project outputs exist (e.g. overall land use planning, reporting to UNFCCC).
5. The results are good and reveal worthwhile / critical investment of effort.

MEXICO

1. Model validation is necessary and accurate data is missing. Mexican colleagues encourage workshop participants to develop a campaign to collect field data to calibrate the models.
2. A legend should be added to the maps to clarify that the results are estimates. Mexican participants can contribute recent national data to jointly validate the models.
3. Some aspects of the N-SPECT and CLUE-S methodologies are not clear in particular with respect to concepts and variables. For example, it is not clear what were the criteria to reduce the LU/LC classes in the GEO scenarios.

4. Meteorological sporadic or extraordinary events should be incorporated into the N-SPECT model. Evaluate the possibility to run the model for different time periods (e.g., quarterly, monthly).
5. The Markets First and the Policy First scenarios showed similar results. Evaluate if a new or intermediate scenario can be created. The scenarios for a 25-year period don't show drastically different results.
6. The Yucatan Peninsula should be treated as a special case in the N-SPECT model since its underground water flow is difficult to estimate. The Mexican group estimated that the preliminary model results are not representative of the real flow dynamics and should be taken out of the maps (or highlighted as preliminary). Need to incorporate the results of the JICA study on underground water flow into N-SPECT (when it becomes available).
7. The N-SPECT model does not show "real" results for Yucatan and can lead decision makers to judge that the sediment and pollution flow to the MAR is not significant.
8. Keep in mind that the Yucatan peninsula does not suffer from what is normally termed as soil erosion. Instead, if suffers from dissolution of the bedrock due to soil characteristics.
9. Consider including higher resolution data for the Rivera Maya to pinpoint the effects of large coastal developments (e.g., Cancun, Playa del Carmen).
10. Consider the development of a special N-SPECT model only for the Yucatan Peninsula.

GUATEMALA

1. First impression of the work is very good, but there is the need to incorporate more detailed data and national datasets.
2. It is essential to calibrate the model and adjust its variables.
3. Results seem logical, but are they significant?
4. Recommendation to look at extreme events, not necessary a second Hurricane Mitch, but something more dramatic than the monthly and annual data that the models have used. Looking at rainfall events could be a good first step.
5. Recommendation to create maps that better illustrate the differences between the scenarios. This is not clear from the maps presented, though maps highlighting the differences are presented in the CLUE-S technical report on the training CD.
6. Further information is needed about the assumptions that were made and restrictions of the models/methodologies. Joep Luijten mentioned that for CLUE-S some information of this nature can be found in the technical report on the training CD.
7. It must be made clear that if two scenarios show the same percentage land cover for a particular land use type, there could still be significant differences in the spatial distribution of land use. Thus, just having a table that lists the percentages of area covered by each land use type is misleading.
8. Need to include socio-economic variables in the models. For example, if the area of forest decrease with 5%, what is the $ value of the change? How much do the changes affect tourism?
9. Largest differences on forest and cropping. Application is useful for sustainable forest management and integrated watershed management.

HONDURAS

1. The delineation of watersheds looks good but small coastal watersheds should be merged with larger adjacent ones so that the overall delineation better matches the country's official watersheds.
2. Would like to see a method to include dams in the model. At present there is a hydro-power dam in the Ulua watershed and the Honduras team will be interested in calculating the accumulation of sediment behind the dam. How could this variable (i.e. existence of dams) be incorporated into the model?
3. Results will help the team prioritize areas where reforestation programs and soil conservation programs could take place.
4. The results are valuable for decision-makers in both the private and public sector. This would be an excellent tool for the land-use planning that recently started in Honduras.
5. Work collaboratively at the regional level to promote the use of the same GIS technologies for better management of natural resources.
6. The datasets and products provided by ICRAN-MAR in the workshop are not final; instead they should be viewed as intermediate products that need to be refined at the national level to provide scientific information useful for decision-making.
7. The model should include socio-economic data that can be presented to decision makers.
8. Participants should reach a formal compromise whereby they agree to apply and improve the models provided in accordance with the local capacities and existing informational needs.
9. Need to work at higher resolutions: 90 or 30 meters. It should be noted that such small resolution are not practical when the models are applied to a country or the MAR region as a whole because the required simulation times would be far too long.

DISCUSSION AND RECOMMENDTATIONS

The policy session ended with a two-hour review, conducted by the whole group, on the ICRAN-MAR watershed component and the workshop results and follow-up activities; it centered on the need to inform policy makers in participating countries about the results of the ICRAN-MAR exercise, and on the need to provide follow-up support to agencies that decide to use the models and datasets produced by the watershed component of ICRAN-MAR.

A summary of the main issues raised during the review follows:

- **Results are useful for some specific purposes.** The MAR-drainage-wide watershed analysis was regarded as ambitious. Participants recognize the amount of effort that went into the analysis; appreciate the region-wide comparable results; but recommend that the results be shared with instructions about appropriate and inappropriate use. These are estimates of sediment and nutrient delivery from coastal watersheds given current land cover and given several scenarios of future land cover.
- **Scenario results are not that different:** Differences between the scenarios are not large; most participants had expected to see greater contrasts. This could be related to the relatively short time period (2000-25) or be because the scenarios

are too general and are unable to adequately reflect critical changes that appear on a local level or in the immediately coastal areas.

- **Model results need to be validated.** There is a need to better calibrate the models and validate model results. There is ongoing work with SeaWifs (with the University of Miami) and there are data from the WRISC project that can be used to evaluate the estimates for several watersheds. WRI asked participants to provide data for validation.
- **Information can influence policy.** A participant asked how ICRAN-MAR can use results to preserve forests. Lauretta Burke responded that having a good, integrated information infrastructure (to support sound spatial analysis) and having channels to decision-makers is key.
- **Local application of modeling tools will produce the most useful, detailed results.** Technology transfer and capacity building is an important part of the workshop. Participants will be able to use local data (as inputs and for validation), and therefore can do more detailed analysis and obtain more accurate results back in their agencies.
- **Results are not final:** The analysis results are not a final product. ICRAN-MAR needs to build capacity to use the models offered during the workshop within the region, so that people can use local information to refine results and validate the modeling.
- **Extreme Events.** The N-SPECT modeling focused on mean annual precipitation. Extreme events such as hurricanes and tropical storms are the major source of sediment. It would be valuable to model extreme events and the seasonality of discharge.
- **Clarification on N-SPECT Units.** The MBRS representative thought that the N-SPECT model outputs were "relative" and not in meaningful units. WRI's experience is that N-SPECT output is in liters for discharge and kilograms for sediment and pollutants.
- **Basin Delineation style.** There was some discussion of the MAR basin delineation, focusing on the small coastal watersheds. Many participants would prefer to have these small watersheds lumped into the larger, adjacent basins. WRI cannot do such lumping, as it would be inconsistent with hydrologic flow within the DEM. However, N-SPECT uses an algorithm that does merge small adjacent watersheds. These results are provided on the data CD.
- **Yucatan.** WRI acknowledged that the basin delineation for the Yucatan is not very good due to underground rivers and few perennial surface rivers. The group from Mexico also pointed out this limitation, and mentioned that JICA is now working on estimating underground water flow. As policy-makers will dismiss the Yucatan results, they encouraged WRI to consider excluding the basins in the Yucatan from the results, or issue strong and appropriate disclaimers about the problems with the model in the Yucatan.
- **Scenario results.** The analysis of change in sediment between natural and current land cover is striking and clearly shows the extent of human impact. The results of the N-SPECT modeling for the three future land cover scenarios, however, do not look very different. This is because

a) the land cover scenario data sets are not so extremely different

b) the results are presented at the basin-level. WRI can explore presenting them at the sub-watershed level.

- **Management Practices.** Due to the lack of regional data on agricultural crops and the fact that the management practices module of the N-SPECT model is not yet implemented, WRI's analysis focuses on the impact of land cover change on sediment and pollutant delivery. It would be very valuable to include management practices in the model in the future.
- **Dams.** Some participants asked WRI to look into the possibility of incorporating dams into the N-SPECT model as a sediment trap. WRI will research the issue further.
- **Relevance of Results to Policy.** There was discussion of the difficulty of moving from analysis results to changes in policy. The inclusion of socio-economic values was encouraged.
- **Erosion monitoring.** WWF is monitoring soil erosion on citrus, palm oil and sugar cane plantations. This data would be very valuable if WRI could, under a future project or future project phase, attempt to include different crops and management practices in the hydrologic analysis.
- **Economic Valuation.** Several participants encouraged including economic variables in the results, such as the value of lost soil, lost agricultural productivity, and damage to coral reefs. The models are very technical and the simulation results are very scientific. It is essential to make this information more accessible to decision-makers by adding monetary values to some of the results.
- **National datasets:** Participants pointed out that for some countries (and for certain regions inside countries) there are newer or more detailed datasets that could be incorporated into future versions of the models.
- **Running models at a smaller scale.** The models should be run at higher resolutions (30 meter or 90 meter) when operated in the countries. The Mexican participants highlighted the need of more detailed models for coastal areas to analyze the impact of coastal development (e.g., new golf courses, hotels).
- **Land use demand for scenarios.** Participants expressed the desire for more details about the use of the International Futures and IMAGE models for calculating the future demand (i.e., area) for each land cover type and why we chose to use these models. As these models were not covered during the training, participants wanted to know whether they could deploy these models themselves to analyze different parameters (e.g. different population growth rates). What alternative methods are available for calculating land demand?
- **Explanatory factors (location factors).** Participants struggled with the concepts and practical application of the explanatory factors (location factors) that were used as part of the land use modeling methodology. This is arguably the most complicated part of the CLUE-S model development. Participants wanted to know whether they could include additional location factors.
- **Land Cover Validation.** Participants asked whether the land cover data had been validated by WCMC. No validation was undertaken. It should be noted that WCMC used well-known land cover data from reputable sources. The Ecosystem

Map datasets were created as part of a multi-year, multi-partner effort. Validation of these third-party datasets was not part of the project plan.

- **Follow-up activities**. Participants expressed their desire to be part of a group that helps move this work forward. A participant mentioned that existing national groups dealing with water issues or geospatial issues could lead this task.

TECHNICAL SESSION

The technical session was held at the GIS lab of Galen University on the afternoon of August 16 and on August 17 and 18. Twenty-two participants from Honduras, Guatemala, Belize, and Mexico attended (see the list of participants in Appendix 3).

The objective of the technical session was to provide hands-on training so that participants can carry out their own watershed analyses in the future. Training was provided in hydrologic modeling using ArcMAP GIS, the Nonpoint Source Polution and Erosion Comparison Tool (N-SPECT) and the CLUE-S models, and as well as guidance on datasets developed by the watershed component of the ICRAN-MAR project. These tools allow users to delineate watersheds; model runoff and sediment and pollution loads at river mouths across the region, and simulate land use changes under alternative scenarios. SERVIR Viz software was also distributed to participants by Emil Cherrington on behalf of the Mesoamerican Regional System for Visualization & Monitoring (SERVIR), hosted at CATHALAC, Panama.

During the first component of this session (afternoon of August 16) Lauretta Burke (WRI) explained and conducted an exercise on how to delineate watersheds using the SRTM 90-meter dataset and Spatial Analyst tools available in ArcMAP. A detailed explanation of how the MAR watersheds were delineated was offered. In addition, Lauretta guided an exercise on evaluating the vulnerability of land to erosion (on a grid cell basis).

On August 17 Zachary Sugg (WRI) led a training session on the use of the N-SPECT model for estimating river runoff and sediment and pollutant loads. Participants ran the model using different land use scenarios for several MAR watersheds. WRI gave each participant a CD containing the model software, the results of running N-SPECT for different land use scenarios for the MAR region, and the complete MAR watershed delineation, together with a wide array of white papers and background documents that provide in-depth information about the model.

On August 18 Joep Luijten (WCMC) gave training in land cover change modeling using the CLUE-S model. First he introduced the model and the different types of input parameters and the datasets that define different scenarios. Much of the day was spent in hands-on exercises. Initially a small sample dataset was used that allowed the participants to rapidly become familiar with the model's user-interface and analyze the effects of changes in selected model parameters. In the afternoon participants looked at some more advanced model features and worked with the complete dataset for Belize. Joep provided to participants a CD that contained the CLUE-S model software, the complete datasets for Belize, Mexico, Guatemala and Honduras, the MAR GEO scenario results (25 year period), and background materials.

An evaluation sheet presented to participants can be found in Appendix 4, and a summary of the results of the evaluation in Appendix 5.

Participants also filled out another questionnaire designed to help ICRAN-MAR evaluate what type of follow-up activities are useful and can be supported by the project. Most participants clearly identified a need for additional training/outreach in the MAR countries, in the short term, at two different levels:

- **LEVEL 1. Training/outreach seminars for managers and decision-makers**: Participants recommended the organization of seminars targeted at managers and decision makers on the basic functionality and the usefulness of the models, emphasizing how their results can be incorporated into decision-making. The models should be tested using local and national data - at high resolutions – in order to improve their results and facilitate their use in the national context.

- **LEVEL 2. Technical training for GIS and ICT specialists**: Responses to the questionnaire also clearly show that the countries could benefit from additional in-depth training in the models. Participants requested additional training that will reach a broader group of specialists on each country.

The following general recommendations were also offered by the technical group:

- Offer additional and more in-depth training on the CLUE-S and N-SPECT models that incorporates:
    - the use of national and local datasets,
    - detailed explanations of the parameters used,
    - a review of the methodologies used for the creation of the model input datasets.
- Increase efficiency of the training by offering train-the-trainers workshops, where national specialists learn the basic operation of the models and are able to conduct seminars geared towards decision-makers.
- Support remote technical assistance to participants who implement the models in order to support their use in real scenarios.
- Assist in the creation of a technical users' group whose core will be formed by workshop participants. The group can offer its members basic technical assistance and support on the use of the models provided in the workshop. ICRAN-MAR could support it with seed funding needed to start its operation.

WCMC and WRI will evaluate the feedback received from participants, will contact participants to ascertain their current needs, and will design and conduct follow-up activities to the extent possible with remaining ICRAN-MAR funds during the first semester of 2007.

The follow-up evaluation sheet presented to participants can be found in Appendix 6, and a summary of the results of the evaluation can be found in Appendix 7.

APPENDIX 1. Workshop Agenda

PART 1: POLICY WORKSHOP

Policy Workshop on Land-based threats to the Mesoamerican Reef (Duration: 1.5 days)

Goals:

1) Inform policy makers and other potential information users of the information outputs and tools that have been developed under this project.
2) Learn about the ICRAN MAR watershed project and the analytical components on land cover change analysis, watershed delineation, hydrologic modeling and circulation modeling.
3) Review scenarios of land cover change and provide feedback on these scenarios.
4) Review results of predictive modeling of land-based sources of pollution and sediment discharge to the Mesoamerican Reef
5) Raise awareness of the linkages between human activities on the land and threats to the Mesoamerican Reef.
6) Identify policy questions / applications for the analytic tools, as well as future users of the analytic tools.

Day 1 - Tuesday August 15 *(All-day Policy Workshop)*

Facilitator: *Eric Van Praag,*

08:30 Registration

09:00 National Anthem

09:03 Invocation. *Father Kevin Nederman at the Sacred Heart Parish*

09:05 Opening remarks, introduction to the ICRAN-Mesoamerican Reef Alliance (ICRAN-MAR Project). *Liza Agudelo, Project Coordinator*

09:10 Workshop goals, introductions of participants and organizers. *Eric Van Praag, UNEP-WCMC Consultant*

09:30 Key note presentation: Health of Corals and threats to the Mesoamerican Reef. *Dr. Melanie McField, Healthy Reefs Initiative.*

09:50 Key note presentation: "Conceptual evolution of watershed management in the Mesoamerican Region". *Dr. Carlos Rivas, Senior Advisor for Mesoamerica, Swedish International Development Cooperation Agency (SIDA).*

10:10 Overview of the Watershed Theme (Component) of the ICRAN-MAR project. *Lauretta Burke, World Resources Institute*

10:20 Coffee/Tea Break

10:40 Overview of scenario development. *Joep Luijten, UNEP-WCMC*

- Scenario studies with regional land use change modeling
- Adaptation of GEO-4 scenarios for the MAR region; storylines
- Discussion/feedback

11:20. Overview land use change modeling. *Joep Luijten, UNEP-WCMC*

- Quantification of change in land demand (IFS, IMAGE models)
- Modeling the allocation of land over time and space (CLUE-S model)
- Model results. Changes in land use distribution over time.
- Discussion/feedback

12:15 Lunch

13:15 Overview of Hydrologic and Circulation Modeling for the MAR. *Lauretta Burke, WRI*
- Watershed delineation
- Vulnerability analysis
- Hydrologic analysis using N-SPECT
- Circulation modeling
- Model calibration

14:00 Results of Hydrologic and Circulation Modeling. *Lauretta Burke, WRI*
- How much has sediment and nutrient delivery already increased due to human activities?
- Which coastal areas are most heavily impacted at present?
- How much is sediment and nutrient delivery likely to increase under future scenarios?

14:30 Review of results by participants
- Review of watersheds
- Review of sediment and nutrient delivery estimates
- Discussion

15:15 Coffee/Tea Break

15:40 Results from activities with Agribusiness for the adoption of Better Management Practices. *Jose Vasquez, WWF Honduras*

16:00 Group Discussion. Four country breakout groups to:
- review of land cover change scenarios and hydrologic model results;
- discussion of potential policy applications of the modeling tools;
- discussion of alternative pathways of development for region

17:30 Close for day

Day 2 - Wednesday August 16 *(Policy Session - morning only)*

09:00 Brief review of modeling results from previous day

09:15 Plenary:
Feedback from break groups (in open discussion format) on:
- utility and validity of the land cover scenario modeling;
- utility and validity of hydrologic / sediment transport modeling

10:00 Discussion
- policy applications of these tools
- alternative pathways for development in the region

10:30 Coffee/Tea Break

10:45 Introduction to the Data CD and data products

11:30. Closing Discussion

12:00 Lunch

PART 2: TECHNICAL WORKSHOP

Technical workshop on land cover change modeling and hydrologic modeling for different scenarios for the Mesoamerican Reef (Duration: 2.5 days)

Goals:

1) Learn how to delineate basins (watersheds) from digital elevation data

2) Learn how to use ArcMAP Spatial Analyst to identify land most vulnerable to erosion.
3) Learn how to use the Nonpoint Source Pollution and Erosion Comparison Tool (N-SPECT) extension to evaluate the impact of land cover change on sediment and nutrient delivery to the coastal zone.
4) Understand how to perform a statistical analysis of explanatory factors of land use patterns, and the different data that must be collected and prepared.
5) Learn how to install and use the CLUE-S model for analyzing different scenarios of land cover change (for this data for a smaller area will be used)
6) Learn how the data collection, data preparation and the use of the model as it been done for the MAR region, country by country, and review results.

Day 2 (Wednesday August 16) *(Technical session - afternoon only)*

Overview and Watershed Delineation

13:30 Overview of Model Components \ Program and Workshop Goals.
a) Models and associated software
b) Order of analysis
14:00 Introduction to Data CD for MAR region
14:30 Watershed Delineation (using Spatial Analyst)
- Includes discussion of Sinks, flow direction and flow accumulation, "burning of rivers," delineation of basins, identification of pour points
- Prepare DEM for later use in N-SPECT delineation

15:30 Break

15.45 Spatial Analysis Erosion Vulnerability Analysis (using Spatial Analyst)
- Derive slope;
- use map calculator to combine grids to map relative vulnerability to erosion
- Summarize by watershed

17:30 Close for day

Day 3 - Thursday August 17 – Erosion and Pollution Modeling using N-SPECT

9:00 Introduction to N-SPECT
a. Overview of the N-SPECT modeling Tool
i. Capabilities / Functions
ii. RUSLE
iii. Where data and outputs live
iv. Processing time estimates
10:00 Watershed Delineation Using N-SPECT
b. Preparing the DEM
c. Options
d. Exercise on watershed delineation
11:00 Erosion and pollution analysis using N-SPECT
e. Data requirements
f. FACTORS
g. Options
h. Outputs

12:00 Lunch

13:00 Exercise on erosion modeling
14:00 Exercise on Local Effect modeling (RUSLE)

Break

15:00 Exercise on pollutant modeling
16:00 Discussion on implementation of other scenarios

17:00 Close

Day 4 (Friday 18th August) - Land cover change modeling and the CLUE-S model

09:00 Introduction to land use change modeling and the CLUE-S model
- Different types of land use change models
- History and applications of CLUE-S in the world
- CLUE-S model structure and key input files
- Separate regression analysis of driving factors in SPSS

10:00 Introduction to case study area (Sibuyan island, Philippines)

10:15 Break

10:30 Practical CLUE-S
- System requirements and installation. Demo *vs.* full version
- Exercise 1: Learning to know the user-interface and displaying results.
- Overview of input data files and model parameters files
- Exercise 2: Parameter files and simulating alternative scenarios

12:00 Lunch

13:00 Practical CLUE-S (continued)
- Regression equation parameters files and probability surfaces
- Land use conversion matrix and conversion sequences
- Creating land use requirement (demand) files
- Spatial policies and area restriction files
- Conversion elasticities and crop rotations
- Exercise 3: Creating new area restriction and land requirement files

14:30 Background on the MAR land use change scenario simulations, and CLUE-S data sets for Belize, Guatemala, Mexico and Honduras
- Separate data and simulation per country
- Calculation of the land demand for different scenarios
- Dynamic and static driving factors; protected areas data

14:45 Break

15:00 MAR simulations, continued
- Regression equations and probability surfaces
- Exercise 4: Working with actual scenario data for Belize

16:30 End

APPENDIX 2. Policy Session Participants

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APPENDIX 3. Technical Session Participants

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APPENDIX 4. Technical Session Evaluation Sheet

EVALUACIÓN DEL TALLER
Proyecto ICRAN-MAR

Taller sobre Manejo de Cuencas, Modelaje de Escenarios de Cambio en la Cobertura Terrestre y Modelaje de Descarga Hídrica de Sedimentos y Nutrientes

San Ignacio, Belice, 15 – 18 de Marzo de 2006

Agradecemos su tiempo para responder algunas preguntas que nos permitirán mejorar aspectos del curso y evaluar su impacto. Utilice la siguiente escala de valores para responder a las preguntas:
[1 = muy pobre, no adecuado, no útil, 5 = muy bueno, muy buena capacidad, muy útil]

1. El curso
Marque con un círculo el valor de su respuesta

¿Qué tan útil resultó el taller para Ud.?	1	2	3	4	5
¿Fueron valiosas las presentaciones de la Sección de Políticas?	1	2	3	4	5
Las sesiones teóricas fueron:	1	2	3	4	5
Las sesiones prácticas fueron:	1	2	3	4	5
El nivel de los instructores fue:	1	2	3	4	5
La calidad del entrenamiento fue:	1	2	3	4	5
¿Fue el curso compatible con sus intereses, conocimiento previo y responsabilidades laborales?:	1	2	3	4	5
¿Qué tan útil fue el entrenamiento en CLUE-S?	1	2	3	4	5
¿Qué tan útil fue el entrenamiento en N-SPECT?	1	2	3	4	5
¿Qué tan útil fue el componente sobre ArcMAP y herramientas hídricas?	1	2	3	4	5

2. Resultados del entrenamiento en N-SPECT
¿Ud. se siente capaz de?:

Realizar una delimitación de cuencas	1	2	3	4	5
Calcular escorrentía (runoff) y acumulación de sedimentos	1	2	3	4	5
Calcular acumulación de contaminantes	1	2	3	4	5
Calcular local effects (erosión local)	1	2	3	4	5
Utilizar sus propios datos en el modelo N-SPECT	1	2	3	4	5

3. Resultados del entrenamiento en CLUE-S
¿Ud. se siente capaz de?:

Entender los distintos datos y parámetros de entrada	1	2	3	4	5
Preparar los datos de entrada para CLUE-S	1	2	3	4	5
Visualizar los resultados de CLUE-S en un SIG	1	2	3	4	5
Preparar y comparar sus propios escenarios para CLUE-S (land demand, area restriction files)	1	2	3	4	5
Trabajar con los datos de su país contenidos en el CD	1	2	3	4	5
Calcular nuevos coeficientes de regresión utilizando software de estadísticas y el manual de CLUE-S	1	2	3	4	5

4. Desarrollo del curso
Evalúe el curso de acuerdo a los siguientes criterios

Habilidad de transmitir conocimiento de formar clara	1	2	3	4	5
Habilidad de generar interés en los temas	1	2	3	4	5
Capacidad de transmitir conocimiento sobre el modelo CLUE-S a otros especialistas	1	2	3	4	5
Capacidad de transmitir conocimiento sobre el modelo N-SPECT a otros especialistas	1	2	3	4	5

5. Recursos del curso
Ofrezca su opinión sobre los siguientes recursos

El salón de entrenamiento:	1	2	3	4	5
Los computadores:	1	2	3	4	5
El material audiovisual:	1	2	3	4	5
El material impreso:	1	2	3	4	5
El CD de entrenamiento:	1	2	3	4	5
La traducción simultánea (sesión de políticas)	1	2	3	4	5
La traducción en la sesión técnica	1	2	3	4	5

6. Agenda
Agradecemos sus comentarios sobre la agenda del curso. ¿Le pareció correcta? ¿Se cubrieron los temas con el tiempo adecuado? ¿Hay temas que se debieron dar mas a fondo o mas rápido? ¿Qué aspectos de la agenda se pueden mejorar?
(See summary of responses in Appendix 5)

7. Por favor especifique cómo los temas ofrecidos en el curso le apoyarán en su trabajo

(See summary of responses in Appendix 5)

8. ¿Piensa que usará estos modelos en el futuro? Por favor especifique su respuesta para CLUE-S y N-SPECT y el tipo de aplicaciones donde los usaría?

(See summary of responses in Appendix 5)

9. ¿Cómo visualiza que los resultados de los modelos serán presentados y explicados a tomadores de decisiones y autoridades? Favor explicar:

(See summary of responses in Appendix 5)

10. Comentarios generales:

(See summary of responses in Appendix 5)

APPENDIX 5. Summary of Technical Evaluation Results.

Question 6: Please provide comments on the workshop agenda: was it appropriate? Did it offer enough time to cover each topic correctly? Are there topics that should have been covered in more detail? Can the agenda be improved?

Summary of responses:

Responses suggested that it would be useful to:

- Provide more information on the development of the scenarios and on the generation of the model parameters.
- Have additional time (i.e., longer workshop) to cover some of the topics in more detail.
- Explain better where the models' input data came from and how it was developed.
- Provide more time to complete the exercises.
- Give more time to explain the CLUE-S model.
- Have the workshop in one language only or using instant translation. Too much time was lost due to the need to translate to Spanish.

Question 7: How will the training received help you in your work?

Summary of responses:

- It supports some agencies' mandate to monitor watersheds.
- It offers tools useful for decision-making.
- It is useful in evaluating the hydrological cycle and sedimentation patterns.
- It complements one agency's work, where satellite imagery is being used to model hydrological resources.
- It supports some agencies' need to identify and measure threats to turtle nesting and feeding sites.

Question 8: Are you likely to apply these models? Please refer to CLUE-S and N-SPECT specifically and explain how these models could be used by your agency.

Summary of responses:

- CLUE-S will be very useful for modelling vegetation cover in NPAs in Mexico.
- N-SPECT won't be useful for the Yucatan Peninsula, unless underground water flow is incorporated into the model.
- One respondee wishes to test both models in an area with great environmental degradation and to evaluate the results.
- The USAID MIRA project will use N-SPECT as part of its watershed project component.
- Some agencies will use the models to simulate the impact of major climatic events.
- N-SPECT will prove useful for the scientific community and general decision makers who need better information on sedimentation and pollution patterns.
- N-SPECT can be useful in estimating community health needs/status/trends in Southern Belize.
- The models will be most useful if national datasets can be incorporated and tested.
- Some agencies will compare N-SPECT results with existing model results.

- Some agencies commented that further training in the use of CLUE-S is needed since the model is so complex.
- CLUE-S will be useful for planning land use in the framework of UN conventions such as UNCCD and UNFCCC.
- The set of models is useful for explaining the connections between forest cover and the health of the sea.

Question 9: How can the model results be presented and explained to senior management and decision makers?

Summary of responses:

- ICRAN-MAR should train more specialists in the use of the models, who in turn will inform decision makers locally about the models' benefits.
- The countries should run the models using national and local datasets in order to generate a greater impact when presenting to decision makers.
- In presenting the results, we should emphasize the economic impact of misguided management decisions, both through greater pollution and sedimentation, and through impacts of land cover changes on the tourism sector.
- Special care should be taken in explaining the "relative nature" of the results, lest decision makers consider the model results as absolute value predictions.
- There is a need to prepare training material for different types of seminars geared at users with different needs.

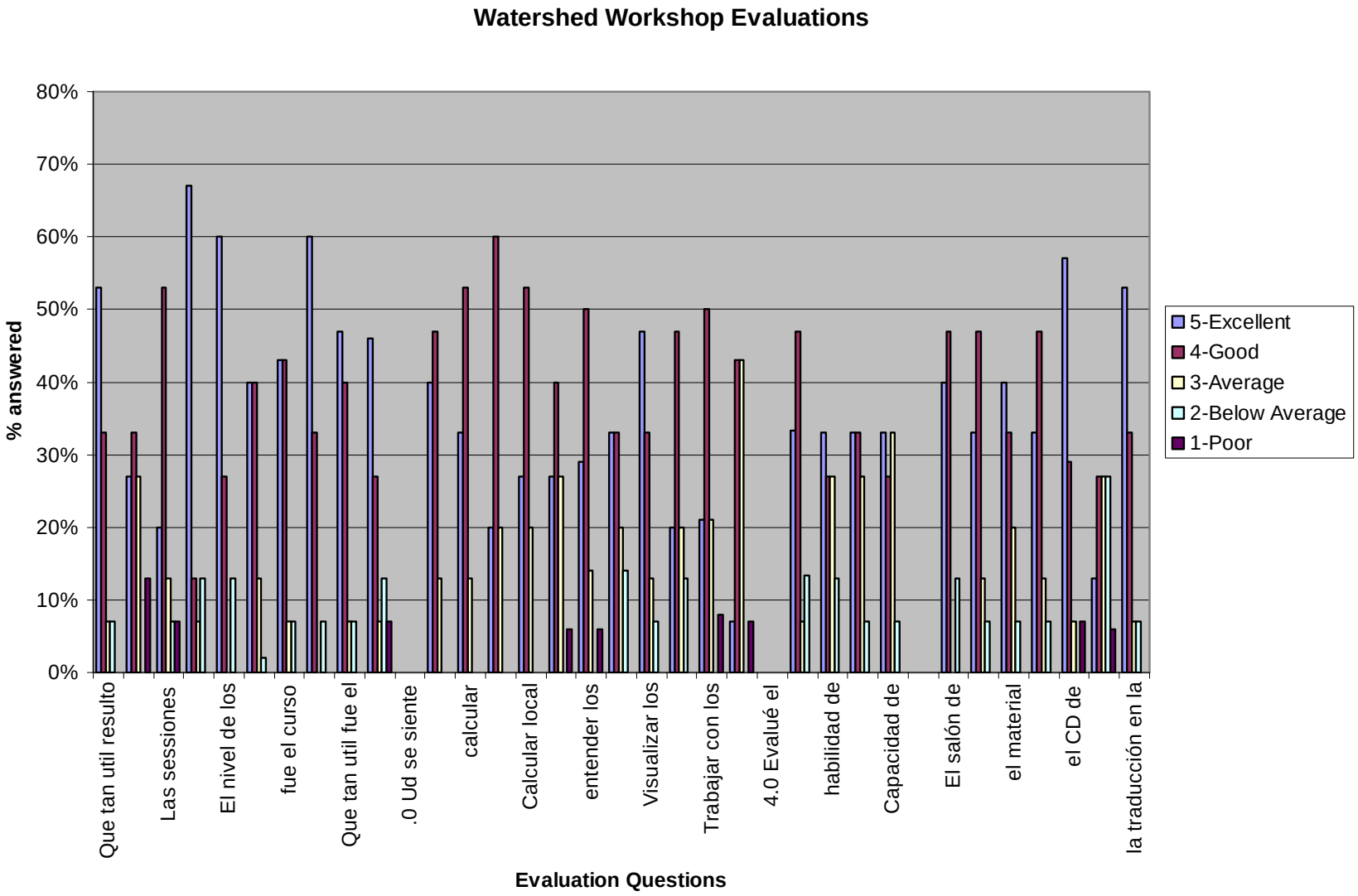
Question 10: General comments.

Summary of responses:

- Need to incorporate socio-economic variables in the models.
- Need to translate all the training and support material to Spanish.
- Need to conduct follow-up activities.
- Need to establish a MAR monitoring network that will allow for the calibration and improvement of the models and for comparing the different outputs and scenarios.

Many of the responses commented on how useful the workshop was and thanked the organizers for conducting it.

ICRAN MAR WATERSHED WORKSHOP EVALUATIONS					
	5-Excellent	4-Good	3-Average	2-Below Average	1-Poor
Que tan util resulto el taller para ud	53%	33%	7%	7%	
Fueron valiosas las presentaciones de la seccion de politicas	27%	33%	27%		13%
Las sessiones teoricas fueron	20%	53%	13%	7%	7%
Las sesiones practicas fueron	67%	13%	7%	13%	
El nivel de los instructores fue	60%	27%		13%	
La calidad del entrenamiento fue	40%	40%	13%	2%	
fue el curso compatible con sus intereses, conocimiento previo y responsabilidades laborales	43%	43%	7%	7%	
que tan útil fue el entrenamiento en CLUE-S	60%	33%		7%	
Que tan util fue el entrenamiento en N-SPECT	47%	40%	7%	7%	
que tan util fue el componente sobre Arc Map y herramientas hidricas	46%	27%	7%	13%	7%
.0 Ud se siente capaz de					
Realizar una delimitacion de cuencas	40%	47%	13%		
calcular escorrentía (runoff) y acumulación de sedimentos	33%	53%	13%		
calcular acumulación de contaminantes	20%	60%	20%		
Calcular local effects (erosion local):	27%	53%	20%		
Utilizar sus propios datos en el modelo N-SPECT	27%	40%	27%		6%
entender los distintos datos y parámetros de entrada	29%	50%	14%		6%
preparar los datos de entrada para CLUE-S	33%	33%	20%	14%	
Visualizar los resultados de CLUE-S en un SIG	47%	33%	13%	7%	
. Preparar y comprar sus propios escenarios para CLUE-S (land demand, area restriction files):	20%	47%	20%	13%	
Trabajar con los datos de su país contenidos en el CD	21%	50%	21%		8%
Calcular nuevos coeficientes de regresión utilizando software de estadísticas y el manula de CLUE-S	7%	43%	43%		7%
4.0 Evalué el curso de acuerdo a los siguientes criterios					
habilidad de transmitir conocimiento de formar clara	33.30%	47%	7%	13.30%	
habilidad de generar interese en los temas	33%	27%	27%	13%	
capacidad de transmitir conocimientos sobre el modelo CLUE-S a otros especialistas:	33%	33%	27%	7%	
Capacidad de transmitir conocimiento sobre el modelo N SPECT o otros especialistas	33%	27%	33%	7%	
0 Ofrezca su opinión sobre los siguientes recursos					
El salón de entrenamiento	40%	47%		13%	
los computadores	33%	47%	13%	7%	
el material audiovisual	40%	33%	20%	7%	
el material impreso	33%	47%	13%	7%	
el CD de entrenamiento	57%	29%	7%		7%
La traducción simultanea	13%	27%	27%	27%	6%
la traducción en la sesión técnica	53%	33%	7%	7%	


Watershed Workshop Evaluations
% answered
80%
70%
60%
50%
40%
30%
20%
10%
0%
Que tan util resulto
Las sessiones
El nivel de los
fue el curso
Que tan util fue el
.0 Ud se siente
calcular
Calcular local
entender los
Visualizar los
Trabajar con los
4.0 Evalué el
habilidad de
Capacidad de
El salón de
el material
el CD de
la traducción en la
Evaluation Questions
5-Excellent
4-Good
3-Average
2-Below Average
1-Poor

APPENDIX 6. Follow-up Technical Questionnaire

EVALUACIÓN DE OPORTUNIDADES PARA CAPACITACIÓN Y SEGUIMIENTO

Proyecto ICRAN-MAR

Taller sobre Manejo de Cuencas, Modelaje de Escenarios de Cambio en la Cobertura Terrestre y Modelaje de Descarga Hídrica de Sedimentos y Nutrientes
San Ignacio, Belice, 15 – 18 de Marzo de 2006

Nombre:

Institución:

Teléfono:

Email:

Agradecemos su tiempo para responder algunas preguntas que nos permitirán planificar potenciales actividades de capacitación posteriores al taller

1. **¿Qué tipo de entrenamiento adicional y complementario considera que se podría ofrecer a Ud. y su institución relacionado con los temas cubiertos en el taller?**

(See summary of responses in Appendix 7)

2. **Por favor indique que instituciones de su país considera que podrían beneficiarse de una capacitación similar a la ofrecida durante el taller actual (indique para cada una nombre de persona contacto y lista especialistas que deben asistir).**

(See summary of responses in Appendix 7)

3. **Por favor describa los beneficios que tendría una capacitación adicional para su institución y para otras instituciones de su país.**

(See summary of responses in Appendix 7)

4. **¿Qué temas ofrecidos durante el taller considera de mayor interés para su institución (u otras instituciones de su país) para una futura capacitación? Por favor describa.**

(See summary of responses in Appendix 7)

5. **¿Cuenta su institución con un laboratorio SIG adecuado para ofrecer capacitación similar a la ofrecida en el taller? En caso contrario, por favor indique si conoce de otra institución que podría ofrecer un laboratorio adecuado para el entrenamiento.**

(See summary of responses in Appendix 7)

6. **¿Qué entrenamiento adicional es requerido para garantizar que los resultados de los modelos apoyen acciones concretas?**

(See summary of responses in Appendix 7)

APPENDIX 7. Summary of Results Follow-Up Questionnaire.

The following table offers a summary of the responses to the following questions:

1. What additional training do you consider should be offered to your institution associated with the topics offered in the workshop?

and,

6. What additional training is required to guarantee that the results of the models support concrete actions?

Responses	From
In Mexico	
Support field data collection to improve the models	UNIPESCA
Organize a seminar for decision makers to explain the benefits of the models	UNIPESCA Centro GEO
Development of scenarios	CONANP
Better explain the use of certain parameters and details of the model not covered during the training	CONANP
Basic GIS training for non-specialists to allow them to benefit from the models	CONANP
More detailed training of the models using local datasets to develop parameters appropriate to the MAR region	ECOSUR INEGI
Training on the generation of the model input datasets	ECOSUR INEGI
In Honduras	
Training to develop better source data as input for models, such as precipitation grids or land cover maps.	USAID MIRA
In Belize	
Training to establish a methodology to validate N-SPECT using real data from selected MAR watersheds	Hydrology and Meteorology Service (HMS)
Assist to establish a national network that monitors erosion and sedimentation in river channels	Hydrology and Meteorology Service
Test the models incorporating local datasets. Ideally, have countries validate these datasets previously	TNC Belize
Guidelines to collect data for model calibration	TIDE Belize
Support the establishment of a regional network of specialists on the modeling tools	TIDE Belize
Obtain funding for additional follow-up support	TIDE Belize
Training in ArcGIS 9 and basic GIS data handling to improve the data input to the models	WCS Belize HMS
In Guatemala	
Economic valuation of the different model scenarios	Univ. Valle
Organize a seminar that shows how the results of the models can be used to solve real problems	Univ. Valle
Support policy formulation based on model results	MARN
Development of indicators to assist the testing of the models	MARN
Concept and context of general scenario development	MARN

Summary of responses to Question No 2: Please indicate which institutions in your country can benefit from training such as the one offered in this workshop.

- **Mexico**: Universities (related to agronomy and environment), disaster management unit of the government. CONANP, CONAFOR, Amigos de Sian Koan, CINVESTAN (Merida), PRONATURA, UQROO, EPOMEX, Instituto Nacional de Ecología, Comisión Nacional de Agua, CONABIO, SEMARNAT, INEGI, Secretaría de Marina.
- **Honduras**: Dirección de Recursos Hídricos, COHDEFOR.
- **Belize**: Private sector (e.g., fruit growers). SATTIM, YATCHE, TASTE, TIDE, Belize Agricultural Health Authority, Agricultural Department, Department of Oil and Mining, Belize University, Program for Belize.
- **Guatemala**: Instituto de Hidrología, Vulcanología y Meteorología (INSIVUMEH), Secretarìa General de Planificación (SEGEPLAN), Instituto de Estadística (INE), Instituto Geográfico Nacional, Ministerio de Agricultura (MAGA), Instituto Nacional de Bosques (INAB), Consejo Nacional de Areas Protegidas, Ministerio del Ambiente (MARN).

Summary of responses to Question No 3: Please describe the benefits of further training to your institution and other institutions in your country.

Mexico:

- Spread of results to a wider public.
- Change of attitude by decision-makers. Development of sensitivity to themes such as water management.
- Better GIS capacity for technicians and planners.
- New users will improve the model results and will help improve the input datasets.
- Development of legislation using scientific data.
- Centro GEO could consider training trainers on the models to spread these technologies in Mexico.

Belize:

- Better developmental planning.
- Identify areas with threat from runoff.
- Establishment of mitigation measures for natural disasters.

Guatemala:

- Stimulus to use new technologies and methodologies at the national level.

Summary of responses to question No. 4: What topics offered in the workshop do you consider more important for future training.

Mexico:

- Pollution.
- Deforestation.
- CLUE-S (4 responses) and IMAGINE (1 response).
- N-SPECT for watershed analysis (3 responses).

Honduras:

- N-SPECT.

Belize:

- CLUE-S (2 responses).
- Development of better land use policies.
- Water quality and monitoring of sedimentation.
- Development of scenarios

Guatemala:

- N-SPECT.

Summary of responses to Question No 5: Which institutions in your country have GIS labs where additional training could be offered?

Mexico: Consejo Nacional de Áreas Protegidas, MAGA. Ministerio de Agricultura, ECOSUR, INEGI, Centro GEO.

Honduras: Zamorano.

Belize: TNC Belize, Land Information Center.

Guatemala: Universidad del Valle.

APPENDIX 8. Useful Links

Introduction and Key Note Presentations:

- http://www.icranmar.org
- http://www.healthyreefs.org/

Land Cover Modeling and Scenarios:

- http://www.ifsmodel.org/
- http://www.mnp.nl/image/
- http://www.cluemodel.nl/
- http://www.unep.org/geo
- http://www.scenariosforsustainability.org

Hydrologic – Circulation Modeling:

- http://reefsatrisk.wri.org

GIS data dissemination links

- Biodiversity and Environmental Resource Data System of Belize: http://www.biodiversity.bz
- Belize Clearing House Mechanism: http://www.chm.org.bz
- The Mesoamerican Regional System for Visualization & Monitoring - SERVIR: http://servir.nsstc.nasa.gov
- N-SPECT page: http://www.csc.noaa.gov/crs/cwq/nspect.html

Watershed modelling discussion group

- http://groups.google.com/group/mar-watersheds