# Rapid Visual Site Analysis for Post-disaster Landscape Planning: Expanding the Range of Choice in a Tsunami-affected Town in Japan

JAMES L WESCOAT JR AND SHUN KANDA

## Problem statement

In post-disaster situations, it is often necessary to undertake rapid visual site reconnaissance to characterise patterns of damage and identify reconstruction opportunities and constraints. Rapid visual site analysis can occur over a period of hours to days rather than weeks to months. The time constraint is often necessary to assess the viability of initial reconstruction scenarios and help broaden the range of choice among site planning options. Rapid assessment can also minimise the use of scarce local post-disaster resources during the initial reconnaissance phases of planning. Because it involves visual methods rather than equipment-intensive survey techniques, it serves as an initial scoping of alternatives. It may follow emergency shelter response planning methods (for example, Sphere Project, 2011, ch 4) and be followed by more comprehensive site mapping and screening.

This action–research project reviews the literature on post-disaster site analysis with an emphasis on the tsunami-affected area of north-eastern Japan. Because research on rapid visual site analysis in post-disaster contexts is limited, we combined field-based site analysis methods, adapted for post-disaster planning, with visual methods for assessing seismic and tsunami hazards.

## Tsunami damage and pilot study project

The site analysis and visual methods were tested in a pilot study that sought to identify potential sites for new community centres in a tsunami-devastated town in north-eastern Japan. The town of Utatsu is one of several major coastal settlements in the administrative district of Minamisanriku, in the Miyagi Prefecture of the Tohoku region (Figure 1). The coastal landscape of Minamisanriku consists of steep watersheds that drain the southern tip of the Kitakami Mountains in eastern Honshu Island. It has a *rias* ('drowned' or 'sawtooth') coastline with highly productive artisanal fisheries in a large number of small coastal settlements. The steep hillslopes have an evergreen forest cover (*Pinus thunbergii*) and deliver abundant sediment to valley floors that, before the tsunami, supported rice paddies and discharged onto small coastal plains that had mixed residential, commercial, transportation and civic development.

As a result of tsunamis in the nineteenth and twentieth centuries, settlement patterns were established and protective measures designed to reduce people's exposure to disaster (Noh, 1966). Initiatives included marker stones of previous wave inundation heights, land use zoning, siting schools on higher terraces, warning and evacuation procedures and seawall construction. Over time, however,

*James L Wescoat Jr is Aga Khan Professor, Department of Architecture, Massachusetts Institute of Technology, 77 Massachusetts Ave, Cambridge, MA 02139, United States of America.*
*Telephone: +1–617–253–0567*
*Fax +1–617–258–8172*
*Email: wescoat@mit.edu*

*Shun Kanda is Senior Lecturer, Department of Architecture, Massachusetts Institute of Technology, 77 Massachusetts Ave, Cambridge, MA 02139, United States of America.*
*Telephone: +1–617–253–4791*
*Fax +1–617–492–5201*
*Email: kanda@mit.edu*

KEY WORDS
*Disaster planning*
*Site analysis*
*Range of choice theory*
*Tsunami*
*Japan*

RESEARCH

alluvial coastal and riparian flats were developed, streams were channelised and evacuation scenarios were not sufficiently tested; and, therefore, many settlements could not cope with the unprecedented magnitude of the earthquakes and tsunami in March 2011.

The earthquakes and tsunami struck on 11 March 2011. The greater Sanriku coast in eastern Honshu was directly and severely impacted, with wave elevations and run-up along river valleys of more than 15 metres above mean sea level (Mikami, Shibayamay and Esteban, 2012, p 4). The number of dead and missing in Minamisanriku Town was estimated to be about 900 out of a population of just over 17,000 (ibid, p 6). Devastation of coastal buildings was nearly total. Regional Japan Rail tracks and coastal highway bridges were knocked down. Saltwater inundation damaged agricultural and forest vegetation. Massive amounts of debris from the built, cultural and natural landscape posed challenges for recovery. Six months later, the Miyagi Prefectural Government (2011, p 2) released a disaster recovery plan that called for new methods of reconstruction planning and design.

## *Pilot study aims*

On 12 March, the day after the great north-eastern earthquakes and tsunami, architecture faculty from Miyagi University approached colleagues at Massachusetts Institute of Technology (MIT) in Cambridge, Massachusetts, to organise a joint reconstruction design studio. Initial reconnaissance trips and contact with community officials and members, followed by weekly Skype conversations, sought to identify a town, project type and approach for a pilot

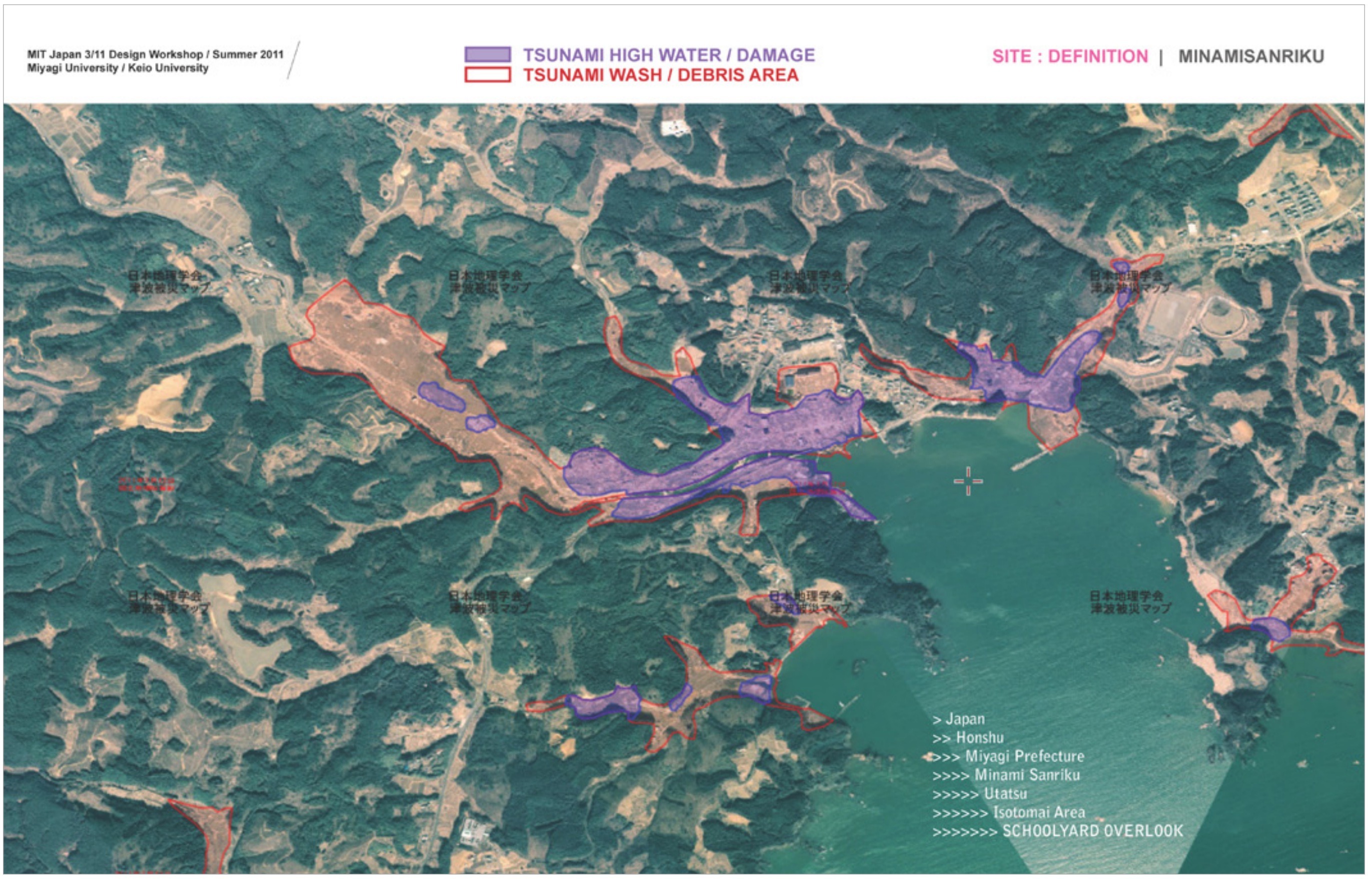


*Figure 1: Map of Utatsu with tsunami damage area and Minamisanriku.*[1]

study. As the government of Japan had placed a moratorium on rebuilding pending larger-scale policy and planning decisions, the organisers of the design studio decided to focus on the expressed need for 'community centres' with an emphasis on small towns that had lost much of their civic space as well as housing and infrastructure.

This pilot study explores what hazards researcher Gilbert White termed 'the range of choice' among reconstruction alternatives (Mitchell, 2008; Wescoat, 1987, 2011; White, 1961). White observed that reconstruction often occurs on sites subject to repeated risk and focuses quickly on a single alternative that overlooks other possibilities. The location of a post-disaster community centre, for example, might begin with assumptions about a high-elevation, high-visibility site. While this is a reasonable option, the sensitivity of high-elevation areas provides an argument for exploring alternatives.

The 'range of choice' phase of site analysis focuses on site conditions that help expand the perceived array of community building possibilities, opportunities and constraints. The community building programme was not pre-specified and was itself a variable discerned in part through the process of site analysis, community observations and discussion.

## Review of post-disaster site analysis research

Peer-reviewed research on site analysis in post-disaster contexts is limited, so we examined research on tsunami reconstruction and site analysis methods. The former body of research is extensive. The Avery Index of Architectural Periodicals alone yielded 82 peer-reviewed hits that included significant contributions by landscape architects and planners, for example, Mazereeuw (2011) and Mitani, et al (2011) (see also National Research Council and National Academy of Environmental Design, 2010). The Tohoku Geographical Association published assessments of tsunami damage and reconstruction planning including geographic information systems (GIS) mapping in the Onagawa port area (Ikoda, 2011; Mimura, et al, 2011; see also Kyoto University, 2012). The American Society of Civil Engineers (ASCE, 2011) conducted multi-team rapid reconnaissance in the Minamisanriku area. The Indian Ocean tsunami of 2004 also generated a large volume of evaluation literature (ALNAP, 2007; Jayasuriya and McCawley, 2010). In a study comparable with this one, but covering a much larger region, Free (2005) developed site analysis checklists for reducing seismic–tsunami risk when siting facilities.

For previous research on site analysis methods, a bibliographic search was conducted in the following major interdisciplinary journal indexes:

- Avery Index for Art and Architectural Periodicals;
- Engineering Village (Compendex);
- Web of Knowledge (including Science and Humanities indexes);
- WorldCat – books and articles.

The results were disparate but with some interesting patterns. The major scientific journal indexes included tens of hits for the phrase 'site analysis' in title, abstract and key word searches (Table 1).

| Index | Key words | Gross hits |
|---|---|---|
| Avery (art, architecture) | 'Site analysis' anywhere | 12 |
| Compendex (engineering) | 'Site analysis' in title or abstract | 13; 21 |
| ArticleFirst (interdisciplinary) | 'Site analysis' as key word AND 'landscape' OR 'hazard' OR 'disaster' | 99; 47; 26 |
| Web of Knowledge (science, humanities) | 'Site analysis' as topic AND 'landscape' OR 'hazard' | 26; 29; 3 |

*Table 1: Summary of journal index search results for 'site analysis'.*[2]

In this case, the Avery Index yielded only 12 hits on 'site analysis', none of which dealt with hazards.[3] Four of the hits were reviews of James LaGro's 2007 influential textbook *Site Analysis: A Contextual Approach to Sustainable Land Planning and Site Design*. We cross-checked the Avery results with searches of online journal archives and obtained further results: *Landscape and urban planning* (36 hits); *Landscape Research* (10 hits); *Journal of Landscape Architecture* (3 hits); *Landscape Journal* (8 hits plus book and conference reviews). These results indicated several patterns of site analysis research:

- early research on terrain analysis in landscape assessment (Harris, 1988; Way, 1982);
- late twentieth-century frameworks for site interpretation vis-à-vis traditional site analysis (for example, Corbin, 2003, on the significance of vacancy; Francis, 2001, on landscape architectural case studies; Meyer, 2001, on Marcel Smets's ideas about *casco* as a guiding concept for seeing; Braae and Diedrich, 2012, on the concept of site specificity; and National Research Council and National Academy of Environmental Design, 2010);
- continuing development of spatial analysis, computer cartography and GIS applications (for example, Jun, 2000; Mutunayagam, 1986; and Showalter and Lu, 2010).

The Compendex index added technical studies of facilities siting, site analysis failures and site analysis in environmental restoration (for example, Anon, 1985; Miron, Rutz and Ray, 2007; Powers, 1981). The Miron, et al (2007) article, in particular, describes a semester-long site analysis course at Tuskegee University in Tuskegee, Alabama, on radiation and hazardous waste hazards assessment. General article indices, such as the ArticleFirst and Web of Knowledge, added important research on GIS methods in siting emergency evacuation shelters (Kar and Hodgson, 2008); remote sensing of seismic hazards in site analysis (Xu, et al, 2010); landslide susceptibility (Gabriele, Barchiesi and Catallo, 2009); avalanche hazards simulation (Bocciola, Medagliani and Rosso, 2009); and sustainable site planning for disaster risk reduction (Ozdemir, 2008).

The *PreventionWeb* of the United Nations International Strategy for Disaster Reduction (UNISDR) yielded 82 hits on site analysis in disaster risk reduction websites. UNISDR (2006) also produced a *Tsunami Bibliography* in the wake of the 2004 Indian Ocean tsunami. A study by the National Tsunami Hazard Mitigation Program (2001, p 22) highlighted the role of site analysis in tsunami preparedness:

> The site analysis phase can be used to establish site plan parameters for tsunami mitigation. Many communities have mapped hazard areas. Within these areas, communities may also have more detailed plans that include site analysis. The analysis typically includes geographic conditions, critical infrastructure (see

> Principle 6), area access and egress (see Principle 7), and existing and future development patterns. The analysis may also include economic feasibility and community design objectives.

Because our study emphasised visual methods conducted by non-expert design students and faculty, it also drew upon the *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook* by the US Federal Emergency Management Agency (FEMA) (2002) (Figure 2). That volume developed visual assessment techniques for screening potential seismic hazards in buildings and, thus, differs in subject and purpose from our study of site alternatives in post-disaster contexts; however, they share an emphasis on rapid visual screening methods. Our study identified the presence and absence of tsunami damage and debris to identify different types of sites for potential community use.

The literatures surveyed above were used to adapt the site analysis variables listed in LaGro (2007) and other environmental planning texts (for example, Marsh, 2010; Murphy, 2005; White, 2004) and to incorporate post-tsunami landscape disturbance and siting considerations (Table 2).

## Site analysis methods

The site analysis methods were developed in three phases. The first involved off-site preparation, compiling and studying base maps, satellite imagery before and after the tsunami, supporting data, and field logistics before arrival. The second phase involved design and implementation of the on-site transect analysis procedures. The third phase involved off-site studio synthesis of fieldwork results. These methods are elaborated in further detail below.

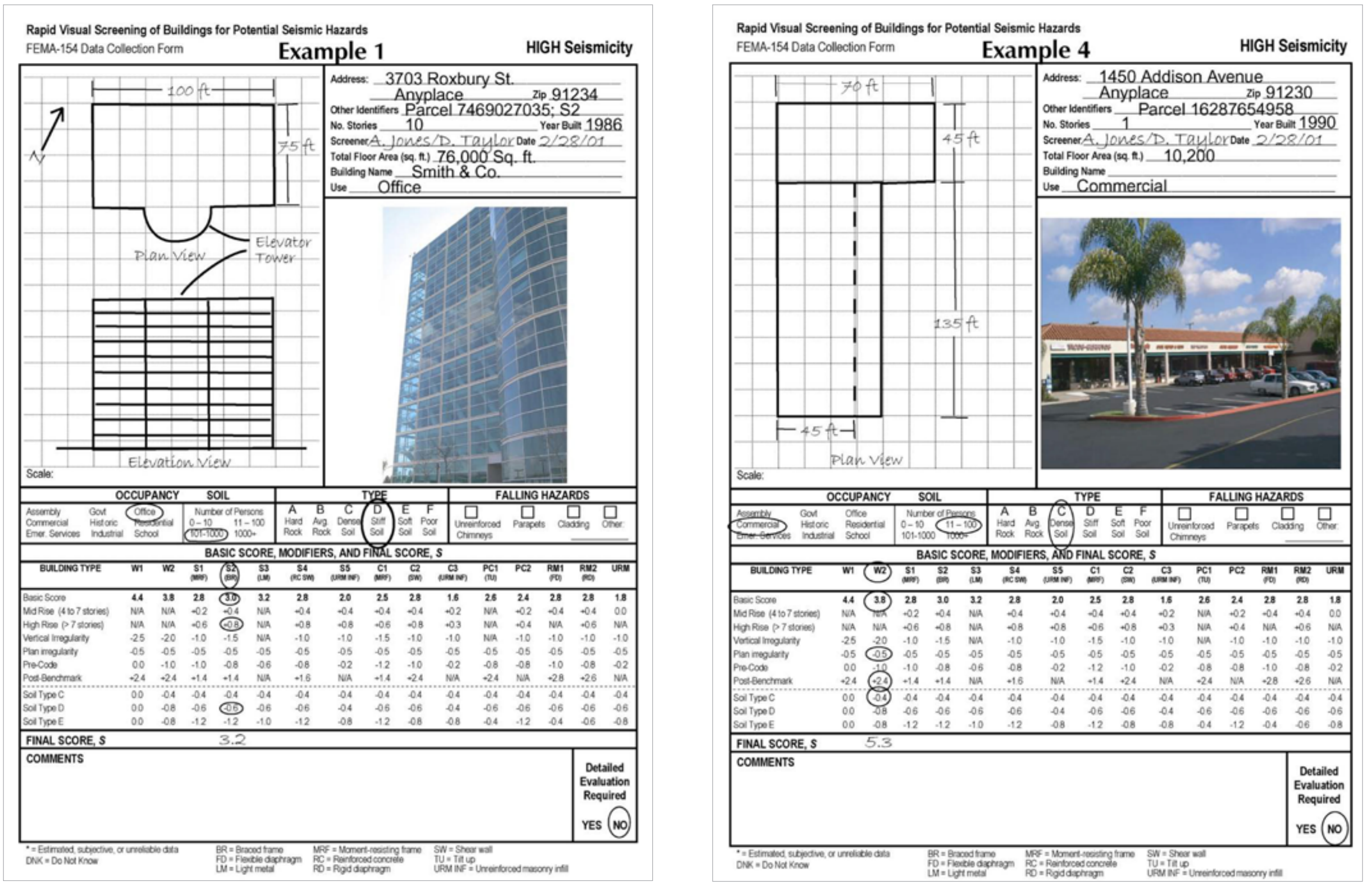


*Figure 2: FEMA rapid visual screening templates (FEMA, 2002, pp 57, 63).*

**Rapid Visual Screening of Buildings for Potential Seismic Hazards**
FEMA-154 Data Collection Form
**Example 1**
**HIGH Seismicity**

Address: 3703 Roxbury St.
Anyplace Zip 91234
Other Identifiers Parcel 7469027035; S2
No. Stories 10 Year Built 1986
Screener A. Jones/D. Taylor Date 2/28/01
Total Floor Area (sq. ft.) 76,000 Sq. ft.
Building Name Smith & Co.
Use Office

Scale:

| OCCUPANCY | | | SOIL | | TYPE | | | | | | FALLING HAZARDS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Assembly | Govt | [✓ Office] | Number of Persons | | A | B | C | [✓ D] | E | F | ☐ | ☐ | ☐ | ☐ |
| Commercial | Historic | Residential | 0 – 10 | 11 – 100 | Hard Rock | Avg. Rock | Dense Soil | [✓ Stiff Soil] | Soft Soil | Poor Soil | Unreinforced Chimneys | Parapets | Cladding | Other: |
| Emer. Services | Industrial | School | [✓ 101-1000] | 1000+ | | | | | | | | | | |

**BASIC SCORE, MODIFIERS, AND FINAL SCORE, *S***

| BUILDING TYPE | W1 | W2 | S1 (MRF) | [✓ S2 (BR)] | S3 (LM) | S4 (RC SW) | S5 (URM INF) | C1 (MRF) | C2 (SW) | C3 (URM INF) | PC1 (TU) | PC2 | RM1 (FD) | RM2 (RD) | URM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Basic Score | 4.4 | 3.8 | 2.8 | [✓ 3.0] | 3.2 | 2.8 | 2.0 | 2.5 | 2.8 | 1.6 | 2.6 | 2.4 | 2.8 | 2.8 | 1.8 |
| Mid Rise (4 to 7 stories) | N/A | N/A | +0.2 | +0.4 | N/A | +0.4 | +0.4 | +0.4 | +0.4 | +0.2 | N/A | +0.2 | +0.4 | +0.4 | 0.0 |
| High Rise (> 7 stories) | N/A | N/A | +0.6 | [✓ +0.8] | N/A | +0.8 | +0.8 | +0.6 | +0.8 | +0.3 | N/A | +0.4 | N/A | +0.6 | N/A |
| Vertical Irregularity | -2.5 | -2.0 | -1.0 | -1.5 | N/A | -1.0 | -1.0 | -1.5 | -1.0 | -1.0 | N/A | -1.0 | -1.0 | -1.0 | -1.0 |
| Plan irregularity | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 |
| Pre-Code | 0.0 | -1.0 | -1.0 | -0.8 | -0.6 | -0.8 | -0.2 | -1.2 | -1.0 | -0.2 | -0.8 | -0.8 | -1.0 | -0.8 | -0.2 |
| Post-Benchmark | +2.4 | +2.4 | +1.4 | +1.4 | N/A | +1.6 | N/A | +1.4 | +2.4 | N/A | +2.4 | N/A | +2.8 | +2.6 | N/A |
| Soil Type C | 0.0 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 |
| Soil Type D | 0.0 | -0.8 | -0.6 | [✓ -0.6] | -0.6 | -0.6 | -0.4 | -0.6 | -0.6 | -0.4 | -0.6 | -0.6 | -0.6 | -0.6 | -0.6 |
| Soil Type E | 0.0 | -0.8 | -1.2 | -1.2 | -1.0 | -1.2 | -0.8 | -1.2 | -0.8 | -0.8 | -0.4 | -1.2 | -0.4 | -0.6 | -0.8 |

**FINAL SCORE, *S*** 3.2

**COMMENTS**

**Detailed Evaluation Required**
YES [✓ NO]

* = Estimated, subjective, or unreliable data
DNK = Do Not Know
BR = Braced frame
FD = Flexible diaphragm
LM = Light metal
MRF = Moment-resisting frame
RC = Reinforced concrete
RD = Rigid diaphragm
SW = Shear wall
TU = Tilt up
URM INF = Unreinforced masonry infill

**Rapid Visual Screening of Buildings for Potential Seismic Hazards**
FEMA-154 Data Collection Form
**Example 4**
**HIGH Seismicity**

Address: 1450 Addison Avenue
Anyplace Zip 91230
Other Identifiers Parcel 16287654958
No. Stories 1 Year Built 1990
Screener A. Jones/D. Taylor Date 2/28/01
Total Floor Area (sq. ft.) 10,200
Building Name
Use Commercial

Scale:

| OCCUPANCY | | | SOIL | | TYPE | | | | | | FALLING HAZARDS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Assembly | Govt | Office | Number of Persons | | A | B | [✓ C] | D | E | F | ☐ | ☐ | ☐ | ☐ |
| [✓ Commercial] | Historic | Residential | 0 – 10 | [✓ 11 – 100] | Hard Rock | Avg. Rock | [✓ Dense Soil] | Stiff Soil | Soft Soil | Poor Soil | Unreinforced Chimneys | Parapets | Cladding | Other: |
| Emer. Services | Industrial | School | 101-1000 | 1000+ | | | | | | | | | | |

**BASIC SCORE, MODIFIERS, AND FINAL SCORE, *S***

| BUILDING TYPE | W1 | [✓ W2] | S1 (MRF) | S2 (BR) | S3 (LM) | S4 (RC SW) | S5 (URM INF) | C1 (MRF) | C2 (SW) | C3 (URM INF) | PC1 (TU) | PC2 | RM1 (FD) | RM2 (RD) | URM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Basic Score | 4.4 | [✓ 3.8] | 2.8 | 3.0 | 3.2 | 2.8 | 2.0 | 2.5 | 2.8 | 1.6 | 2.6 | 2.4 | 2.8 | 2.8 | 1.8 |
| Mid Rise (4 to 7 stories) | N/A | N/A | +0.2 | +0.4 | N/A | +0.4 | +0.4 | +0.4 | +0.4 | +0.2 | N/A | +0.2 | +0.4 | +0.4 | 0.0 |
| High Rise (> 7 stories) | N/A | N/A | +0.6 | +0.8 | N/A | +0.8 | +0.8 | +0.6 | +0.8 | +0.3 | N/A | +0.4 | N/A | +0.6 | N/A |
| Vertical Irregularity | -2.5 | -2.0 | -1.0 | -1.5 | N/A | -1.0 | -1.0 | -1.5 | -1.0 | -1.0 | N/A | -1.0 | -1.0 | -1.0 | -1.0 |
| Plan irregularity | -0.5 | [✓ -0.5] | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 | -0.5 |
| Pre-Code | 0.0 | -1.0 | -1.0 | -0.8 | -0.6 | -0.8 | -0.2 | -1.2 | -1.0 | -0.2 | -0.8 | -0.8 | -1.0 | -0.8 | -0.2 |
| Post-Benchmark | +2.4 | [✓ +2.4] | +1.4 | +1.4 | N/A | +1.6 | N/A | +1.4 | +2.4 | N/A | +2.4 | N/A | +2.8 | +2.6 | N/A |
| Soil Type C | 0.0 | [✓ -0.4] | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 |
| Soil Type D | 0.0 | -0.8 | -0.6 | -0.6 | -0.6 | -0.6 | -0.4 | -0.6 | -0.6 | -0.4 | -0.6 | -0.6 | -0.6 | -0.6 | -0.6 |
| Soil Type E | 0.0 | -0.8 | -1.2 | -1.2 | -1.0 | -1.2 | -0.8 | -1.2 | -0.8 | -0.8 | -0.4 | -1.2 | -0.4 | -0.6 | -0.8 |

**FINAL SCORE, *S*** 5.3

**COMMENTS**

**Detailed Evaluation Required**
YES [✓ NO]

* = Estimated, subjective, or unreliable data
DNK = Do Not Know
BR = Braced frame
FD = Flexible diaphragm
LM = Light metal
MRF = Moment-resisting frame
RC = Reinforced concrete
RD = Rigid diaphragm
SW = Shear wall
TU = Tilt up
URM INF = Unreinforced masonry infill

*Table 2: Site analysis variables.*

*Physical conditions*

- Post-tsunami conditions
  - surviving features
  - rubble surfaces (composition, materials, texture, foundations)
  - post-disaster actions (grading, sorting, removal, filling)
- Land forms and slopes
  - land form types, relations, assets
  - relative elevations
  - slopes (percentage, shape, cut/fill, constraints on circulation/building)
- Soils
  - type/description (texture, colour, moisture)
  - drainage/compaction
  - erosion (existing/potential)
- Geology (visible bedrock, alluvial, fill land, stability)
- Hydrology
  - drainage patterns
  - channel width, depth, form
  - flood hazards
- Coastal
  - access/assets/exposure
  - structures (breakwater, edge)
  - nearshore/offshore currents, tides, features
- Microclimates (sun/shade, temperature, humidity, precipitation, wind)

*Biological conditions*

- Ecosystem types/assets/impacts
- Vegetation
  - structure (tree/shrub/groundcover; evergreen/deciduous)
  - density (percentage cover – 100 percent to bare ground)
  - tsunami damage (wave, salinity)
- Wildlife (terrestrial, marine)
- Fisheries pre-tsunami and post-tsunami (nearshore, offshore habitat and abundance)

*Socio-economic, cultural and built environment conditions*

- Communities (locations, structure, needs, interests, demographics)
- Shelter – camps/temporary housing (locations, structure, needs, interests, demographics)
- Places of work (temporary, supply chain, industrial organisation and restructuring)
- Land use and tenure
  - public/private, owned/leased
  - land use/open space pattern
- Public infrastructure and services (transportation, access, utilities, social services)
- Extant buildings
  - building typology/architectural assets/settlement morphology
  - rapid visual screening (adapt FEMA forms)
- Cultural heritage (structures, places, sites, intangible)
- Visual analysis and landscape aesthetics
  - visual experience (view directions, lengths, qualities)
  - sense of place

## *Preparatory phase of site analysis*

Site information is often inaccessible, damaged or destroyed in post-disaster landscapes, which means intensive preparation is required before arrival on site. The Japan 3.11 workshop preparatory analysis included the following.

1. The international team's aims, scope, methods, logistics and funding were coordinated through Skype and telephone conversations held nearly each

week for several months before the workshop. These deliberations and reconnaissance visits led to the selection of Utatsu, one of three main towns in Minamisanriku (the others being Shizugawa and Togura; there are many other small settlements like Minato and Hadenya; and an inland town at Iriya). It also led to the decision to focus on the need for small community centres.

2. Preparatory meetings were held with workshop members that addressed the potential hazards of field work (earthquake aftershocks; typhoon storms in late summer; scientific information about radiation plumes in the atmosphere, water, land and food chain; tsunami debris hazards and general first aid).
3. A 'Resource-CD' was compiled for workshop members, which included:

   01_Key Workshop Documents (for example, schedule, contact information, project brief)

   02_Base Maps (at multiple scales and geographic extents, from satellite imagery to Japan's Zenrin topographic maps at 5-metre contour intervals)

   03_Site Analysis Resources (for example, literature review above)

   04_2011 Tohoku Earthquake and Tsunami Documents (initial damage assessments and monitoring data)

   05_Japan Disaster Research and Management Resources (institutional mapping of Japanese government and non-governmental aid organisations involved in Tohoku earthquake and tsunami recovery; list of Japanese disaster research centres and downloaded publications)

   06_Technical Disaster Resources (for example, FEMA manuals and US Army Corps of Engineers *Coastal Engineering Manual*)

   07_Disaster Resilient Design Resources (for example, design precedents database from the United Nations Human Settlements Programme (UN-HABITAT), Active Learning Network for Accountability and Performance in Humanitarian Action (ALNAP), Architecture for Humanity and 2004 Indian Ocean tsunami case studies).

These digital resources were deemed important because internet access was negligible in Minamisanriku during the early months following the tsunami disaster.

4. Base maps were selected and printed at multiple scales to provide a perspective of the regional context as well as for site analysis. The three main scales selected were the:
   - full Minamisanriku administrative area, which consolidates the three main towns and their coastal watersheds;
   - greater Utatsu area, which comprises the formerly settled coastal bay, middle terraces that support the town's schools and emergency housing, upper forested hillslopes and riparian corridors that drain the hillslopes to the coastal bay;
   - detailed imagery of Utatsu town including areas that survived the tsunami where community safe havens might be located, as well as areas partially or wholly damaged that might have other community purposes (for example, for workplace and livelihood-related activities).

Cartographic resources for the Utatsu area were greater than what would have been available a decade ago but still limited. For example, Google Earth historical maps and images, and tsunami inundation maps, were available soon after the event. However, Zenrin topographic base maps for coastal towns were available at a 5-metre contour interval, which provided limited information on buildable or evacuable slopes. The Utatsu area did not have GIS coverage for land use or land cover.

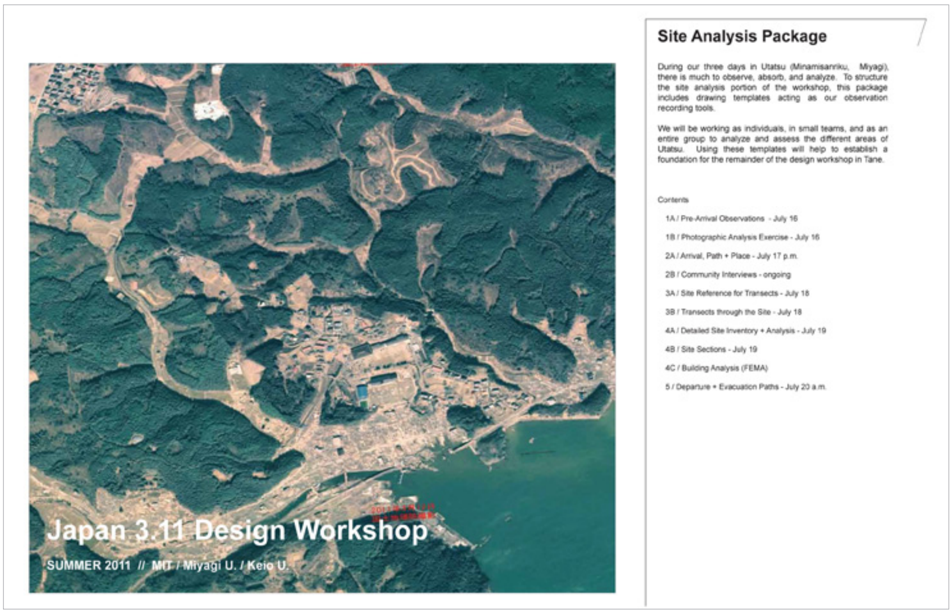
5. Site analysis field drawing packages were prepared for all participants (12 pages of pre-formatted field mapping sheets linked with daily fieldwork at 297 × 420 millimetres (A3)). These drawing sets enabled continuous mapping, note taking and drawing while site transects were walked (Figure 3).

## *On-site analysis*

The US–Japan design team travelled by road from Sendai to Minamisanriku. The initial arrival on site began with silent meditation and an intuitive walk through the coastal area, adjacent river valleys and upland settlements without photography, discussion or analysis. This first step was suggested by our Japanese project leaders as an appropriate way to begin. It resonates with the interpretive cultural traditions of site inquiry noted above, and is important for responders as well as survivors in post-disaster contexts (Aloudat and Christensen, 2012; Hewitt, 2012).

*Day 1*: *Transect analysis*. Site analysis teams of two to four members analysed one transect each of nearly 0.5 kilometres in length (the distance from sea to upper settlements or steep forested slopes). Transect methods were demonstrated in the field (for example, delineation of sections, distance pacing, slope and height estimation, documentary photography and annotation). Seven transects were selected based on Minamisanriku's complex terrain; they followed or cut across major ridge and valley land forms in a gridded alignment that might be more applicable in gentler terrain (bracketed numbers below refer to transect numbers in Figure 4). The transects included:

- three riparian corridors (the main stream valley [1], west valley [3] and east valley [7]), which supported rice cultivation and limited settlement;



Japan 3.11 Design Workshop

SUMMER 2011 // MIT / Miyagi U. / Keio U.

**Site Analysis Package**

During our three days in Utatsu (Minamisanriku, Miyagi), there is much to observe, absorb, and analyze. To structure the site analysis portion of the workshop, this package includes drawing templates acting as our observation recording tools.

We will be working as individuals, in small teams, and as an entire group to analyze and assess the different areas of Utatsu. Using these templates will help to establish a foundation for the remainder of the design workshop in Tane.

Contents

1A / Pre-Arrival Observations - July 16
1B / Photographic Analysis Exercise - July 16
2A / Arrival, Path + Place - July 17 p.m.
2B / Community Interviews - ongoing
3A / Site Reference for Transects - July 18
3B / Transects through the Site - July 18
4A / Detailed Site Inventory + Analysis - July 19
4B / Site Sections - July 19
4C / Building Analysis (FEMA)
5 / Departure + Evacuation Paths - July 20 a.m.

*Figure 3: Site analysis drawing package cover page.*

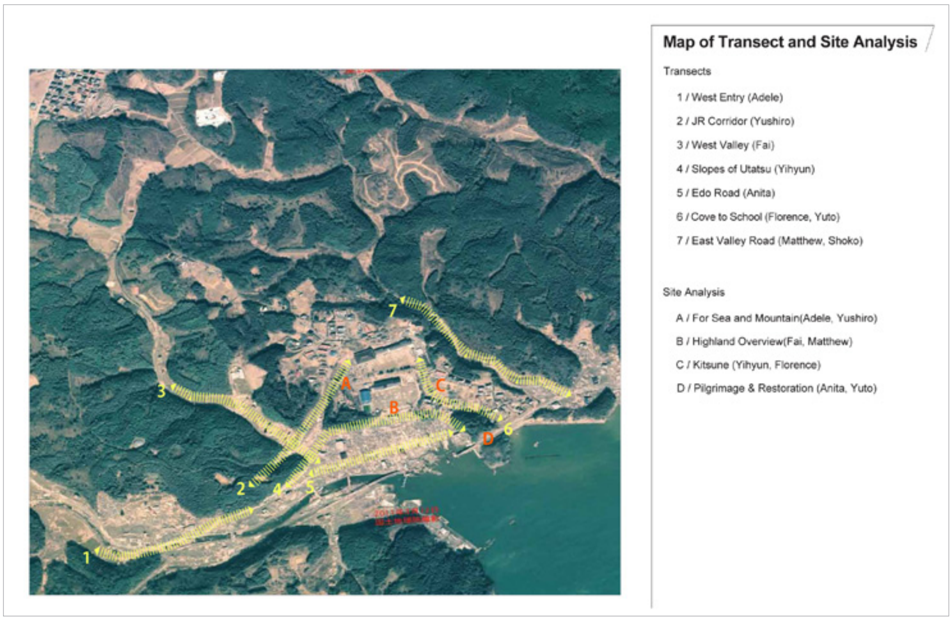


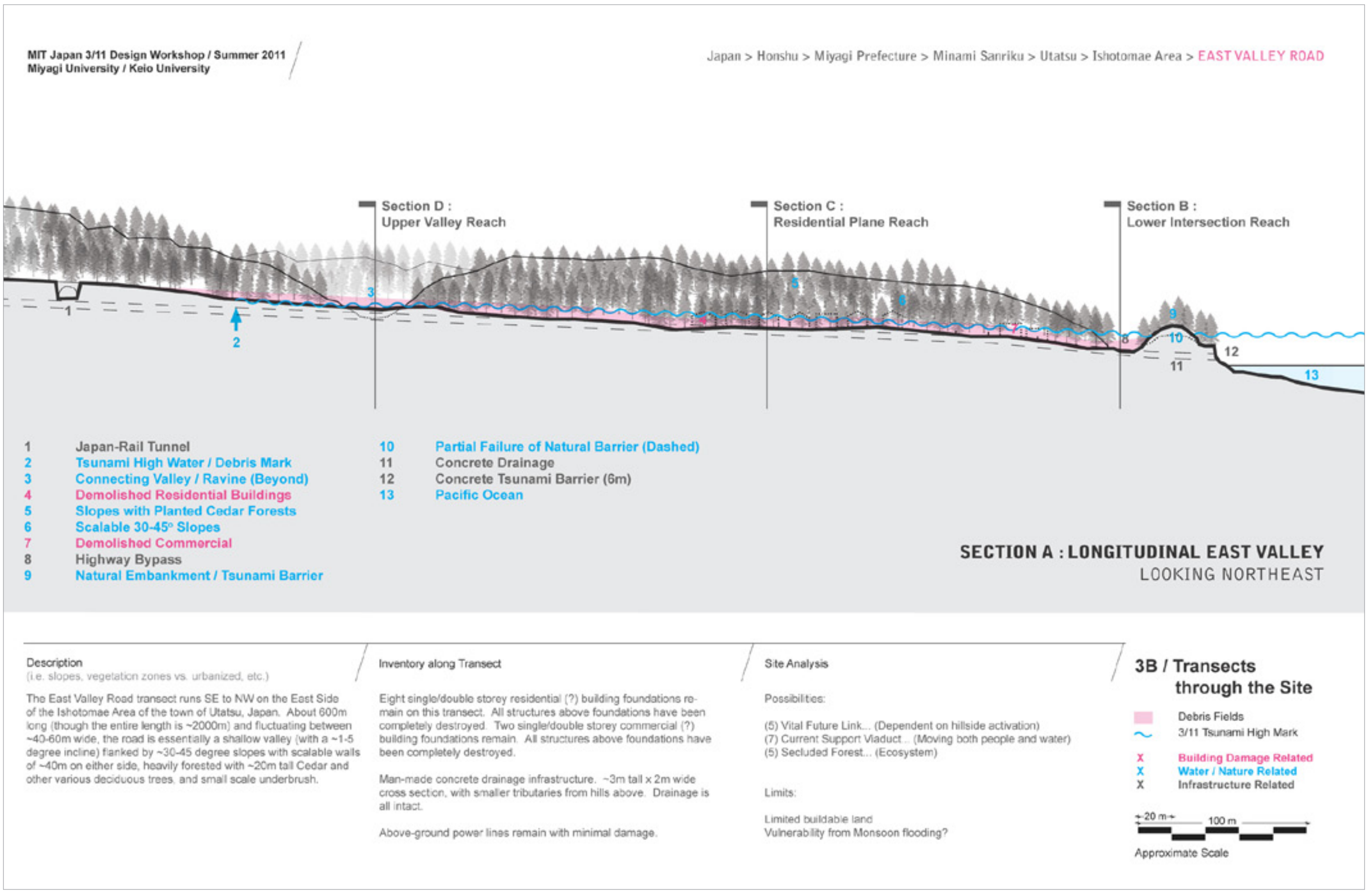
*Figure 4: Transects identified in yellow lines.*

- three transportation corridors (the Japan Rail line [2], an historic coastal road [5] and a small road from a coastal cove to upland school buildings [6]);
- a series of six hillslope sections [4], most of which were sharp barriers to evacuation and settlement, though several had paths or small switchback roads to upland areas and midslope terraces that escaped tsunami damage and served important community functions.[4]

As a *rias* coast, with steep mountain drainages and heavily forested hilltops, Utatsu has a limited buildable area and significant barriers to vertical evacuation.

Transect analysis is a method of site sampling that intensively examines conditions observable over linear paths through a study area. It is widely employed in geomorphology, biogeography, disturbance ecology and built environment research (for example, Buckland, 2001; Goudie, 1990; Kent, et al, 1997; and www.transect.org where land use transects are linked with development codes). In this project, transect analysis entailed the following field tasks.

- Longitudinal sections were constructed along the transect line. Longitudinal transects looked in both directions from the centre line to evidence at a visible distance from, as well as immediately along, the section line (these drawings used conventions of lighter lines for more distant information). As transects followed rather narrow paths, this background information ranged from 5 to 50 metres from the centre line (Figure 5).
- Transverse sections were constructed across the transect line at intervals selected to identify major construction constraints (for example, slopes greater than 30 degrees, the ocean and densely forested areas) and opportunities (for example, elevated open areas, trafficable slopes and attractive sight lines) (Figure 6).
- Surface conditions (damage, debris, land use and land cover) were mapped on a gross scale between the transverse sections to the boundaries of the visible evidence.



The East Valley Road transect runs SE to NW on the East Side of the Ishotomae Area of the town of Utatsu, Japan. About 600m long (though the entire length is ~2000m) and fluctuating between ~40-60m wide, the road is essentially a shallow valley (with a ~1-5 degree incline) flanked by ~30-45 degree slopes with scalable walls of ~40m on either side, heavily forested with ~20m tall Cedar and other various deciduous trees, and small scale underbrush.

Eight single/double storey residential (?) building foundations remain on this transect. All structures above foundations have been completely destroyed. Two single/double storey commercial (?) building foundations remain. All structures above foundations have been completely destroyed.

Man-made concrete drainage infrastructure. ~3m tall x 2m wide cross section, with smaller tributaries from hills above. Drainage is all intact.

Above-ground power lines remain with minimal damage.

Possibilities:

(5) Vital Future Link... (Dependent on hillside activation)
(7) Current Support Viaduct... (Moving both people and water)
(5) Secluded Forest... (Ecosystem)

Limits:

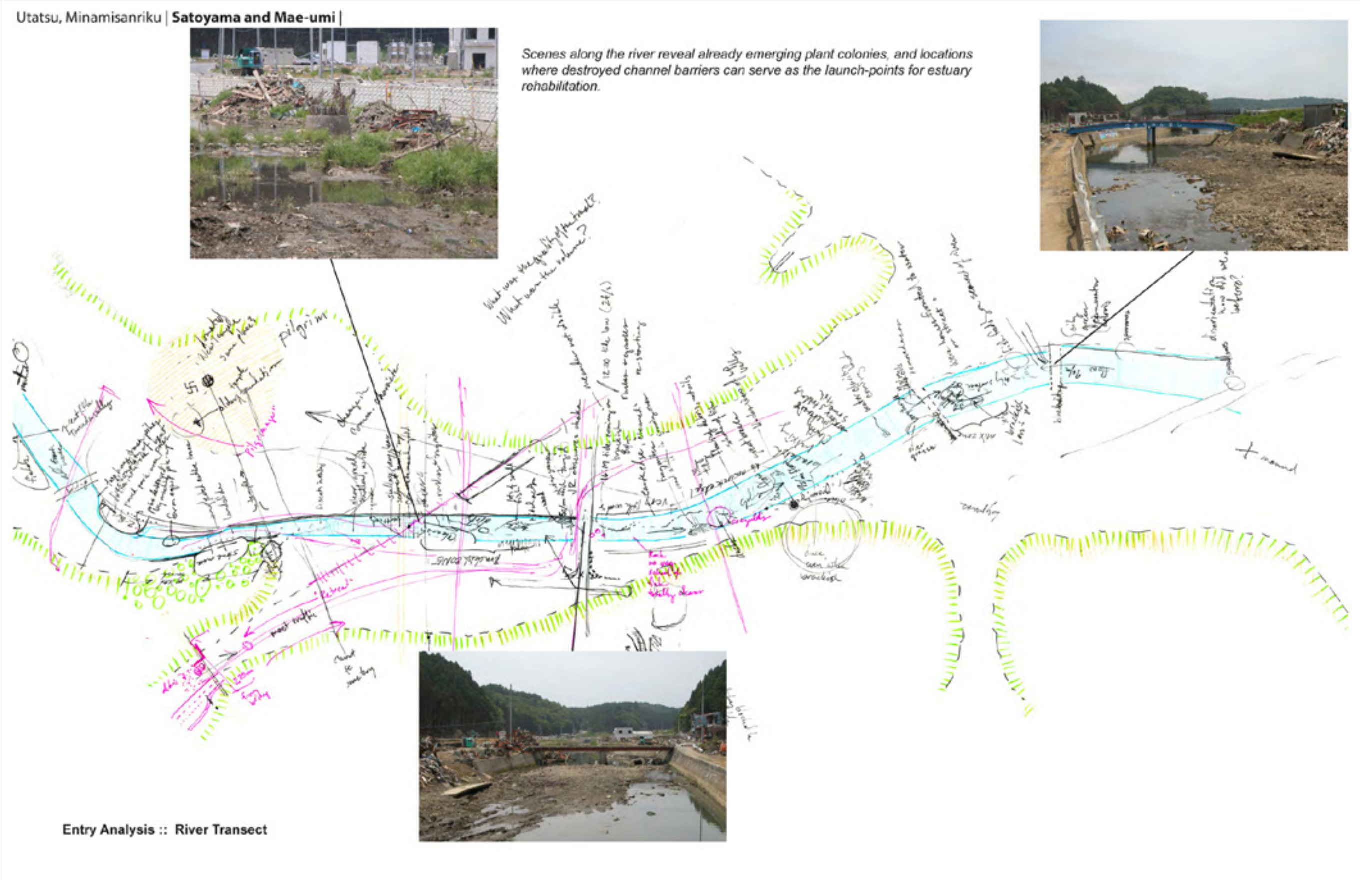
Limited buildable land
Vulnerability from Monsoon flooding?

*Figure 5: Longitudinal transect along a coastal river valley. (Image courtesy of Matthew Bunza.)*

In each section and plan, the aim was to identify slope conditions affecting evacuation, damage and debris patterns that indicated relative safety in this event, and areas of around 20 square metres or more that might support community activities. This one-day survey along a well-defined transect helped each team develop a fine-grained perspective on post-disaster landscape conditions, forensics, opportunities and constraints. The information recorded was collected by direct observation while walking transects repeatedly to gain insights from viewing transects in different upslope and downslope directions.

In the evenings, teams attended community meetings in the towns of Utatsu and Togura for insight into redevelopment interests and concerns. They compared hand-drawn transect maps and sections, which had two main benefits. First, it indicated more and less successful drawing and mapping techniques. Participants showed creativity in annotation methods, map symbols, observational acuity and supporting analysis (for example, the slope analysis matrix in Figure 7). Comparing preliminary transects also helped develop a collective understanding of the complex terrain of Utatsu (as indicated in Figure 4 above).

*Day 2: Potential community spaces along the transects.* In the morning of the second day, teams re-surveyed transects for missing data and inferences about pre-disaster development patterns, tsunami damage processes and reconstruction prospects. The teams then tested the fruitfulness of these methods by identifying potential community spaces along each transect. Draft site planning criteria and programme possibilities were informed by discussions with local residents and the evening meetings with community members. These discussions revealed diverse



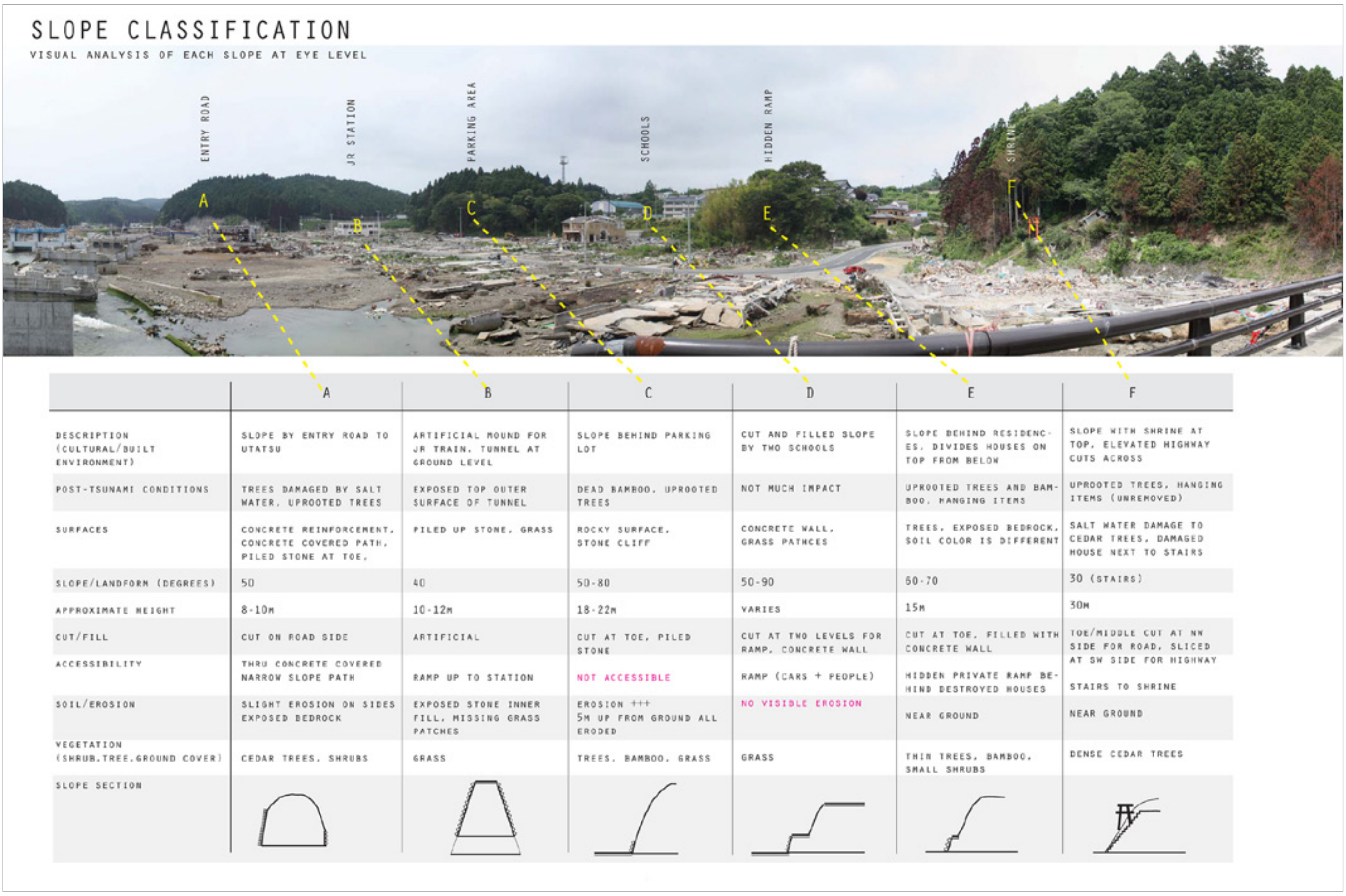
*Scenes along the river reveal already emerging plant colonies, and locations where destroyed channel barriers can serve as the launch-points for estuary rehabilitation.*

**Entry Analysis :: River Transect**

*Figure 6: Lateral transects across a coastal river channel. (Image courtesy of Adele Phillips.)*

interests and attitudes. Some community members sought to resume coastal fishing livelihoods as soon as possible while others wanted to relocate away from the ocean – visually as well as spatially. This combination of diverse views and complex terrain supported the approach of expanding the range of community spaces considered rather than seeking to identify a single site as the community centre. Potential sites identified along the transects are described below.

- The three riparian corridors yielded important information about tsunami damage caused by ‘run-up’ that swept away bridges, buildings and rice fields, as well as hillside ‘splash-up’ that aggravated salinity impacts on pine forests. In light of this severe damage and the steep sideslopes, no community centre spaces were identified along the east or west valley transects. However, the mouth of the main riparian corridor was identified as an estuarine restoration area that could link the reconstruction of community fishing livelihoods and workplaces with environmental education and recreation. This coastal lowland site had not been anticipated at the outset of inquiry and thus its inclusion expanded the range of choice.
- The three transportation corridors also suffered major structural damage from direct tsunami wave forces. Japan Rail tracks were torn off; highway bridge structures and buildings along the old Edo-period road on the coastal plain were destroyed. However, the cove to school road team identified variable damage patterns, including areas where small differences in exposure resulted in differential damages and protection. Each transportation corridor team identified protected areas that could support



| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| DESCRIPTION (CULTURAL/BUILT ENVIRONMENT) | SLOPE BY ENTRY ROAD TO UTATSU | ARTIFICIAL MOUND FOR JR TRAIN, TUNNEL AT GROUND LEVEL | SLOPE BEHIND PARKING LOT | CUT AND FILLED SLOPE BY TWO SCHOOLS | SLOPE BEHIND RESIDENCES, DIVIDES HOUSES ON TOP FROM BELOW | SLOPE WITH SHRINE AT TOP, ELEVATED HIGHWAY CUTS ACROSS |
| POST-TSUNAMI CONDITIONS | TREES DAMAGED BY SALT WATER, UPROOTED TREES | EXPOSED TOP OUTER SURFACE OF TUNNEL | DEAD BAMBOO, UPROOTED TREES | NOT MUCH IMPACT | UPROOTED TREES AND BAMBOO, HANGING ITEMS | UPROOTED TREES, HANGING ITEMS (UNREMOVED) |
| SURFACES | CONCRETE REINFORCEMENT, CONCRETE COVERED PATH, PILED STONE AT TOE. | PILED UP STONE, GRASS | ROCKY SURFACE, STONE CLIFF | CONCRETE WALL, GRASS PATHCES | TREES, EXPOSED BEDROCK, SOIL COLOR IS DIFFERENT | SALT WATER DAMAGE TO CEDAR TREES, DAMAGED HOUSE NEXT TO STAIRS |
| SLOPE/LANDFORM (DEGREES) | 50 | 40 | 50-80 | 50-90 | 60-70 | 30 (STAIRS) |
| APPROXIMATE HEIGHT | 8-10M | 10-12M | 18-22M | VARIES | 15M | 30M |
| CUT/FILL | CUT ON ROAD SIDE | ARTIFICIAL | CUT AT TOE, PILED STONE | CUT AT TWO LEVELS FOR RAMP, CONCRETE WALL | CUT AT TOE, FILLED WITH CONCRETE WALL | TOE/MIDDLE CUT AT NW SIDE FOR ROAD, SLICED AT SW SIDE FOR HIGHWAY |
| ACCESSIBILITY | THRU CONCRETE COVERED NARROW SLOPE PATH | RAMP UP TO STATION | NOT ACCESSIBLE | RAMP (CARS + PEOPLE) | HIDDEN PRIVATE RAMP BEHIND DESTROYED HOUSES | STAIRS TO SHRINE |
| SOIL/EROSION | SLIGHT EROSION ON SIDES EXPOSED BEDROCK | EXPOSED STONE INNER FILL, MISSING GRASS PATCHES | EROSION +++<br>5M UP FROM GROUND ALL ERODED | NO VISIBLE EROSION | NEAR GROUND | NEAR GROUND |
| VEGETATION (SHRUB.TREE.GROUND COVER) | CEDAR TREES, SHRUBS | GRASS | TREES, BAMBOO, GRASS | GRASS | THIN TREES, BAMBOO, SMALL SHRUBS | DENSE CEDAR TREES |
| SLOPE SECTION | | | | | | |

*Figure 7: Slope analysis and classification matrix. (Image courtesy of Yihyun Lim.)*

community activities. The Japan Rail team identified a small upland site adjacent to the rail line used for overflow parking that was protected from, yet had partial views of, the ocean, which could serve the varied wishes of residents with respect to views of the ocean. Another team identified an upland site adjacent to the school road that had a small abandoned play area suitable for redevelopment. The coastal road team suggested that restoration of highway corridor cut slopes could accommodate some of the massive volume of debris along the coastline and could, in turn, re-link a hilltop Shinto shrine with a high coastal promontory park. Although the first two sites might have been discovered through other methods, their strong linkages with potential evacuation routes and adjacent community land uses were identified through transect analysis. The alternative for restoring a highway cut through the coastal headlands had not been imagined at the start of the project.

- The hillslope sections identified a promising community site on a central axis from the former town centre through the middle terrace with surviving schools and emergency housing. This central location, served by an existing road, was envisioned at the outset of the inquiry. However, the transect slope analysis identified opportunities for lower slope reconstruction with tsunami-deposited debris and access and/or evacuation road improvements.

In these ways, transect analysis helped advance the concept and substance of expanding the range of choice. It identified two completely unanticipated sites, two unanticipated sites that might have been identified through different methods but that were closely linked with evacuation paths through transect analysis, and one anticipated site whose opportunities and requirements were innovatively elaborated through transect analysis.

*Day 3: Departure and reflection.* Field work ended with reflections similar to the way that it began. The team had a silent departure with reflections on leave-taking, reconstruction and return. The analytical field methods were thus bookended by contemplative experience. While the methods described above emphasise the analytical approach, the importance of subjective experience deserves comment. Participants underscored their reflections on, as well as observations of, the patterns of devastation – and a sense of promise in the alternatives identified. They reported that these emotive aspects of field work shaped the interpretive level of transect analysis, and that balancing the reflective, analytical and descriptive aspects of site analysis is important for imagining the potential implications of site conditions.

### *Off-site analysis workshop methods*

Following the field work, the team lived for three days in a Zen monastery in Kyoto, continuing to reflect in part on landscape analysis, experience and alternatives at Utatsu. The design workshop then resumed off-site for three weeks where multi-university teams transcribed field data into digital format and developed initial site planning concepts. One test of the rapid visual site analysis methods was whether team members would retain a high level of clarity, detail and salience of site analysis knowledge during the off-site portion of the project. (A point of comparison was Orland and Bellafiore, 1990, where that did not occur, and where the authors reported that landscape experience and alternatives lost salience over time and with distance from the site.)

## Evaluation and discussion

This section presents the participant and author evaluations of how well different site analysis materials and techniques performed in practice. Criteria for evaluation were whether a method or resource was used, participant comments about its utility and author judgements about its contribution toward the identification of site alternatives. We distinguish methods that worked well as planned, worked well when adapted, performed with mixed results or performed weakly.

### *Preparatory materials*

The site analysis drawing set had an overall positive performance. Participants described the package as valuable for orientation in a complex post-disaster landscape, as an effective format for rapid recording when walking transect alignments and for comparing observations. Maps, plans and section worksheets were intensively used. The transect section methods worked well only after they were demonstrated in the field. The list of site analysis variables was deemed useful but would have been more so if reformatted as worksheets and checklists similar to those in some of the disaster literature reviewed above. Community meeting and personal reflection worksheets were used less. Although deeming them important, participants preferred other formats for note taking.

The Resource-CD held a large volume of relevant technical reports and data, but its performance was weaker. It worked well as a repository for immediately relevant project information, for example, base maps, but technical resources were little used. Its lack of use should perhaps not come as a surprise in a study that stresses visual methods, but we conclude that use of supporting scholarly information could be enhanced by establishing specific links with site analysis variables and hotlinks for ready access in the field.

## *On-site field methods*

Overall, the transect analysis method worked well. Each team was able to cover the nearly 0.5 kilometre alignment in the time available and record detailed visible evidence on commonly formatted plans and sections. Each team succeeded in using site analysis to expand the range of community centre alternatives and justify further study of those possibilities with fine-grained analysis. As emphasised above, rapid visual site analysis is an early phase of post-disaster reconstruction inquiry that must be followed by detailed site survey, screening, siting and planning.

Participants reported one way in which transect analysis as designed in this study was limited. Namely, time should have been allocated for all participants to undertake a rapid reconnaissance of all transects. Although the transects had several points of intersection, particularly in the coastal lowlands, which gave some sense of connectivity, the team concluded that expanding the range of choice is not merely an additive process but also one of envisioning combinations of site alternatives, for example, in networks or constellations of community spaces in Utatsu (Figure 8).

Again, participants reported favourably on the balance between descriptive, analytical and interpretive methods in the transect analysis. They stressed the challenges of maintaining that balance in post-disaster field work and indicated that each mode of site inquiry contributed separately and jointly to the aim of expanding the range of site alternatives worthy of further consideration.

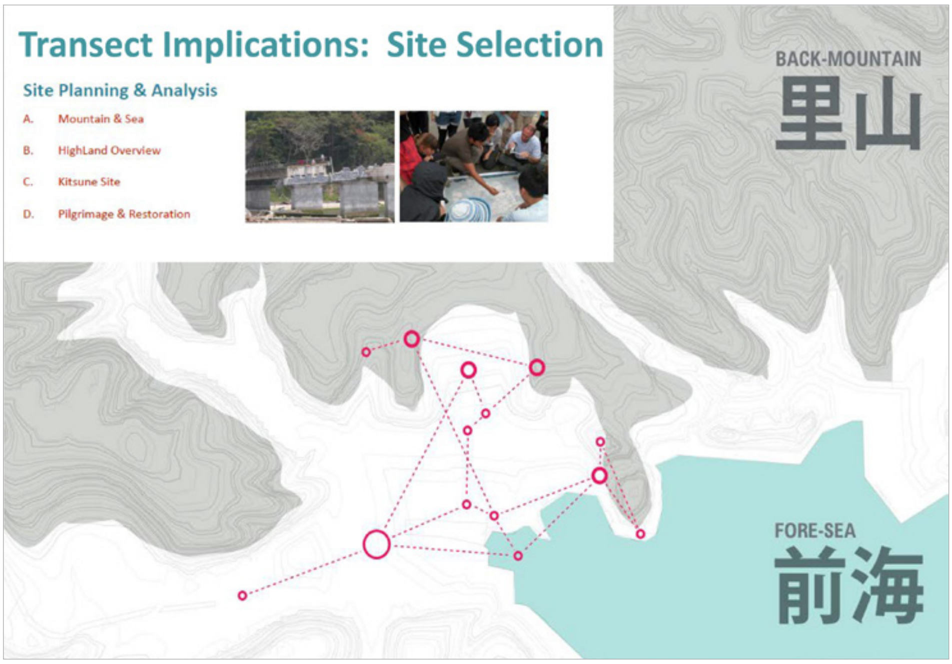


*Figure 8: Constellation of community centres and spaces identified in Utatsu, Japan. (Image courtesy of Yoshiro Okamoto.)*

### *Off-site synthesis*

Site analysis and planning methods employed after the field work had mixed results. On the positive side, the field-based site analysis work appeared to retain its salience and clarity for participants and in the evaluation of project leaders. Few expressed concerns about information gaps or deficiencies for the purposes of this initial pilot study. The main challenges involved changes in team membership that included the departure of some field researchers and arrival of others who had not participated in the field work. These challenges could be mitigated to an extent by more robust field drawing and annotation methods. The final section of this paper identifies further extensions of rapid visual site analysis methods for post-disaster landscape planning and design.

## Future extensions

Future research should enhance and test the replicability of methods employed at Utatsu. Enhancements could include refined field worksheets, stronger links with supporting scientific data and testing of alternative recording methods (for example, audio and/or video and tablet computing platforms). In substantive terms, it is important to determine how rapid visual assessment performs in different types and sizes of towns, for example, from the large municipal centre of Shizugawa to small fishing settlements such as the Hadenya area of Togura in Minamisanriku.[5] Further testing of transect methods for their robustness across different types of terrain is also necessary, for example, from rocky coastal headlands to the flat Sendai coastal plain. Future research must link visual site analysis with community-based methods of post-disaster landscape planning. Finally, in light of the hundreds of small coastal communities affected by disasters such as the Tohoku earthquake and tsunami, priority should be given to the adaptation of rapid visual site analysis methods for numerous small teams of local designers and community members.

## Acknowledgements

The authors gratefully acknowledge the co-leadership of Professor Yoshihiro Hiraoka of Miyagi University. Professor Hiroto Kobayashi and his team from Keio University also contributed. The MIT team benefited from generous funding from the MIT Japan 3.11 Initiative, Department of Architecture and Aga Khan Program for Islamic Architecture at MIT, Japan Disaster Relief Fund – Boston, Geraldine Kunstadter, and Japan Foundation Center for Global Partnership. Emily Lo helped design the site analysis drawing templates and Shoko Takemoto MCP helped with community meeting minutes and translations. Architect Saya Suzuki was an invaluable teaching assistant. Professor Jacky Bowring, Matthew Bunza and three anonymous reviewers provided helpful criticism and recommendations. Student participants from MIT, Miyagi and Keio universities devoted themselves to testing these disaster mitigation site analysis methods and expanding the range of choice.

## NOTES

1 All figures were prepared by MIT–Miyagi University Japan 3.11 workshop participants except as noted. The workshop took place in July 2011 (see Acknowledgements).

2 After screening to eliminate unrelated terms (for example, in the fields of chemistry, biology, physics), false hits ('web site analysis') and related terms that denote different types of environmental site analysis ('on-site analysis', 'multi-site analysis').

3 These limited results may reflect the move away from site analysis and related survey analysis and design methods in late twentieth-century practice (for example, Turner, 1991; though see response by Stiles, 1992). In the journal searches, new approaches were sometimes contrasted with 'conventional' or 'traditional' site analysis. Interestingly, one article included a critic's argument that site analysis was not research because it compiles existing knowledge and does not create new knowledge, which the critic deemed a matter of practice rather than research (Milburn and Brown, 2003).

4 Technically, the hillslope analysis follows an irregular alignment along the toe of slopes rather than a straight line and is not a 'transect' in a strict sense but rather a series of mini-transects cut where lower hillslopes meet the coastal plain.

5 Enhanced methods were tested in the settlement of Hadenya in August 2012 that included circuit and thematic areal analyses to complement transect and siting methods.

## REFERENCES

Active Learning Network for Accountability and Performance in Humanitarian Action (ALNAP) (2007) *Synthesis Report: Expanded Summary. Joint Evaluation of the International Response to the Indian Ocean Tsunami*, London: ALNAP Technical Evaluation Committee.

Aloudat, T and Christensen, L (2012) Psycho-social Recovery. In *The Routledge Handbook of Hazards and Disaster Risk Reduction*, B Wisner, JC Gaillard and I Kelman (eds), London: Routledge, pp 569–579.

American Society of Civil Engineers (2011) *Japan earthquake/tsunami reconnaissance teams, April 2011*. Accessed 25 October 2012, www.asce.org/PPLContent.aspx?id=12884906436

Anon (1985) Inadequate Site Analysis Caused Dam Failure, *World Construction* 38(8), pp 38–39.

Bocchiola, D, Medagliani, M and Rosso, R (2009) Use of a Regional Approach for Long-term Simulation of Snow Avalanche Regime: A Case Study in the Italian Alps, *Arctic, Antarctic, and Alpine Research* 41(3), pp 285–300.

Braae, E and Diedrich, L (2012) Site Specificity in Contemporary Large-scale Harbour Transformation Projects, *Journal of Landscape Architecture* 7(1), pp 20–33.

Buckland, ST (2001) *Introduction to Distance Sampling: Estimating Abundance of Biological Populations*, New York: Oxford University Press.

Corbin, CI (2003) Vacancy and the Landscape: Cultural Context and Design Response, *Landscape Journal* 22(1), pp 12–24.

FEMA (2002) *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook* (2nd edn), FEMA 154/155. Washington, DC: United States Federal Emergency Management Agency.

Francis, M (2001) A Case Study Method for Landscape Architecture, *Landscape Journal* 20(1), pp 15–29.

Free, M (2005) Earthquake Hazard Assessment – Some Lessons Learned from the December 2004 Sumatra–Andaman Islands Earthquake and Indian Ocean Tsunamis, *67th European Association of Geoscientists and Engineers – Extended Abstracts*, pp 1361–1363.

Gabriele, L, Barchiesi, F, Catallo, F, Dramis, F, Fubelli, G, Lucifora, S, Mattei, M, Pezzo, G and Puglisi, C (2009) GIS Methodology to Assess Landslide Susceptibility: Application to a River Catchment of Central Italy, *Journal of Maps* 2009, pp 87–93.

Goudie, A (1990) *Geomorphological Techniques*, Abingdon, UK: Routledge.

Harris, T (1988) Digital Terrain Modelling and Three-dimensional Surface Graphics for Landscape and Site Analysis in Archaeology and Regional Planning, *Computer and Quantitative Methods in Archaeology 1987*: CAA87, pp 161–170.

Hewitt, JK (2012) Culture, Hazard, and Disaster. In *The Routledge Handbook of Hazards and Disaster Risk Reduction*, B Wisner, JC Gaillard and I Kelman (eds), London: Routledge, pp 85–96.

Ikoda, Y (2011) Moving the Whole Town up Hill: An Algorithmic Search of Developable Land in Tsunami-hit Onagawa Town, *The 2011 East Japan Earthquake Bulletin of the Tohoku Geographical Association*. Accessed 25 October 2012, http://tohokugeo.jp/disaster/articles/e-contents19.html

Jayasuriya, S and McCawley, P (2010) *The Asian Tsunami: Aid and Reconstruction after a Disaster*, Cheltenham, UK: Edward Elgar Publishing with the Asian Development Bank Institute.

Jun, C (2000) Design of an Intelligent Geographic Information System for Multi-criteria Site Analysis, *URISA Journal* 12(3), pp 21–41.

Kar, B and Hodgson, ME (2008) A GIS-based Model to Determine Site Suitability of Emergency Evacuation Shelters, *Transactions in GIS* 12(2), pp 227–248.

Kent, M, Gill, W, Weaver, RE and Armitage, RP (1997) Landscape and Plant Community Boundaries in Biogeography, *Progress in Physical Geography* 21(3), pp 315–353.

Kyoto University (2012) Tohoku Research 1: Post-disaster Recovery, Kyoto University, Kyoto, Japan. Accessed October 2012, www.preventionweb.net/files/27633_tohokuresearchgroupkyotouniversity.pdf

LaGro, J (2007) *Site Analysis: A Contextual Approach to Sustainable Land Planning and Site Design* (2nd edn), New York: John Wiley & Sons.

Marsh, W (2010) *Landscape Planning: Environmental Application* (5th edn), New York: John Wiley & Sons.

Mazereeuw, M (2011) Preemptive Landscape: A Prototype for Coastal Urbanization along the Pacific Ring of Fire, *Topos* (76), pp 82–85.

Meyer, E (2001) Review of the Conference on: Territories: Contemporary European Landscape Design Harvard University Graduate School of Design, Cambridge, Massachusetts, 19–21 April 2001, *Landscape Journal* (20), pp 201–204.

Mikami, T, Shibayamay, T and Esteban, M (2012) Field Survey of the 2011 Tohoku Earthquake and Tsunami in Miyagi and Fukushima Prefectures, *Coastal Engineering Journal* 54(1), pp 1–26. Accessed 25 October 2012, www.worldscientific.com/doi/pdf/10.1142/S0578563412500118

Milburn, LS and Brown, RD (2003) The Relationship between Research and Design in Landscape Architecture, *Landscape and Urban Planning* (64), pp 47–66.

Mimura, N, Yasuhara, K, Kawagoe, S, Yokoki, H and Kazama, S (2011) Damage from the Great East Japan Earthquake and Tsunami – A Quick Report, *Mitigation and Adaptation Strategies for Global Change* 16(7), pp 803–816.

Miron, A, Rutz, E and Ray, P (2007) Site Analysis and Environmental Restoration, *ASEE Annual Conference and Exposition, Conference Proceedings*, *2007 ASEE Annual Conference and Exposition*. Accessed 25 October 2012, www.icee.usm.edu/icee/conferences/asee2007/papers/519_SITE_ANALYSIS_AND_ENVIRONMENTAL_RESTORAT.pdf

Mitani, H, Shinozawa, K, Takahashi, S and Tanabe, Y (2011) Tsunami Landscape: Reflections from Japan, *Topos* (76), pp 77–81.

Mitchell, JK (2008) Perspectives on Alternatives: Differentiation and Integration in Pursuit of a Better Fit between Society and Nature, Mini-forum on the Contributions of Gilbert F. White, *Progress in Human Geography* 32(3), pp 451–458.

Miyagi Prefectural Government (October 2011) *Miyagi Prefecture Earthquake Disaster Recovery Plan: The Bond between Miyagi, Tohoku and Japan – from Recovery to Prosperity*. Accessed 25 October 2012, www.pref.miyagi.jp/seisaku/sinsaihukkou/keikaku/keikakugaiyou_en.pdf

Murphy, MD (2005) *Landscape Architecture Theory: An Evolving Body of Thought,* Long Grove, IL: Waveland Press.

Mutunayagam, NB (1986) *Cartography and Site Analysis with Microcomputers: A Programming Guide for Physical Planning, Urban Design, and Landscape Architecture*. New York: Van Nostrand Reinhold.

National Research Council (United States) and National Academy of Environmental Design (United States) (2010) Disaster-Resilient Design Workshop, 20 October 2010, Washington, DC. Accessed 9 December 2012, http://dels-old.nas.edu/dr/f30.shtml

National Tsunami Hazard Mitigation Program (NTHMP) (2001) *Designing for Tsunamis— Seven Principles for Planning and Designing for Tsunami Hazards.* Seattle: National Tsunami Hazard Mitigation Program.

Noh, T (1966) Sanriku Coast Prepared for Tsunami: A Preliminary Report on Men's Defense against Natural Disaster. Accessed 25 October 2012, http://ir.library.tohoku.ac.jp/re/bitstream/10097/44873/1/AA0045945066165.pdf

Orland, B and Bellafiore, VJ (1990) Development Directions for a Sacred Site in India, *Landscape and Urban Planning* 19(2), pp 181–196.

Ozdemir, A (2008) Preventing Natural Hazard Risks through Sustainable Site Design, *Polish Journal of Environmental Studies* 17(4), pp 457–462.

Powers, RD (1981) Fatal Accident Site Analysis, Proceedings of the Paving Conference 18th, University of New Mexico, Albuquerque, New Mexico, 7–9 January, pp 332–336.

Showalter, PS and Lu, Y (eds)(2010) *Geospatial Techniques in Urban Hazard and Disaster Analysis,* New York: Springer.

Sphere Project (2011) *Humanitarian Charter and Minimum Standards in Humanitarian Response,* Rugby, UK: Practical Action Publishing.

Stiles, R (1992) Determinism versus Creativity, *Landscape Design* (212), pp 30–32.

Turner, T (1991) The SAD Design Method vs Pattern Analysis And Design, *Landscape Design* Issue #204 (updated and edited with additional essays). Accessed 25 October 2012, www.gardenvisit.com/history_theory/garden_landscape_design_articles/design_methods/sad_design_method

UNISDR (2006) *Tsunami Bibliography*, Geneva: United Nations International Strategy for Disaster Reduction.

Way, DS (1982) *Terrain Analysis: A Guide to Site Selection Using Aerial Photographic Interpretation* (2nd edn), Stroudsburg, PA: Hutchinson Ross Publishing Company.

Wescoat, JL Jr (2011) Disaster-resilient Design, *Architecture, Design, Art* 15, pp 77–83.

——(1987) The Practical Range of Choice in Water Resources Geography, *Progress in Human Geography* 11(1), pp 41–59.

White, ET (2004) *Site Analysis: Diagramming Information for Architectural Design*, Tallahassee, FL: Architectural Media Ltd.

White, GF (1961) The Choice of Use in Natural Resources Management, *Natural Resources Journal* 1, pp 23–40.

Xu, L, Yu, H, Cao, W and Xie, L (2010) Evaluation of Site Dependence and Methods for Site Analysis Based on Far-field Ground Motions from the Wenchuan Earthquake, *Acta Seismologica Sinica (Earthquake Science)* 32(2), pp 175–183.