**MEMANFAATKAN JARINGAN SENSOR NIRKABEL DENGAN SENSOR PERCEPATAN H48C SEBAGAI SISTEM AKUISISI DATA DAN SISTEM PERINGATAN DINI BENCANA TANAH LONGSOR**

Analisis bentuk lahan (landform) untuk penilaian bahaya dan risiko longsor di pulau ternate provinsi maluku utara. Berdasarkan pengamatan penulis, bencana alam yang terjadi di pulau ini, terutama tanah longsor dan banjir, tampaknya mengiringi fenomena klimatik (hujan) dan perubahan penggunaan lahan terutama yang berlangsung di wilayah perbukitan. Untuk itu fenomena perubahan penggunaan lahan di pulau ini sudah waktunya untuk dikaji dengan lebih seksama. manfaat sebagai upaya dalam pengurangan risiko bencana terutama longsor. Dan bahan masukan bagi Pemerintah Kota Ternate dalam upaya penanggulangan bencana terutama tanah longsor.

Parameter longsor dianalisis dengan penentuan skor dan bobot serta pengkelasan tiap parameter seperti hasil observasi lapangan. Ini sesuai dengan Van Western et al (2003) bahwa tingkat bahaya longsor dapat dianalisis menggunakan kombinasi antara skoring dan pembobotan berdasarkan kontribusi relatif parameter terhadap bahaya tanah longsor.

Faktor kerentanan (susceptible) longsor dan faktor pemicu longsor yang dipadukan dapat membantu dalam menganalisis wilayah bahaya longsor. Faktor pemicu longsor yang digunakan pada penelitian ini yaitu aktifitas manusia. Hal ini dimaksudkan untuk melihat sejauh mana aktifitas manusia dalam mempengaruhi potensi longsor. Lahan di lokasi penelitian yang cenderung memicu terjadinya longsor didominasi oleh lahan terbuka, penambangan pasir dan batu, dan semak belukar. Lahan terbuka dapat dengan mudah melongsorkan material longsoran karena tidak ada pelindung pada area tersebut yang dapat menahan pemicu longsor seperti hujan. Penambangan pasir dan batu dapat memicu longsor karena dapat merubah stabilitas lereng dengan cara memotong lereng dan menggalinya.

Sedangkan penggunaan lahan di lokasi penelitian yang diduga dapat menghindarkan proses pelongsoran seperti hutan, perkebunan tahunan, pemukiman dan bandara. Hutan dan perkebunan tahunan yang juga berfungsi menjadi hutan dapat menghindarkan proses longsor (Shear strength) karena memiliki sistem perakaran pohon yang dalam sehingga dapat menahan laju longsoran. Permukiman dan bandara juga dapat menghindarkan longsor karena tidak berada pada tebing yang terjal sehingga tidak menyebabkan daya tekan (shear stress).

Jejak longsor ini sebagian besar relatif disebabkan oleh ulah manusia (anthropogenik) yang merubah kemiringan lereng sehingga dapat membuat lereng lebih berpotensi longsor. Resiko longsor akan terus meningkat jika penggunaan lahan untuk permukiman tidak dikendalikan secara baik.

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| Tabel 1. Jenis Disabilitas dan Sistem Peringatan Bencana   |  |  |  | | --- | --- | --- | | **Jenis Disabilitas** | **Kebutuhan** | **Sistem Peringatan Bencana** | | Kecacatan/ | • *Landmarks*/Petunjuk | • Sistem Sinyal Berbasis | | Gangguan Visual | • *Hand-rails* | Suara/*Alarm* | |  | • Dukungan personal | • Pengumuman lisan | |  | • Pencahayaan yang baik | • Poster yang ditulis dengan | |  | • Antrian terpisah | huruf yang besar dan warna yang mencolok | | Kecacatan/ | • Bantuan penglihatan | • Sistem Sinyal Berbasis | | Gangguan Pendengaran | • Komunikasi dengan | *Visual*: simbol, bendera | |  | gambar | merah, dll | |  | • Antrian terpisah | * Gambar * Sinyal kedip lampu | | Kecacatan/ | • Berbicara pelan | • Sinyal khusus: simbol, | | Gangguan Mental | • Bahasa yang sederhana | bendera merah, dll | |  | • Dukungan personal | • Pengumuman yang jelas dan | |  | • Antrian terpisah | lengkap oleh tenaga siaga bencana | | Kecacatan/ | • Baju hangat/selimut | • Sistem Sinyal berbasis | | Gangguan Fisik | • Kasur, tempat kering, | Suara/Alarm | |  | alat higienis • Dukungan personal   * Alat bantu * Sarana publik yang dimodifikasi ( pegangan tangan, jalan landai) • Antrian terpisah | • Pengumuman lisan |   Sumber: Handicap International, 2005  Tabel 1. Domain Perhitungan   |  |  |  |  | | --- | --- | --- | --- | | **Domain** | **Jarak Grid DX=DY (m)** | **Jumlah Grid** | **Batas Koordinat** | | A | 614.79 | 1948 x 1029 | 104.93o s/d 115.93o  BT  5.756o s/d 11.52o LS | | B | 204.93 | 571 x 286 | 110.52o s/d 111.59o BT  8.03o s/d 8.56o LS | | C | 68.31 | 1084 x 679 | 110.74o s/d 111.41o BT  8.09o s/d 8.51o LS | | D | 22.77 | 1780 x 1327 | 110.90o s/d 111.27o  BT  8.13o s/d 8.41o LS | | E | 7.59 | 2203 x 2014 | 111.02o s/d 111.16o BT 8.17o s/d 8.31o LS | | F | 2.54 | 2125 x 2236 | 111.06o s/d 111.12o BT 8.19o s/d 8.24o LS |   Tabel 2. Skenario Gempa dan Simulasi LimpasanTsunami Sampai ke Daratan   |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **Skenario** | **MW** | **Epicenter** | | **Depth** | **Stk** | **Dip** | **Slip** | **L** | **W** | **D** | |  |  |  |  |  |  |  |  |  | |  |  | **Lat** | **Lon** | **deg** | **deg** | **deg** | **km** | **km** | **km** | **m** | | 1 | 7.7 | -9.861 | 110.905 | 12 | 280 | 15 | 90 | 111 | 46 | 9 | | 2 | 8.0 | -9.861 | 110.905 | 12 | 280 | 15 | 90 | 165 | 15 | 15 | | 3 | 8.3 | -9.861 | 110.905 | 12 | 280 | 15 | 90 | 240 | 20 | 20 | |  |  |  |  |  |  |  |  |  |  |  | | 4 | 7.7 | -9.459 | 110.979 | 24 | 280 | 15 | 90 | 111 | 46 | 3 | | 5 | 8.0 | -9.459 | 110.979 | 24 | 280 | 15 | 90 | 165 | 60 | 5 | | 6 | 8.3 | -9.459 | 110.979 | 24 | 280 | 15 | 90 | 240 | 75 | 7 |   Tabel 3. Pencatatan Tinggi Tsunami dan Waktu Tempuhnya Skenario 1   |  |  |  |  | | --- | --- | --- | --- | | ***Point*** | **TTT** | **T*max*** | **Waktu** | |  | **(menit)** | **(m)** | **( menit )** | | 1 | 34.0 | 7.27 | 35.8 | | 2 | 34.3 | 9.16 | 35.4 | | 3 | 34.3 | 8.73 | 35.6 | | 4 | 34.3 | 7.15 | 35.5 |   Keterangan:  Point : titik-titik observasi  TTT: Tsunami *Travel Time* (waktu tempuh tsunami)  T *max* : ketinggian maksimum tsunami  *Time* : waktu terjadinya tinggi maksimum  Tabel 4. Pencatatan tinggi tsunami dan waktu   |  |  |  |  | | --- | --- | --- | --- | | **Point** | **TTT** | **Tmax** | **Waktu** | |  | **(menit)** | **(m)** | **( menit )** | | 1 | 33.7 | 13.62 | 34.9 | | 2 | 34.0 | 15.79 | 34.9 | | 3 | 33.9 | 14.13 | 35.2 | | 4 | 33.7 | 11.57 | 35.2 |   tempuhnya skenario 2    Dari hasil pacu model selama 1 jam  Tabel 5. Pencatatan tinggi tsunami dan waktu  tempuhnya skenario 3   |  |  |  |  | | --- | --- | --- | --- | | ***Point*** | **TTT** | **T*max*** | **Waktu** | |  | **(menit)** | **(m)** | **( menit )** | | 1 | 33.2 | 17.08 | 35.1 | | 2 | 33.6 | 20.68 | 34.8 | | 3 | 33.5 | 19.26 | 35.0 | | 4 | 33.3 | 15.08 | 35.2 |   Tabel 6. Pencatatan tinggi tsunami dan waktu tempuhnya skenario 4   |  |  |  |  | | --- | --- | --- | --- | | **Point** | **TTT** | **T*max*** | **Waktu** | |  | **(menit)** | **(m)** | **( menit )** | | 1 | 29.5 | 3.47 | 32.6 | | 2 | 30.0 | 4.28 | 32.1 | | 3 | 29.9 | 4.16 | 32.9 | | 4 | 30.1 | 3.78 | 32.7 |   Tabel 7. Pencatatan tinggi tsunami dan waktu  tempuhnya skenario 5   |  |  |  |  | | --- | --- | --- | --- | | ***Point*** | **TTT** | **T*max*** | **Waktu** | |  | **(menit)** | **(m)** | **( menit )** | | 1 | 29.2 | 6.22 | 31.9 | | 2 | 29.6 | 7.22 | 31.5 | | 3 | 29.5 | 7.01 | 31.9 | | 4 | 29.6 | 6.39 | 31.8 |   Tabel 8. Pencatatan tinggi tsunami dan waktu  tempuhnya skenario 6   |  |  |  |  | | --- | --- | --- | --- | | ***Point*** | **TTT** | **T*max*** | **Waktu** | |  | **(menit)** | **(m)** | **(menit)** | | 1 | 28.7 | 8.40 | 32.3 | | 2 | 29.1 | 8.46 | 30.9 | | 3 | 29.0 | 8.32 | 31.3 | | 4 | 29.0 | 7.85 | 32.1 |   Tabel 1. Kepadatan penduduk menurut  Kabupaten/Kota di Provinsi Maluku  UtaraPeringatan Bencana   |  |  |  |  | | --- | --- | --- | --- | |  |  |  | Kepadatan | |  | Luas | Jumlah | Penduduk | | Kabupaten/Kota | daratan | Penduduk | ( Jiwa/ | |  | (Km2) | (Jiwa) | Km2) | | Halmahera Barat | 2.612,24 | 97.971 | 38 | | Halmahera Tengah | 2.276,83 | 34.821 | 15 | | Halmahera Selatan | 8.779,32 | 192.312 | 22 | | Halmahera Utara | 5.447,30 | 194.778 | 36 | | Halmahera Timur | 6.506,20 | 69.912 | 11 | | Ternate | 250,85 | 172.604 | 688 | | Tidore Kep. | 9.564 | 82.302 | 9 | | Kep. Sula | 9.632,92 | 34.821 | 14 |   Sumber : BPS Provinsi Maluku Utara, 2010  Tabel 2. Jenis dan sumber data Penelitian dilaksanakan selama 6 bulan   |  |  | | --- | --- | | **Jenis data** | **Sumber data** | | Batas pulau Ternate      Lereng  Tekstur tanah    Penggunaan lahan      Bentuklahan  (*landform*)    Bangunan  Risiko longsor | Peta administrasi Kota  Ternate 1:50.000. Bappeda Kota  DEM SRTM 90 m  Pengamatan lapang, unit lahan 1:50.000  Peta tutupan lahan Kota  Ternate 1:50.000. Bappeda Kota Ternate  DEM SRTM 90 m,  *Hillshade*, Geo Eye pada  *Google Earth*  Bappeda Kota Ternate  Peta bahaya dan peta kerentanan |   Tabel 3. Kepadatan penduduk menurut  Kabupaten/Kota di Provinsi Maluku  UtaraPeringatan Bencana   |  |  |  | | --- | --- | --- | | **Parameter Skor**  **Lereng (%) 0,4**  0 - 8 1  8 - 15 2  15 - 30 3  30 - 45 4  >45 5 | |  | | **Bentuklahan 0,3** | |  | | • Kawah, dataran pantai anthropogenik, gisik, Maar | | 0 | | • Lereng kaki fluvio vulkanik, aliran lava |  | 1 | | • Lereng bawah kerucut vulkanik |  | 2 | | • Lereng atas kerucut vulkanik |  | 3 | | • Lereng tengah dan lereng puncak kerucut vulkanik |  | 4 | | **Tekstur** | **0 , 2** |  | | • Pasir (*Sand*) |  | 1 | | • Lempung berpasir (*Sandy loam*) |  | 2 | | • Lempung (*Loam*) |  | 3 | | • Lempung berliat (*clay loam*),  Lempung berdebu (*Silt loam*) ,  Liat berpasir (*sandy clay*) |  | 4 | | • Liat (*Clay*) |  | 5 | | **Penggunaan lahan** | **0 , 1** |  | | • Danau, bakau dan hutan |  | 0 | | • Pemukiman, perkebunan tahunan dan bandara |  | 1 | | • Semak belukar |  | 2 | | • Penambangan pasir dan penambangan batu vulkan |  | 3 | | • Lahan terbuka |  | 4 |   Tabel 4. Bentuk lahan di Pulau Ternate   |  |  |  | | --- | --- | --- | | **Jenis landform** | **Luas** | **Persentase** | |  | **(ha)** | **( % )** | | Kawah | 1,9 | 0,019 | | Lereng puncak kerucut | 146 | 1 , 4 | | Lereng atas kerucut | 899 | 8 , 9 | | Lereng tengah kerucut | 2.690 | 26 , 5 | | Lereng bawah kerucut | 3.160 | 31 , 2 | | Lereng kaki fluvio | 2.650 | 26 , 1 | | Aliran lava | 271 | 2 , 7 | | Maar laguna | 16,6 | 0 , 16 | | Maar Tolire besar | 24,3 | 0 , 24 | | Maar Tolire kecil | 2,1 | 0 , 02 | | Gisik pantai (*beach*) | 253 | 2 , 5 | | Daratan pantai *anthropogenik* | 25,1 | 0 , 25 |   Sumber : Hasil analisis, 2012  Tabel 5. Nilai interval kelas bahaya longsor di Pulau Ternate   |  |  |  |  | | --- | --- | --- | --- | | **Kelas**  **Bahaya**  **Longsor** | **Nilai**  **Interval** | **Luasan**  **(Ha)** | **Persentase**  **(%)** | | Aman  Rendah  Sedang  Tinggi | 0,6 – 1,5  1,6 – 2,4  2,5 – 3,2  3,3 – 4,1 | 1.835 2.420 3.015  2.860 | 18 , 1  23 , 8  29 , 7  28 , 2 |   Sumber : Hasil analisis, 2012  Tabel 6. Nilai interval kelas bahaya longsor di  Pulau Ternate   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Kelas** |  | **Jumlah** | **% jumlah** |  | | **Bahaya** | **Persentase** | **titik** | **titik** | **FR** | | **Longsor** | **luasan (%)** | **longsor** | **Longsor** |  | | Aman | 18,1 | 0 | 0 | 0 | | Rendah | 23,8 | 12 | 60 | 2 , 5 | | Sedang | 29,7 | 7 | 35 | 1 , 1 | | Tinggi | 28,2 | 1 | 5 | 0 , 1 |   Sumber : Hasil analisis, 2012  Tabel 7. Nilai kerentanan bangunan terhadap longsor  **Kelas Jumlah bangunan (unit)**   |  |  |  |  | | --- | --- | --- | --- | | **bahaya** | **Rumah** | **Non** | **Jumlah** | | **longsor** |  | **rumah** | **Total** | |  |  |  |  | | Aman | 18.662 | 509 | 19.171 | | Rendah | 7.306 | 163 | 7.469 | | Sedang | 470 | 7 | 487 | | Tinggi | 3 | 1 | 4 | | **Jumlah** | **26.441** | **691** | **27.131** |   Sumber : Hasil analisis, 2012  Tabel 8. Nilai risiko bangunan terhadap longsor   |  |  |  |  | | --- | --- | --- | --- | | **bangunan Bobot** | **Rendah**  0,17 | **Sedang**  0,33 | **Tinggi**  0 , 50 | | Rumah 0,7  Non rumah 0,3 | 0,119  0,051 | 0,231  0,099 | 0 , 35  0 , 15 |   Sumber : Hasil analisis, 2012  Tabel 9. Nilai kerentanan bangunan terhadap longsor  **Kelas Nilai Tipe bangunan (unit) risiko interval Rumah Non**  **penduduk rumah**   |  |  |  | | --- | --- | --- | | Rendah | 0,15 – 0,91 6.996 | 165 | | Sedang | 0,92 – 1,68 455 | 0 | | Tinggi | 1,69 – 2,45 3 | 0 |   Sumber : Hasil analisis, 2012   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  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 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | Tabel 1. Jenis Disabilitas dan Sistem Peringatan Bencana   |  |  |  | | --- | --- | --- | | **Jenis Disabilitas** | **Kebutuhan** | **Sistem Peringatan Bencana** | | Kecacatan/ | • *Landmarks*/Petunjuk | • Sistem Sinyal Berbasis | | Gangguan Visual | • *Hand-rails* | Suara/*Alarm* | |  | • Dukungan personal | • Pengumuman lisan | |  | • Pencahayaan yang baik | • Poster yang ditulis dengan | |  | • Antrian terpisah | huruf yang besar dan warna yang mencolok | | Kecacatan/ | • Bantuan penglihatan | • Sistem Sinyal Berbasis | | Gangguan Pendengaran | • Komunikasi dengan | *Visual*: simbol, bendera | |  | gambar | merah, dll | |  | • Antrian terpisah | * Gambar * Sinyal kedip lampu | | Kecacatan/ | • Berbicara pelan | • Sinyal khusus: simbol, | | Gangguan Mental | • Bahasa yang sederhana | bendera merah, dll | |  | • Dukungan personal | • Pengumuman yang jelas dan | |  | • Antrian terpisah | lengkap oleh tenaga siaga bencana | | Kecacatan/ | • Baju hangat/selimut | • Sistem Sinyal berbasis | | Gangguan Fisik | • Kasur, tempat kering, | Suara/Alarm | |  | alat higienis • Dukungan personal   * Alat bantu * Sarana publik yang dimodifikasi ( pegangan tangan, jalan landai) • Antrian terpisah | • Pengumuman lisan |   Sumber: Handicap International, 2005  Tabel 1. Domain Perhitungan   |  |  |  |  | | --- | --- | --- | --- | | **Domain** | **Jarak Grid DX=DY (m)** | **Jumlah Grid** | **Batas Koordinat** | | A | 614.79 | 1948 x 1029 | 104.93o s/d 115.93o  BT  5.756o s/d 11.52o LS | | B | 204.93 | 571 x 286 | 110.52o s/d 111.59o BT  8.03o s/d 8.56o LS | | C | 68.31 | 1084 x 679 | 110.74o s/d 111.41o BT  8.09o s/d 8.51o LS | | D | 22.77 | 1780 x 1327 | 110.90o s/d 111.27o  BT  8.13o s/d 8.41o LS | | E | 7.59 | 2203 x 2014 | 111.02o s/d 111.16o BT 8.17o s/d 8.31o LS | | F | 2.54 | 2125 x 2236 | 111.06o s/d 111.12o BT 8.19o s/d 8.24o LS |   Tabel 2. Skenario Gempa dan Simulasi LimpasanTsunami Sampai ke Daratan   |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **Skenario** | **MW** | **Epicenter** | | **Depth** | **Stk** | **Dip** | **Slip** | **L** | **W** | **D** | |  |  |  |  |  |  |  |  |  | |  |  | **Lat** | **Lon** | **deg** | **deg** | **deg** | **km** | **km** | **km** | **m** | | 1 | 7.7 | -9.861 | 110.905 | 12 | 280 | 15 | 90 | 111 | 46 | 9 | | 2 | 8.0 | -9.861 | 110.905 | 12 | 280 | 15 | 90 | 165 | 15 | 15 | | 3 | 8.3 | -9.861 | 110.905 | 12 | 280 | 15 | 90 | 240 | 20 | 20 | |  |  |  |  |  |  |  |  |  |  |  | | 4 | 7.7 | -9.459 | 110.979 | 24 | 280 | 15 | 90 | 111 | 46 | 3 | | 5 | 8.0 | -9.459 | 110.979 | 24 | 280 | 15 | 90 | 165 | 60 | 5 | | 6 | 8.3 | -9.459 | 110.979 | 24 | 280 | 15 | 90 | 240 | 75 | 7 |   Tabel 3. Pencatatan Tinggi Tsunami dan Waktu Tempuhnya Skenario 1   |  |  |  |  | | --- | --- | --- | --- | | ***Point*** | **TTT** | **T*max*** | **Waktu** | |  | **(menit)** | **(m)** | **( menit )** | | 1 | 34.0 | 7.27 | 35.8 | | 2 | 34.3 | 9.16 | 35.4 | | 3 | 34.3 | 8.73 | 35.6 | | 4 | 34.3 | 7.15 | 35.5 |   Keterangan:  Point : titik-titik observasi  TTT: Tsunami *Travel Time* (waktu tempuh tsunami)  T *max* : ketinggian maksimum tsunami  *Time* : waktu terjadinya tinggi maksimum  Tabel 4. Pencatatan tinggi tsunami dan waktu   |  |  |  |  | | --- | --- | --- | --- | | **Point** | **TTT** | **Tmax** | **Waktu** | |  | **(menit)** | **(m)** | **( menit )** | | 1 | 33.7 | 13.62 | 34.9 | | 2 | 34.0 | 15.79 | 34.9 | | 3 | 33.9 | 14.13 | 35.2 | | 4 | 33.7 | 11.57 | 35.2 |   tempuhnya skenario 2    Dari hasil pacu model selama 1 jam  Tabel 5. Pencatatan tinggi tsunami dan waktu  tempuhnya skenario 3   |  |  |  |  | | --- | --- | --- | --- | | ***Point*** | **TTT** | **T*max*** | **Waktu** | |  | **(menit)** | **(m)** | **( menit )** | | 1 | 33.2 | 17.08 | 35.1 | | 2 | 33.6 | 20.68 | 34.8 | | 3 | 33.5 | 19.26 | 35.0 | | 4 | 33.3 | 15.08 | 35.2 |   Tabel 6. Pencatatan tinggi tsunami dan waktu tempuhnya skenario 4   |  |  |  |  | | --- | --- | --- | --- | | **Point** | **TTT** | **T*max*** | **Waktu** | |  | **(menit)** | **(m)** | **( menit )** | | 1 | 29.5 | 3.47 | 32.6 | | 2 | 30.0 | 4.28 | 32.1 | | 3 | 29.9 | 4.16 | 32.9 | | 4 | 30.1 | 3.78 | 32.7 |   Tabel 7. Pencatatan tinggi tsunami dan waktu  tempuhnya skenario 5   |  |  |  |  | | --- | --- | --- | --- | | ***Point*** | **TTT** | **T*max*** | **Waktu** | |  | **(menit)** | **(m)** | **( menit )** | | 1 | 29.2 | 6.22 | 31.9 | | 2 | 29.6 | 7.22 | 31.5 | | 3 | 29.5 | 7.01 | 31.9 | | 4 | 29.6 | 6.39 | 31.8 |   Tabel 8. Pencatatan tinggi tsunami dan waktu  tempuhnya skenario 6   |  |  |  |  | | --- | --- | --- | --- | | ***Point*** | **TTT** | **T*max*** | **Waktu** | |  | **(menit)** | **(m)** | **(menit)** | | 1 | 28.7 | 8.40 | 32.3 | | 2 | 29.1 | 8.46 | 30.9 | | 3 | 29.0 | 8.32 | 31.3 | | 4 | 29.0 | 7.85 | 32.1 |   Tabel 1. Kepadatan penduduk menurut  Kabupaten/Kota di Provinsi Maluku  UtaraPeringatan Bencana   |  |  |  |  | | --- | --- | --- | --- | |  |  |  | Kepadatan | |  | Luas | Jumlah | Penduduk | | Kabupaten/Kota | daratan | Penduduk | ( Jiwa/ | |  | (Km2) | (Jiwa) | Km2) | | Halmahera Barat | 2.612,24 | 97.971 | 38 | | Halmahera Tengah | 2.276,83 | 34.821 | 15 | | Halmahera Selatan | 8.779,32 | 192.312 | 22 | | Halmahera Utara | 5.447,30 | 194.778 | 36 | | Halmahera Timur | 6.506,20 | 69.912 | 11 | | Ternate | 250,85 | 172.604 | 688 | | Tidore Kep. | 9.564 | 82.302 | 9 | | Kep. Sula | 9.632,92 | 34.821 | 14 |   Sumber : BPS Provinsi Maluku Utara, 2010  Tabel 2. Jenis dan sumber data Penelitian dilaksanakan selama 6 bulan   |  |  | | --- | --- | | **Jenis data** | **Sumber data** | | Batas pulau Ternate      Lereng  Tekstur tanah    Penggunaan lahan      Bentuklahan  (*landform*)    Bangunan  Risiko longsor | Peta administrasi Kota  Ternate 1:50.000. Bappeda Kota  DEM SRTM 90 m  Pengamatan lapang, unit lahan 1:50.000  Peta tutupan lahan Kota  Ternate 1:50.000. Bappeda Kota Ternate  DEM SRTM 90 m,  *Hillshade*, Geo Eye pada  *Google Earth*  Bappeda Kota Ternate  Peta bahaya dan peta kerentanan |   Tabel 3. Kepadatan penduduk menurut  Kabupaten/Kota di Provinsi Maluku  UtaraPeringatan Bencana   |  |  |  | | --- | --- | --- | | **Parameter Skor**  **Lereng (%) 0,4**  0 - 8 1  8 - 15 2  15 - 30 3  30 - 45 4  >45 5 | |  | | **Bentuklahan 0,3** | |  | | • Kawah, dataran pantai anthropogenik, gisik, Maar | | 0 | | • Lereng kaki fluvio vulkanik, aliran lava |  | 1 | | • Lereng bawah kerucut vulkanik |  | 2 | | • Lereng atas kerucut vulkanik |  | 3 | | • Lereng tengah dan lereng puncak kerucut vulkanik |  | 4 | | **Tekstur** | **0 , 2** |  | | • Pasir (*Sand*) |  | 1 | | • Lempung berpasir (*Sandy loam*) |  | 2 | | • Lempung (*Loam*) |  | 3 | | • Lempung berliat (*clay loam*),  Lempung berdebu (*Silt loam*) ,  Liat berpasir (*sandy clay*) |  | 4 | | • Liat (*Clay*) |  | 5 | | **Penggunaan lahan** | **0 , 1** |  | | • Danau, bakau dan hutan |  | 0 | | • Pemukiman, perkebunan tahunan dan bandara |  | 1 | | • Semak belukar |  | 2 | | • Penambangan pasir dan penambangan batu vulkan |  | 3 | | • Lahan terbuka |  | 4 |   Tabel 4. Bentuk lahan di Pulau Ternate   |  |  |  | | --- | --- | --- | | **Jenis landform** | **Luas** | **Persentase** | |  | **(ha)** | **( % )** | | Kawah | 1,9 | 0,019 | | Lereng puncak kerucut | 146 | 1 , 4 | | Lereng atas kerucut | 899 | 8 , 9 | | Lereng tengah kerucut | 2.690 | 26 , 5 | | Lereng bawah kerucut | 3.160 | 31 , 2 | | Lereng kaki fluvio | 2.650 | 26 , 1 | | Aliran lava | 271 | 2 , 7 | | Maar laguna | 16,6 | 0 , 16 | | Maar Tolire besar | 24,3 | 0 , 24 | | Maar Tolire kecil | 2,1 | 0 , 02 | | Gisik pantai (*beach*) | 253 | 2 , 5 | | Daratan pantai *anthropogenik* | 25,1 | 0 , 25 |   Sumber : Hasil analisis, 2012  Tabel 5. Nilai interval kelas bahaya longsor di Pulau Ternate   |  |  |  |  | | --- | --- | --- | --- | | **Kelas**  **Bahaya**  **Longsor** | **Nilai**  **Interval** | **Luasan**  **(Ha)** | **Persentase**  **(%)** | | Aman  Rendah  Sedang  Tinggi | 0,6 – 1,5  1,6 – 2,4  2,5 – 3,2  3,3 – 4,1 | 1.835 2.420 3.015  2.860 | 18 , 1  23 , 8  29 , 7  28 , 2 |   Sumber : Hasil analisis, 2012  Tabel 6. Nilai interval kelas bahaya longsor di  Pulau Ternate   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Kelas** |  | **Jumlah** | **% jumlah** |  | | **Bahaya** | **Persentase** | **titik** | **titik** | **FR** | | **Longsor** | **luasan (%)** | **longsor** | **longsor** |  | | Aman | 18,1 | 0 | 0 | 0 | | Rendah | 23,8 | 12 | 60 | 2 , 5 | | Sedang | 29,7 | 7 | 35 | 1 , 1 | | Tinggi | 28,2 | 1 | 5 | 0 , 1 |   Sumber : Hasil analisis, 2012  Tabel 7. Nilai kerentanan bangunan terhadap longsor  **Kelas Jumlah bangunan (unit)**   |  |  |  |  | | --- | --- | --- | --- | | **bahaya** | **Rumah** | **Non** | **Jumlah** | | **longsor** |  | **rumah** | **Total** | |  |  |  |  | | Aman | 18.662 | 509 | 19.171 | | Rendah | 7.306 | 163 | 7.469 | | Sedang | 470 | 7 | 487 | | Tinggi | 3 | 1 | 4 | | **Jumlah** | **26.441** | **691** | **27.131** |   Sumber : Hasil analisis, 2012  Tabel 8. Nilai risiko bangunan terhadap longsor   |  |  |  |  | | --- | --- | --- | --- | | **bangunan Bobot** | **Rendah**  0,17 | **Sedang**  0,33 | **Tinggi**  0 , 50 | | Rumah 0,7  Non rumah 0,3 | 0,119  0,051 | 0,231  0,099 | 0 , 35  0 , 15 |   Sumber : Hasil analisis, 2012  Tabel 9. Nilai kerentanan bangunan terhadap longsor  **Kelas Nilai Tipe bangunan (unit) risiko interval Rumah Non**  **penduduk rumah**   |  |  |  | | --- | --- | --- | | Rendah | 0,15 – 0,91 6.996 | 165 | | Sedang | 0,92 – 1,68 455 | 0 | | Tinggi | 1,69 – 2,45 3 | 0 |   Sumber : Hasil analisis, 2012  Untuk mendeteksi pergerakan tanah dengan akselerometer, diperlukan beberapa perangkat keras, yakni :  1. **Modul Wireless RF** Saat ini, telah banyak dikembangkan modul *wireless* RF. Salah satu modul *wireless* RF yang sering dipakai adalah *X-Bee Pro*, buatan Maxstream. Modul ini memiliki spesifikasi XBP-24/1083, dan beroperasi pada frekuensi 2,4 GHz. Fitur yang dimiliki oleh modul ini adalah : 1. Radius jangkauannya mencapai 300 meter di dalam ruangan, dan mencapai 1,5 kilometer di luar ruangan  2. Sensitivitas penerimaan mencapai -100dBm. 3. RF data *rate* 250.000 bps. 4. Setiap *channel* menyediakan alamat jaringan lebih dari 65.000 alamat. 5. Mendukung topologi *peer to peer, point* *to multiple poin,* dan *point to point.* 6. Bentuk paket modul relatif kecil. 7. Kompatible dengan perangkat lain yang mendukung teknologi *Zigbee/* *IEEE* 802.15.4.  **2. Sensor Percepatan 3 Poros H48C (3 Axis** **Accelerometer H48C)** H48C merupakan sensor percepatan yang mampu mendeteksi pergerakan dari 3 sumbu yaitu x, y, dan z. Sensor ini memberikan keluaran berupa data digital hasil konversi tegangan dengan resolusi ADC 12 bit  3. **Controller** Kontroler yang digunakan merupakan perangkat mikrokontroler Arduino board tipe *Deumilanove* dengan mikrokontroler *Atmega*328. *Arduino Board* dipih karena mudah digunakan, terutama karena ada fasilitas *plug and play* pada komunikasi serial dengan komputer  **4. Unit *Real Time Condition*  (RTC)** Unit RTC digunakan sebagai unit sinkronisasi waktu dari tiap - tiap *node*. Unit RTC terhubung dengan *arduino board.* Unit RTC yang digunakan adalah IC DS1307. Tegangan kerja unit RTC disuplai oleh *controller* dan juga oleh baterai *lithium* 3V sebagai cadangan jika terjadi kegagalan suplai dari *controller*.  **5. Komputer**  Komputer berfungsi untuk menerima data dari sensor  **IV. HASIL DAN PEMBAHASAN**  **4.1. Akuisisi Data Percepatan Pergerakan**  **Tanah**  **Dalam penelitian ini, penbacaan percepatan pergerakan tanah menggunakan modul *accelerometer* buatan Parallax.Inc dimana dalam modul ini sensor yang digunakan adalah H48C dan telah terintegrasi dengan 4 *chanel* 12-bit A/D *converter* with serial interface MCP3204.**    **Blok diagram dari H48C ditunjukan oleh gambar 1. Dengan AOX sebagai *analog output* sumbu x, AOY sebagai *analog output* sumbu y, AOZ sebagai *analog output* sumbu y, dan *Vref* sebagai tegangan referensi. Maka, untuk mengetahui besarnya percepatan yang dinyatakan dalam level tegangan analog untuk tiap sumbu adalah sebagai berikut.**  **Skema Rangkaian Percobaan**  **Rangkaian pengujian menggunakan modul 3 *axis accelerometer* H48C dan kontrolernya menggunakan *Arduino board* tipe *Deumilanove*. Skematik rangkaian pengujian ditunjukan oleh gambar 10.**    **Dari modul *accelerometer* hanya dibutuhkan 3 pin untuk melakukan pembacaan, yakni :**  **1. Pin DIO sebagai jalur digital *input* /**  **output, terhubung dengan pin 4 *Arduino***  ***board.***  **2. Pin CLK untuk pemberian *clock triger***  **sensor dan terhubung dengan Pin 5**  ***Arduino board*.**  **Pin CS (*Chip Select*) untuk aktifasi modul, terhubung dengan Pin 6 *Arduino board*.**  **Algoritma Pembacaan Percepatan Tiap Sumbu**  **Pembuatan algoritma pembacaan tiap sumbu didasarkan pada *timing* diagram dari MCP3204 (gambar 19). Dalam modul *accelerometer* yang digunakan, jalur DIN dan DOUT digabungkan menjadi 1 dan disebut pin DIO.**    **gX = AOX – Vref (mV).........................(6) gY = AOY – Vref (mV).........................(7) gZ = AOZ – Vref (mV)..........................(8)**  **Karena pin DIN dan DOUT digabungkan menjadi 1 pin, maka untuk memungkinkan pembacaan data sensor diperlukan kontroler untuk mengatur kondisi pin DIO sebagai output pada saat pengiriman control bit dan sebagai input pada saat pembacaan data hasil konversi MCP3204. Konfigurasi kontrol bit untuk pembacaan tiap chanel sesuai dengan tabel 1.**  **Mengingat bahwa CH0 = AOX, CH1 = AOY, CH2 = AOZ, CH3 = Vref maka alternatif konfigurasi input yang paling mudah adalah dengan *input single – ended* yakni dengan men-set bit *Single/Diff* bernilai 1.**  **Notasi algoritmik untuk pembacaan modul *accelerometer* adalah sebagai berikut .**  **Tabel 1. Konfigurasi Bit Kontrol MCP3204**   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Control Bit**  **Selections** | | | | **Input**  **Configuration** | **Channel**  **Selection** | | **Single/**  **Diff** |  | | | | **D2\*** | **D1** | **D0** | | **1** | **X** | **0** | **0** | **single-ended** | **CH0** | | **1** | **X** | **0** | **1** | **single-ended** | **CH1** | | **1** | **X** | **1** | **0** | **single-ended** | **CH2** | | **1** | **X** | **1** | **1** | **single-ended** | **CH3** | | **0** | **X** | **0** | **0** | **differential** | **CH0 = IN+**  **CH1 =IN-** | | **0** | **X** | **0** | **1** | **differential** | **CH0 = IN-**  **CH1 =IN+** | | **0** | **X** | **1** | **0** | **differential** | **CH2 = IN+**  **CH3 =IN-** | | **0** | **X** | **1** | **1** | **differential** | **CH2 = IN-**  **CH3 =IN+** |   **Procedure getH48C ( input=D1,D0) S et DIO sebagai Output S et CLK sebagai output S et /CS sebagai output { --Kirim start bit--} C LK ke 1 (*Falling edge),*CS=0,DIO=1 *{--Kirim kontrol bit--}* C LK ke 2, DIO=1 *{--single ended--}* C LK ke 3, DIO=0 *{--D2 (don’t care)--}* C LK ke 4, DIO=D1 C LK ke 5, DIO=D0 *{--D1.D0 = 00* *sb x D 1.D0 = 01* *sb y D 1.D0 = 10* *sb z D 1.D0 = 11* *sb Vref--}* C LK ke 6 *{-- --}* C LK ke 7 *{--nul bit--}* S et DIO sebagai Input *{--ambil data dan simpan di array--}* C LK ke 8, dValue[11] = DIO C LK ke 9, dValue[10] = DIO C LK ke 10, dValue[9] = DIO C LK ke 11, dValue[8] = DIO C LK ke 12, dValue[7] = DIO CLK ke 13, dValue[5] = DIO C LK ke 14, dValue[6] = DIO C LK ke 15, dValue[4] = DIO C LK ke 16, dValue[3] = DIO C LK ke 17, dValue[2] = DIO C LK ke 18, dValue[1] = DIO C LK ke 19, dValue[0] = DIO F or i=11 to i=0 begin Data += dValue[i]\*2^i End. C S=1 Return data**  Dari notasi algoritmik diatas, kemudian dikonversi kedalam bahasa C versi arduino karena kontroler yang digunakan adalah *arduino board*.  Untuk pembacaan nilai tegangan dilakukan dengan memanggil prosedur getH48C (D1,D0) dengan D1 = 1 dan D0 = 0 untuk membaca Vref, D1 = 0, D0 = 0 untuk membaca nilai sumbu X, D1 = 0, D0 = 1 untuk membaca nilai sumbu Y, dan D1 = 1 dan D0 = 0 untuk membaca nilai pada sumbu Z. Contoh pemanggilan prosedur untuk pembacaan nilai Vref, sumbu X, sumbu Y, dan sumbu Z adalah sebagai berikut.  integer dX, dY, dZ = 0; ref = getH48C(1,1); dX = getH48C(0,0); dY = getH48C(0,1); dZ = getH48C(1,0);  Sesuai dengan persamaan (6), (7), dan (8) maka level tegangan untuk tiap sumbu dinyatakan dengan mengeksekusi perintah berikut.  Nilai gX, gY, dan gZ masih dalam level tegangan yang dinyatakan dengan nilai ADC 12 bit (0 hingga 4095). Untuk menyatakan kedalam nilai g sesuai dengan jangkauan pembacaan sensor (-3 g hingga +3g) maka digunakan persamaan berikut.  Berdasarkan persamaan 4.4, nilai 4095 adalah nilai maksimum ADC 12 bit, 3.3 adalah tegangan suplai H48C dan 0.3663 adalah nilai tegangan keluaran 1g. Untuk memudahkan penulisan program, persamaan diatas disederhanakan menjadi persamaan 4.5 berikut.  Sehingga, source code untuk pembacaan nilai g untuk tiap sumbu adalah sebagai berikut.  Hasil pengujian program untuk pembacaan nilai g menggunakan source code diatas dilihat menggunakan serial monitor dengan baud rate 9600 bps sesuai dengan gambar 20.  **4.2. Komunikasi Data *X-Bee Wireless* RF**  Untuk mengirimkan data percepatan menggunakan *wireless X-Bee* digunakan 2 buah modul yakni modul *router* dan *coordinator*.  Modul router berfungsi untuk melakukan pengukuran percepatan kemudian mengirimkanya ke modul coordinator sedangkan fungsi coordinator untuk menerima data dari router kemudian mengirimkanya ke server.  Sehingga masing – masing modul menjalankan program yang berbeda.  Pada pengujian digunakan 2 buah router dan 1 buah *coordinator* dengan alamat sebagai berikut.  *Router* 1 = 5070  *Router* 2 =4D36  *Coordinator* = 7E63  **Algoritma Program Router**  1. Menentukan alamat tujuan (ATDL dan  ATDH)  2. Menentukan jumlah payload untuk  menampung data yang akan dikirimkan.  3. Melakukan pembacaan data RTC dan  accelerometer.  4. Menampung data pada payload dan  encode data.  5. Mengirim data.  Pada pengujian digunakan coordinator dengan alamat : 7E63 kemudian jumlah payload adalah 15 dengan rincian sebagai berikut.  • *Payload* [0] menampung data jam.  • *Payload* [1] menampung data menit  • *Payload* [2] menampung data detik  • *Payload* [3] menampung data tanggal  • *Payload* [4] menampung data bulan  • *Payload* [5] menampung data tahun  • *Payload* [6]&[7] menampung data Vref  • *Payload* [8] &[9]menampung data Ax  • *Payload* [10] &[11] menampung data Ay  • *Payload* [12] &[13] menampung data Az  • *Payload* [14] menampung data 0x00  **Algoritma Program Coordinator**  1. Membaca data dari router.  2. Decode data.  3. Mengirim data ke server via USB.  Hasil pembacaan dari *frame* data yang dikirim oleh *router* adalah sebagai berikut.  7E 00 14 81 4D 36 24 00 02 2D 0E 1A 01 0C 07 FF 08 D9 07 7C 09 6D 00 C7  Sehingga dapat di *decode* kan sebagai berikut.  • 7E = *Start byte*  • 00 14 = Panjang data  • 81 = frame type API  • 4D36 = Alamat pengirim  • 24 = Kuat sinyal (RSSI)  • 00 = Sisa data terkirim  • 02 = Data Jam  • 2D = Data menit  • 0E = Data Detik  • 1A = Data tanggal  • 01 = Data bulan  • 0C = Data tahun  • 07 FF= data Vref  • 08 D9 = Data Ax  • 07 7C = Data Ay  • 09 6D = Data Az  • 00 = Data *payload* [14]  • C7 = *Check Sum*    Gambar 21 menunjukan contoh hasil pembacaan coordinator yang ditampilkan menggunakan hyperterminal pada komputer server.  Kesimpulan.  1. *Accelerometer* H48C dapat digunakan  sebagai alat akuisisi data pergerakan  tanah.  2. Data hasil pembacaan sensor  *accelerometer* H48C dapat dikirimkan  secara *remote* menggunakan *wireless*  RF dengan memanfaatkan modul  X-Bee.  3. Dengan mengetahui struktur frame  data komunikasi *wireless* yang  menggunakan protokol *ZigBee*  maka kita dapat dengan leluasa  melakukan pengiriman dan penerimaan  data sesuai kebutuhan.  4. Jaringan sensor nirkabel memiliki  kelebihan dalam segi fleksibilitas  dibandingkan transmisi data  menggunakan kabel. | |