Enhancing the discussion of alternatives in EIA using principle component analysis leads to improved public involvement

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Background 1

1. A linkage between alternatives analysis and public involvement is a key factor for improving the quality of EIA report (Kamijo and Huang 2016);
2. However, alternatives analysis has been a weak aspect in the quality of EIA report (Glasson et al. 1997; Cashmore et al. 2002; Pinho et al. 2007; Sandham et al. 2013); and
3. The discussion of alternatives have also been limited (Rajavanshi 2003; Jalava et al. 2010; Sainath and Rajan 2015).

Background 2

1. Multiple criteria analysis (MCA) is a decision making method by exploring the balance between the pros and cons of different alternatives (Geneletti and Ferretti 2015) and a simple MCA method is most appropriate (Hajikowicz 2008);
2. There are many previous studies about MCA, such as an analytic hierarchy process (AHP) (Dey 2001; Marre et al. 2016), FLAG model (Schetke and Hasse 2008), Delphi method (Zakaira et al. 2013); and
3. These papers explain the mathematical algorithm but do not explain the discussion of alternatives.

Background 3

1. The previous studies reveal the drawbacks of public involvement, such as little consideration to environmental impacts (Sinclair and Diduck 2000), too late participation (Steinemann 2001), a lack of understanding of the process (Wiklund 2011);
2. There are studies focused on alternatives and public involvement (Slotterback 2008; Cuppen et al. 2012; Hoover and Stern 2014); and
3. However, little is know about the actual discussion of alternatives and public involvement or the countermeasures for improving the link between two.

Objective of the study

The study aims:

1. to clarify the actual discussion of alternatives quantitatively;
2. to show a positive correlation between the discussion of alternatives and the sense of public involvement; and
3. to show the effectiveness of principle component analysis (PCA) as a method of alternatives analysis.

Data and methods 1

1. Quantitative text analysis (QTA) is a method of content analysis for analyzing text data using quantitative analysis method;
2. QTA was applied to the minutes of meetings of three projects using five coding rules: environmental issues; social issues; development issues; discussion of alternatives; and the sense of public involvement; and
3. The number of paragraphs corresponding to each coding rule was counted according to each stakeholder and the appearance ratio was calculated.

Data and methods 2

1. PCA is a procedure for identifying a smaller number of uncorrelated variables (principal components: PCs) from a large set of data without much loss of information;
2. PCA was applied to the scores of alternatives against the evaluation criteria for three projects; and
3. PCA was applied to six cases of alternatives analysis contained in previous studies.

Three case studies

1. *Airport Improvement Project in Guatemala (AIP), 2006*

   24 category stakeholders and 8 meetings with 1,231 participants, 19 site alternatives and 6 criteria with summation method.

2. *CALA National Road Project in the Philippines (CNRP), 2006*

   13 category stakeholders and 16 meetings with 996 participants, 4 network alternatives and 8 criteria with summation method.

3. *Second Mekong Bridge Project in Cambodia (SMBP), 2006*

   18 category stakeholders and 15 meetings with 1,595 participants, 4 alternatives and 13 criteria with AHP method.

Data and methods 3

QTA to the minutes of meetings

PCA to the alternatives against criteria

Comparison of PCA and present MCA methods

Coding rule of QTA to the minutes of meetings

*Environmental issues

air, ecosystem, fauna, flora, health, noise, odor, pollution, sedimentation, smell, vibration, waste, or water

*Social issues

accident, acquire, acquisition, AIDS, compensate, compensation, concession, employee, employment, house, income, job, labor, land, landownership, livelihood, living, loss, ownership, poverty, property, relocation, resettle, resettlement, safety, settlement, safety, settlement, settler, squatter, unemployment, or worker

*Development issues

access, cargo, congestion, decentralization, developer, development, economic, economy, factory, industrialization, industry, invest, investment, investor, jam, market, tourism, tourist, traffic, transport, transportation, or traveler

*Alternatives

alternative, criterion, option, scenario, or site

*Sense of public involvement

concensus, consultation, coordination, involve, involvement, participate, participation, stakeholder, or transparency

Public meetings of AIP in Guatemala

Stage	Date and place	Agenda	Attendance and stakeholders
1st stage	July 24, 2004 Escuintla	Outline of project and EIA, JICA EIA guidelines, public consultation process and information disclosure, scoping of EIA study, and alternatives.	141 (NIAPO, MCIH, local governments, CODECO, businesses, industry, agriculture, land owners, local people, NGOs, community members, labor unions, the media, and JICA).
	July 25, 2004 Masagua		181(NIAPO, MCIH, local governments, CODECO, businesses, industry, agriculture, land owners, local people, NGOs, community members, the religious sector, the media, and JICA).
	July 30, 2004 Guatemala		205 (NIAPO, MCIH, local governments, CODECO, businesses, industry, construction, land owners, NGOs, local people, pilots, air cargo, air traffic controllers, NISVMH, colleges, lawyers, the media, and JICA).
2nd stage	Nov. 13, 2004 Masagua	Consideration of alternatives (selection of preferable airport sites).	182(NIAPO, MCIH, local governments, CODECO, businesses, transportation, agriculture, pilots, community members, local people, and JICA).
	Nov. 14, 2004 Escuintla		202 (NIAPO, MCIH, local governments, CODECO, businesses, transportation, construction, land owners, airport users, community members, local people, the media, and JICA).
	Nov. 17, 2004 Guatemala		121 (NIAPO, MCIH, local governments, businesses, agriculture, property owners, land owners, air traffic controllers, labor unions, community members, local people, lawyers, and JICA).
3rd stage	Jan. 27, 2006 Guatemala	Results of feasibility study, draft of EIA report, land use plan, and economic analysis.	52 (NIAPO, MCIH, local governments, businesses, land owners, universities, the media, and JICA).
	Jan. 29, 2006 Masagua		147 (NIAPO, MCIH, local governments, CODECO, businesses, land owners, local people, university, religious groups, and JICA).
Total			Over 1,231

Note: NIAPO: New International Airport Project Office, MCIH: Ministry of Communications, Infrastructure and Housing, CODECO: Community Development Councils, NISVMH: National Institute of Seismology, Volcanology, Meteorology and Hydrology, JICA: Japan International Cooperation Agency.
Source: Data from JICA 2006a.

QTA result of AIP in Guatemala

Stakeholders	Environmental issues		Social issues		Development issues		Alternatives		Sense of public involvement		Paragraph
Airport Improvement Project in Guatemala (AIP)											
NIAPO	25	12%	81	38%	83	39%	55	26%	21	10%	213
Local people	2	3%	20	31%	13	20%	12	18%	2	3%	65
CODECO	7	6%	10	18%	10	18%	3	5%	1	2%	55
Facilitator	0	0%	4	17%	4	17%	1	4%	4	17%	23
Business	2	9%	6	27%	6	27%	5	23%	1	5%	22
Consultant	4	21%	9	47%	5	26%	10	53%	1	5%	19
Landowner	0	0%	17	94%	4	22%	6	33%	2	11%	18
Aviation	7	47%	2	13%	5	33%	4	27%	2	13%	15
MCIH	3	25%	2	17%	1	8%	1	8%	0	0%	12
Farm/Agriculture	0	0%	4	33%	1	8%	2	17%	1	8%	12
Central government	0	0%	8	73%	0	0%	0	0%	2	18%	11
Local government	3	27%	5	45%	1	9%	1	9%	1	9%	11
NGOs	1	13%	3	38%	1	13%	0	0%	0	0%	8
Construction	0	0%	1	17%	2	33%	1	17%	0	0%	6
DGCA	0	0%	3	60%	1	20%	0	0%	1	20%	5
Developer	2	50%	2	50%	3	75%	0	0%	0	0%	4
Media	1	25%	1	25%	1	25%	1	25%	0	0%	4
Labor union	0	0%	3	100%	1	33%	1	33%	1	33%	3
Transportation	0	0%	1	50%	2	100%	1	50%	0	0%	2
Industry	0	0%	1	50%	1	50%	1	50%	0	0%	2
NISVMH	0	0%	0	0%	0	0%	1	50%	0	0%	2
College	0	0%	1	100%	1	100%	1	100%	0	0%	1
Religion	0	0%	1	100%	0	0%	0	0%	0	0%	1
Lawyer	0	0%	0	0%	0	0%	0	0%	0	0%	1
Total	57	11%	185	36%	146	28%	107	21%	40	8%	515
Chi-square		436.8		468.6		445.3		461.3		421.9	

Public meetings of CNRP in the Philippines

Stage	Date and place	Agenda	Attendance and stakeholders
1st stage	March 17, 2005 Pasay City	Outline of project, public consultation process, alternatives, and scoping of EIA.	70 (DPWH, ministries and agancies, local governments, barangay, businesses, developers, homeowners, and JICA).
	June 16, 2005 Muntinlupa		81 (DPWH, ministries and agancies, local governments, businesses, NGOs, and JICA).
2nd stage	Sep. 23, 2005 Kawit, Cavite	Considerations of alternatives and scoping of EIA.	98 (DPWH, ministries and agancies, local governments, barangay, businesses, large property owners, homeowners, NGOs, and JICA).
	Dec. 7, 2005 Cavite	Selected alternatives, progress of EIA study, and framework of project plan.	65 (DPWH, local governments, barangay, large property owners, and JICA).
	Dec. 9, 2005 Laguna		38 (DPWH, local governments, barangay, large property owners, and JICA).
	March 14, 2006 Laguna	Results of EIA study and selected project.	36 (DPWH, ministries and agancies, local governments, large property owners, and JICA)
	March 15, 2006 Cavite		103 (DPWH, ministries and agancies, local governments, barangay, large property owners, and JICA).
3rd stage	June 2, 2006 Cavite	Outline of feasibility study, EIA study, and RP.	115 (DPWH, ministries and agancies, local governments, barangay, businesses, developers, NGOs, and JICA).
	July 18, 2006 Tanza, Cavite	Progress of feasibility study and RAP framework.	11 (DPWH, local governments, affected households, and JICA).
	July 28, 2006 Imus, Cavite		33 (DPWH, local governments, affected households, and JICA).
	Aug. 2, 2006 Trias, Cavite		15 (DPWH, local governments, barangay, and JICA).
	Aug. 4, 2006 Bacoor, Cavite		118 (DPWH, local governments, barangay, affected households, and JICA).
	Aug. 25, 2006 Rosa, Laguna		12 (DPWH, local governments, barangay, and JICA).
	Aug. 26, 2006 Dasmarinas, Cavite		54 (DPWH, local governments, barangay, affected households, and JICA).
	Aug. 29, 2006 Silang, Cavite		16 (DPWH, local governments, barangay, affected households, and JICA).
	Sep. 8, 2006 Dasmarinas, Cavite	Results of feasibility study and RAP framework.	131 (DPWH, ministries and agancies, local governments, barangay, businesses, large property owners, and JICA).
Total			Over 996

Note: DPWH: Department of Public Works and Highways, RP: Resettlement Policy, RAP: Resettlement Action Plan, JICA: Japan International Cooperation Agency.
Source: Data from JICA 2006b.

QTA result of CNRP in the Philippines

Stakeholders	Environmental issues		Social issues		Development issues		Alternatives		Public involvement		Paragraph
CALA National Road Project in the Philippines (CNRP)											
DPWH	9	4%	93	36%	92	36%	43	17%	70	27%	256
Local government	4	5%	21	26%	46	57%	10	12%	11	14%	81
Consultant	2	6%	15	35%	27	63%	11	26%	9	21%	43
Local people	0	0%	19	56%	2	6%	3	9%	0	0%	34
Baranguay	1	3%	11	34%	2	6%	1	3%	1	3%	32
Councillor	0	0%	6	29%	7	33%	0	0%	7	33%	21
Business	1	5%	8	40%	8	40%	5	25%	4	20%	20
Homeowner	0	0%	8	57%	0	0%	1	7%	0	0%	14
Property owner	0	0%	2	67%	2	67%	0	0%	1	33%	3
NGOs	1	50%	2	100%	0	0%	0	0%	2	100%	2
JBIC	0	0%	0	0%	1	100%	0	0%	1	100%	1
HUDCC	0	0%	0	0%	0	0%	0	0%	1	100%	1
Facilitator	0	0%	0	0%	0	0%	0	0%	1	100%	1
Total	18	4%	185	36%	187	37%	74	15%	108	21%	509
Chi-square		361.0		415.0		381.8		402.0		354.0	

Public meetings of SMBP in Cambodia

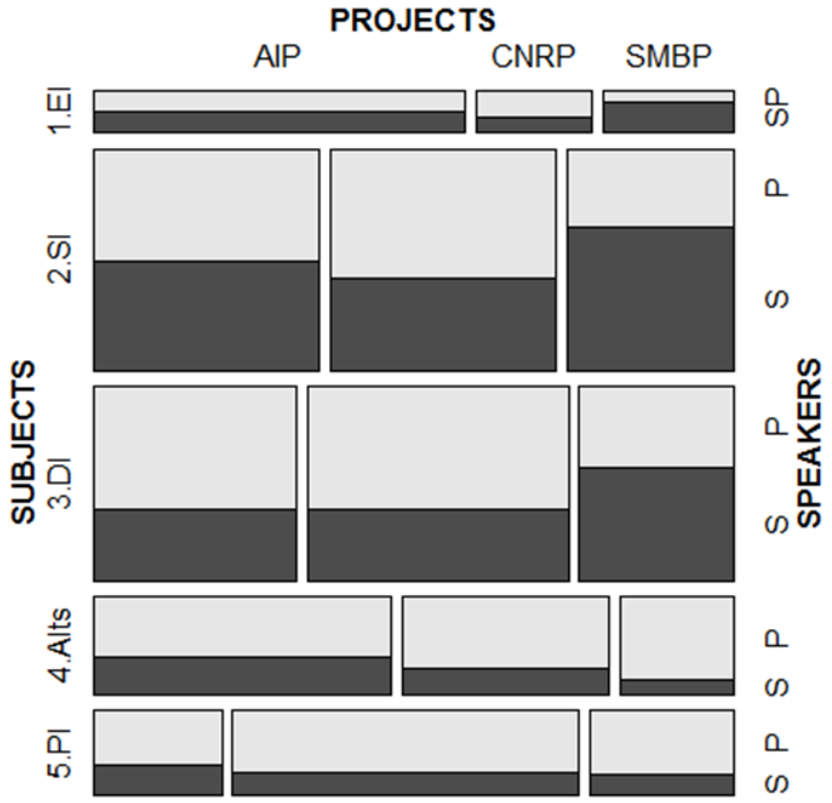
Stage	Date and place	Agenda	Attendance and stakeholders
1st stage	May 24, 2004 Phnom Penh	Outline of project and EIA, JICA EIA guidelines, public consultation process, and scoping of EIA study.	142 (MPWT, ministries and agencies, local governments, communes, Neak Loeung ferry, NGOs, universities, the private sector, embassies, and JICA).
	June 21, 2004 Neak Loeung		107 (MPWT, ministries and agencies, 76 local people, Neak Loeung ferry, NGOs, and JICA).
2nd stage	Oct. 7, 2004 Phnom Penh	Alternatives analysis method and regional development scenario.	71 (MPWT, ministries and agencies, local governments, Neak Loeung ferry, universities, the media, donors, embassies, and JICA).
	Oct. 28, 2004 Neak Loeung		55 (MPWT, 41 minorities (39 Vietnamese and two Muslims), NGOs, and JICA).
	Dec. 27, 2004 Phnom Penh	AHP, alternatives and evaluation criteria.	83 (MPWT, ministries and agencies, local governments, communes, Neak Loeung ferry, NGOs, universities, the media, donors, the private sector, and JICA).
	Dec. 28, 2004 Neak Loeung		132 (MPWT, 79 local people, two Chams, and JICA).
	Mar. 10, 2005 Phnom Penh	Best option selected and consensus process.	Not available.
3rd stage	June 3, 2005 Phnom Penh	Outline and scoping of EIA study and public consultation of RAP.	82 (MPWT, ministries and agencies, local governments, communes, Neak Loeung ferry, universities, the media, donors, the private sector, embassies, and JICA).
	June 7, 2005 Neak Loeung		114 (MPWT, ministries and agencies, 98 local people, NGOs, and JICA).
	June 8, 2005 Neak Loeung		Over 100 (MPWT, 100 local people, and JICA).
	July 11, 2005 Neak Loeung		Over 172 (MPWT, 172 local people, and JICA).
	Sep. 20, 2005 Phnom Penh	Interim result of EIA study, preliminary bridge design and outline of RAP.	92 (MPWT, ministries and agencies, local governments, communes, Neak Loeung ferry, universities, the media, donors, the private sector, and JICA).
	Sep. 21, 2005 Neak Loeung		Over 122 (MPWT, 122 local people, NGOs, and JICA).
	Jan. 24, 2006 Phnom Penh	Final results of EIA study, feasibility study including bridge design, and a draft framework of RAP.	83 (MPWT, ministries and agencies, communes, Neak Loeung ferry, universities, embassies, and JICA).
	Jan. 29, 2006 Neak Loeung		Over 240 (MPWT, ministries and agencies, 240 local people, and JICA).
Total			Over 1,595

Note: MPWT: Ministry of Public Works and Transportation, AHP: Analytic Hierarchy Process, RAP: Resettlement Action Plan, JICA: Japan International Cooperation Agency.
Source: Data from JICA 2006c.

QTA result of SMBP in Cambodia

Stakeholders	Environmental issues		Social issues		Development issues		Alternatives		Public involvement		Paragraph
Second Mekong Bridge Project in Cambodia (SMBP)											
MPWT	2	3%	34	47%	28	39%	13	18%	19	26%	72
Local people	7	11%	49	74%	24	36%	1	2%	0	0%	66
Consultant	2	4%	12	24%	17	33%	21	41%	15	29%	51
Commune	0	0%	11	65%	8	47%	0	0%	0	0%	17
NGOs	2	14%	9	64%	4	29%	2	14%	5	36%	14
District	0	0%	3	25%	5	42%	2	17%	1	8%	12
MRC	2	18%	2	18%	7	64%	0	0%	2	18%	11
Business	2	20%	6	60%	5	50%	0	0%	0	0%	10
Facilitator	1	14%	2	29%	1	14%	1	14%	0	0%	7
Ferry	0	0%	5	100%	0	0%	0	0%	0	0%	5
University	0	0%	1	20%	2	40%	0	0%	0	0%	5
City Hall	0	0%	0	0%	2	40%	0	0%	0	0%	5
MoEF	1	20%	1	20%	4	80%	0	0%	3	60%	5
MoE	1	50%	0	0%	2	100%	1	50%	0	0%	2
Port	0	0%	1	50%	0	0%	0	0%	0	0%	2
MAC	0	0%	0	0%	1	100%	0	0%	0	0%	1
MoA	0	0%	0	0%	1	100%	0	0%	0	0%	1
MoPT	0	0%	0	0%	0	0%	0	0%	0	0%	1
Total	20	7%	136	47%	111	39%	41	14%	45	16%	287
Chi-square		172.1		189.8*		181.7		182.9		209.6**	

QTA results by project proponents and participating stakeholders



AIP: 515, CNRP: 509, SMBP: 287, and Total 1311 paragraphs
EI: environmental issues (95 paragraphs)
SI: social issues (506)
DI: development issues (444)
Alt: alternatives (222)
PI: public involvement (193)
P: project proponent (688)
S: participating stakeholders (623)

Correlation coefficient between alternatives and public involvement: 0.65 (p=.000, n=24)

Alternatives analysis using PCA 1

AIP in Guatemala

Summation table of AIP

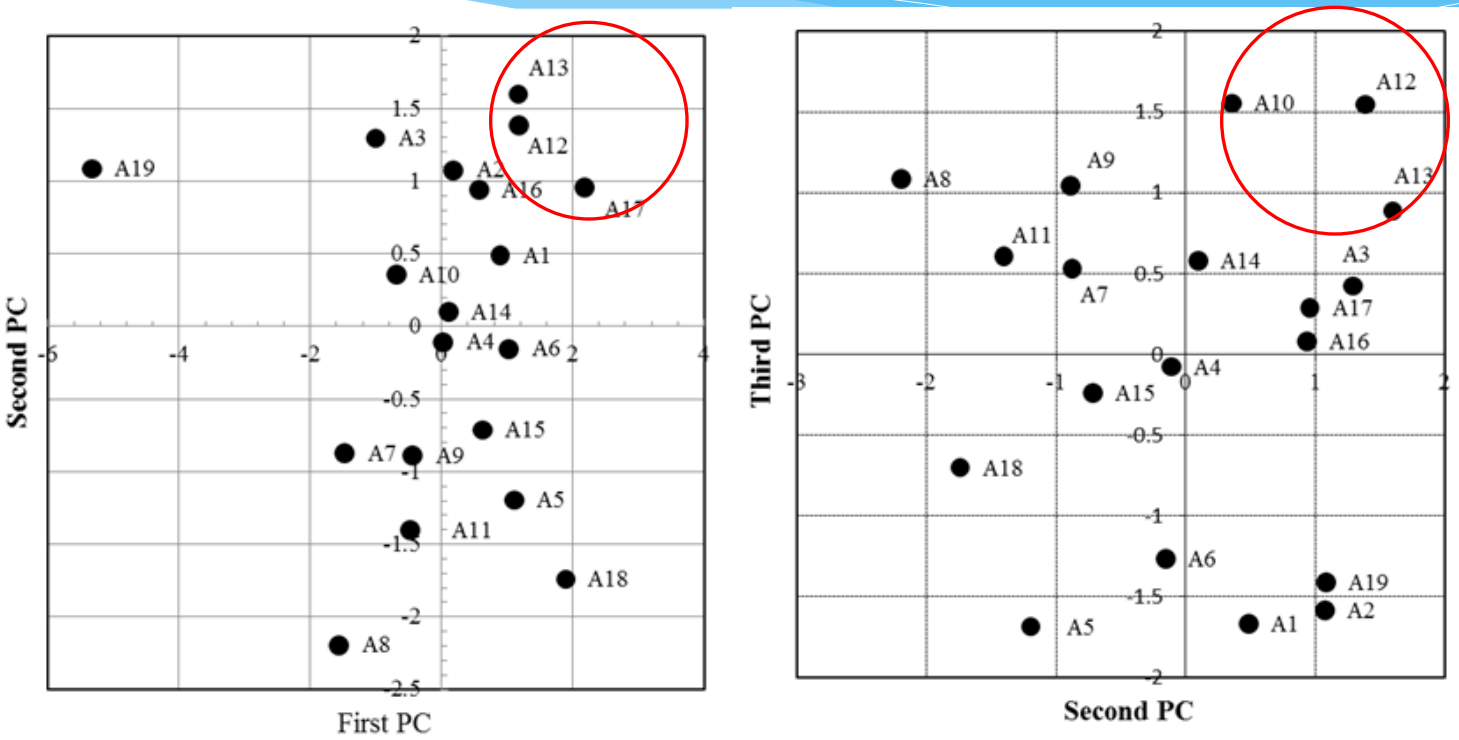
Alternatives	Air space	Environment	Access	Social aspects	Resettlement	Construction	Total
A1	15.2	11.4	8.0	10.0	15.0	9.0	68.6
A2	15.2	12.3	10.0	10.0	12.0	7.4	66.9
A3	20.0	13.2	15.0	8.0	9.0	6.2	71.4
A4	20.0	11.4	9.0	8.0	12.0	9.0	69.4
A5	15.2	10.5	5.0	10.0	12.0	14.0	66.7
A6	15.2	12.3	8.0	10.0	12.0	13.0	70.5
A7	15.2	9.6	20.0	8.0	9.0	13.4	75.2
A8	20.0	9.6	11.0	6.0	6.0	13.8	66.4
A9	20.0	9.6	18.0	8.0	12.0	12.6	80.2
A10	20.0	12.3	18.0	7.0	12.0	10.6	79.9
A11	18.8	8.7	16.0	8.0	12.0	13.2	76.7
A12	20.0	15.0	20.0	9.0	15.0	13.2	92.2
A13	20.0	15.0	16.0	9.0	15.0	10.8	85.8
A14	20.0	11.4	17.0	9.0	12.0	11.2	80.6
A15	20.0	11.4	12.0	10.0	9.0	13.4	75.8
A16	15.2	13.2	16.0	9.0	15.0	12.0	80.4
A17	20.0	15.0	12.0	10.0	15.0	13.4	85.4
A18	20.0	9.3	7.0	10.0	15.0	15.0	76.3
A19	4.0	9.6	23.0	7.0	3.0	4.6	51.2

Source: JICA 2006a.

PCA result of AIP

	1st PC	2nd PC	3rd PC
Eigenvalue	2.62	1.26	1.13
CR	0.44	0.21	0.19
CCR	0.44	0.65	0.83
PC score			
A1	0.89	0.49	-1.67
A2	0.17	1.07	-1.58
A3	-1.00	1.29	0.42
A4	0.03	-0.11	-0.08
A5	1.10	-1.20	-1.69
A6	1.03	-0.15	-1.27
A7	-1.47	-0.87	0.53
A8	-1.56	-2.19	1.09
A9	-0.44	-0.89	1.04
A10	-0.68	0.35	1.55
A11	-0.47	-1.40	0.61
A12	1.18	1.38	1.55
A13	1.17	1.60	0.89
A14	0.11	0.10	0.58
A15	0.63	-0.71	-0.24
A16	0.57	0.94	0.08
A17	2.17	0.96	0.29
A18	1.89	-1.74	-0.70
A19	-5.32	1.08	-1.41

PC scores (AIP)



1st PC: social and resettlement index; 2nd PC: environmental index; and 3rd PC: airspace and access index

Alternatives analysis using PCA 2
CNRP in the Philippines

Alternatives	Traffic	Economy	Industry	Finance	Right of way	Regional development	Natural environment	Social environment	Total
A0	1	1	1	5	5	1	1	5	20
A1	4	4	3	3	2	3	3	2	24
A2	4	4	5	2	3	3	2	3	26
A3	4	4	5	2	3	5	3	4	30

Source: JICA 2006b.

	1st PC
Eigenvalue	6.58
CR	0.82
CCR	0.82
PC score	
A0	-4.42
A1	1.47
A2	1.16
A3	1.80

Note: CR: contribution rate, CCR: cumulative CR.

Alternatives analysis using PCA 3
SMBP in Cambodia

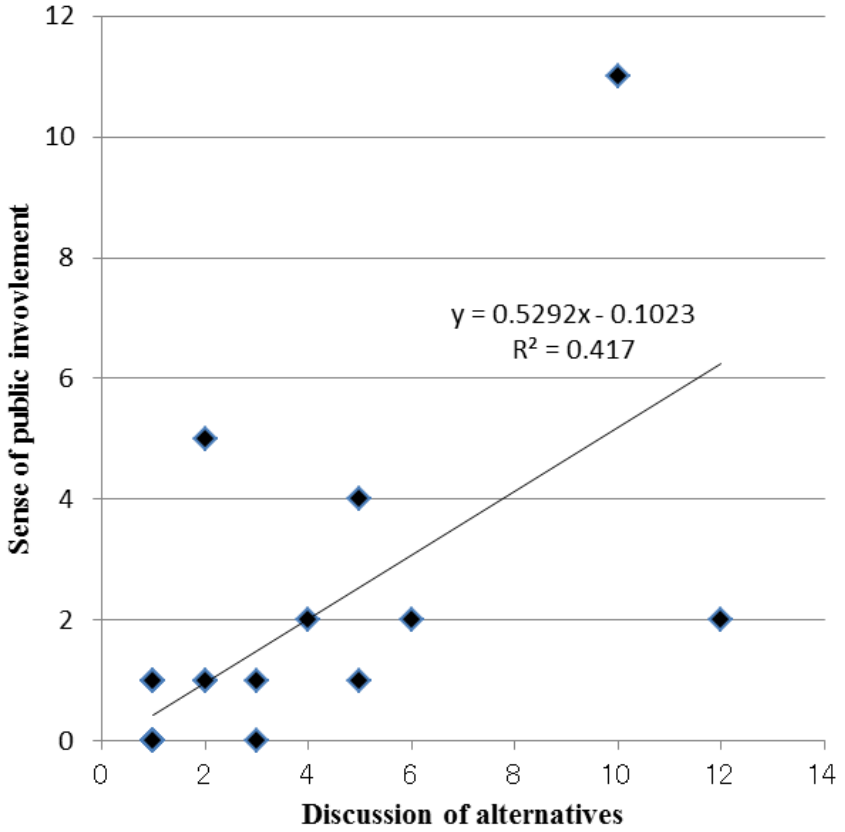
Alternatives	EngC 0.35			EcoC 0.47			EnvC 0.18							AHP score
	Sta	Saf	Sus	TD	IE	RE	NE 0.30			SE 0.70				
	0.26	0.45	0.29	0.39	0.31	0.30	NV	TA	OI	Res	LU	LL	OI	
							0.14	0.63	0.23	0.48	0.17	0.25	0.13	
Weight	0.09	0.16	0.10	0.18	0.14	0.14	0.01	0.04	0.01	0.06	0.02	0.03	0.02	
No action	0.05	0.06	0.06	0.05	0.06	0.05	0.11	0.14	0.35	0.54	0.07	0.10	0.11	0.10
Ferry	0.21	0.12	0.14	0.27	0.26	0.17	0.23	0.14	0.35	0.09	0.11	0.22	0.26	0.19
Bridge	0.20	0.32	0.31	0.17	0.14	0.28	0.25	0.26	0.17	0.17	0.33	0.26	0.27	0.23
Ferry+bridge	0.55	0.49	0.49	0.51	0.54	0.51	0.42	0.46	0.12	0.20	0.49	0.41	0.36	0.48

Note: EngC: engineering criteria; EcoC: economic criteria; EnvC: environmental criteria; NE: natural environment; SE: social environment; Sta: stability; Saf: safety; Sus: sustainability; TD: traffic demand; IE: investment efficiency; RE: regional economy; NV: noise and vibration; TA: traffic accident; OI: other impacts; Res: resettlement; LU: land use; LL: local livelihood.
Source: JICA 2006c.

	1st PC
Eigenvalue	11.32
CR	0.87
CCR	0.87
PC score	
No action	-4.22
Ferry	-1.29
Bridge	0.45
Ferry+bridge	5.06

Note: CR: contribution rate, CCR: cumulative CR.

Single regression equation between the discussion of alternatives and the sense of public involvement (n=24)



Results of PCA to alternatives analysis

Paper	Method	Alternatives	Criteria	PCs	CCR	Selection	PCA
Dey 2001	AHP	4	19	2	0.91	A4	A4
Noble 2002	AHP	5	11	3	0.95	A3	A1, A3 or A5
Sólnes 2003	AHP	3	7	1	0.95	A3	A3
Geneletti 2005	WS	5	5	2	0.91	A4	A3
Bagli et al. 2011	WS	4	4	1	0.94	A3	A3
Betrie et al. 2013	WS	9	7	3	0.96	not noted	A8 or A9

Practical value of PCA

1. PCA reduces criteria to three PCs, addresses high correlation and shows merits of preferable alternatives;
2. PCA makes stakeholders to understand alternatives analysis easier;
3. PCA may enhance the discussion of alternatives and improve public involvement; and
4. PCA is a simple and popular method and does not need any cost.

Conclusion

1. Discussion of alternative increased the sense of public involvement;
2. The recommended numbers of alternatives and criteria are: 19 and 6; 5 and 11; and 9 and 7.
3. PCA is one of effective MCA methods and may be a simpler, easier, and more correct than AHP and WS ; and
4. PCA is likely to enhance the discussion of alternatives and lead to improved public involvement.

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Enhancing the discussion of alternatives in EIA using principle component analysis leads to improved public involvement

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ABSTRACT

The purpose of this study is to show the effectiveness of principle component analysis (PCA) as a method of alternatives analysis useful for improving the discussion of alternatives and public involvement. This study examined public consultations by applying quantitative text analysis (QTA) to the minutes of meetings and showed a positive correlation between the discussion of alternatives and the sense of public involvement. The discussion of alternatives may improve public involvement. A table of multiple criteria analysis for alternatives with detailed scores may exclude the public from involvement due to the general public's limited capacity to understand the mathematical algorithm and to process too much information. PCA allowed for the reduction of multiple criteria down to a small number of uncorrelated variables (principle components), a display of the merits and demerits of the alternatives, and potentially made the identification of preferable alternatives by the stakeholders easier. PCA is likely to enhance the discussion of alternatives and as a result, lead to improved public involvement.

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Thank you for your attention

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