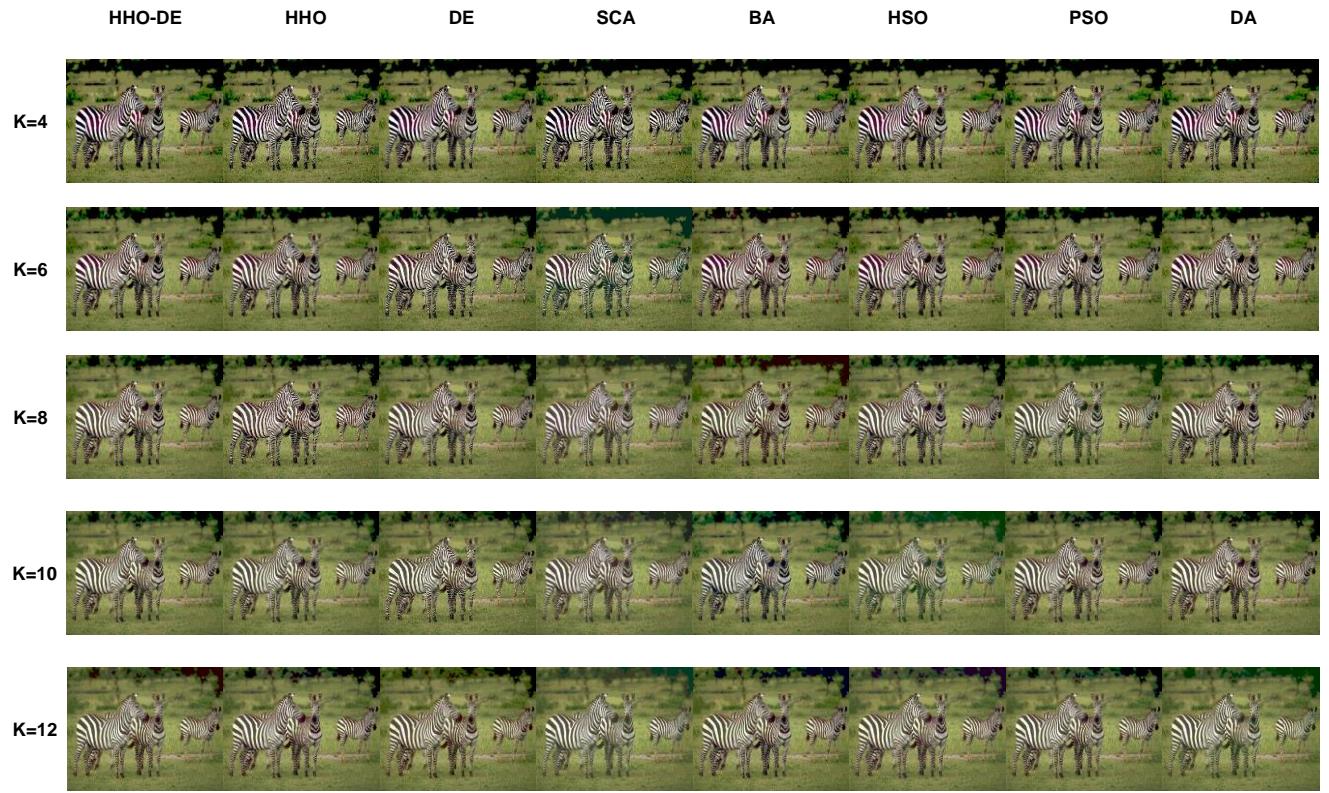


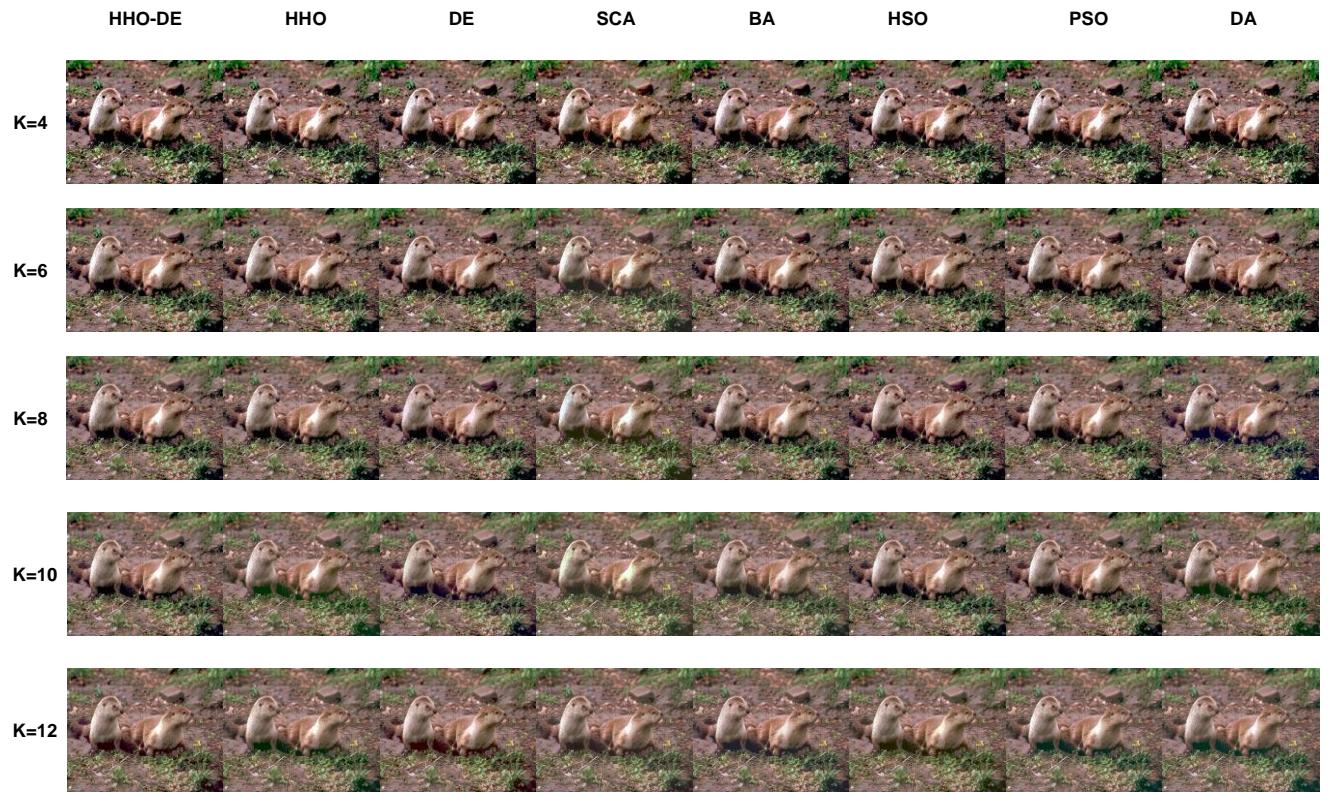
(a) Image1



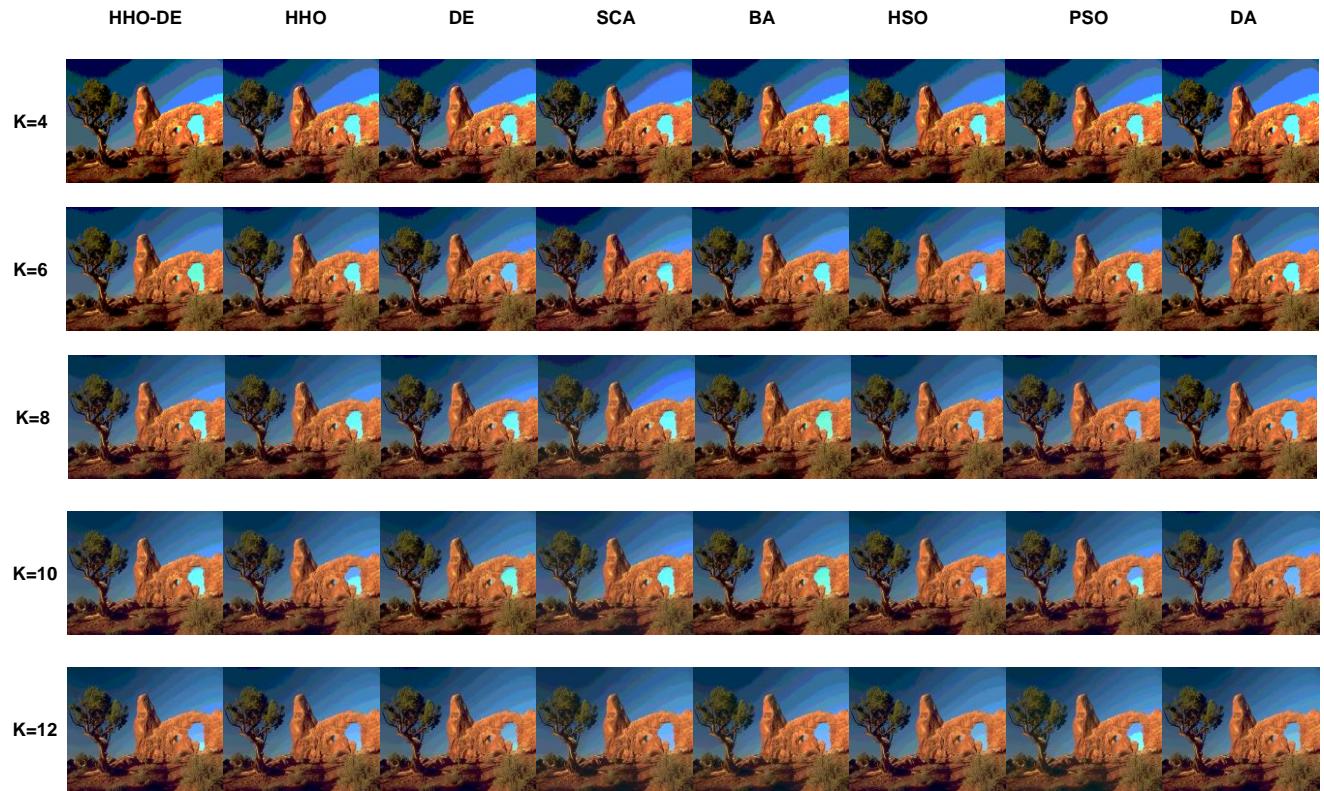
(b) Image2



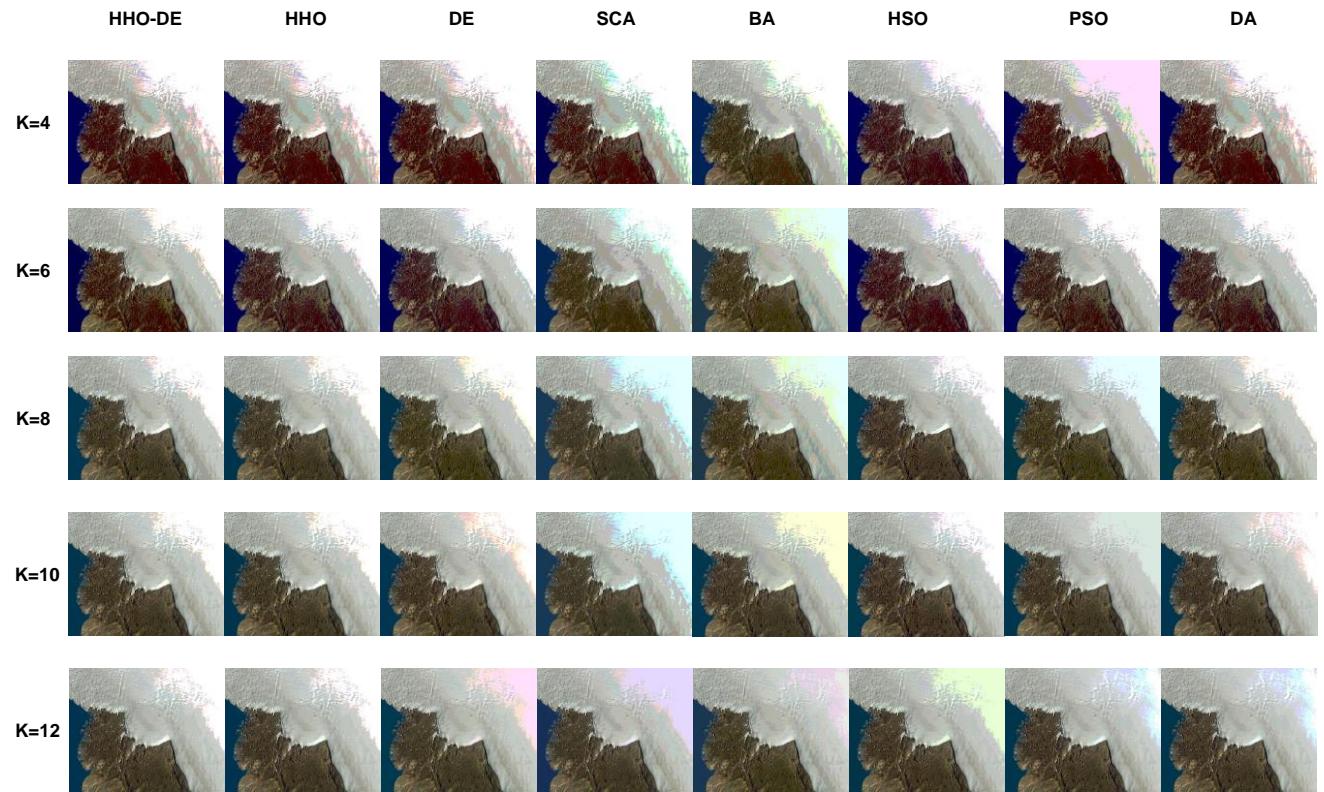
(c) Image3



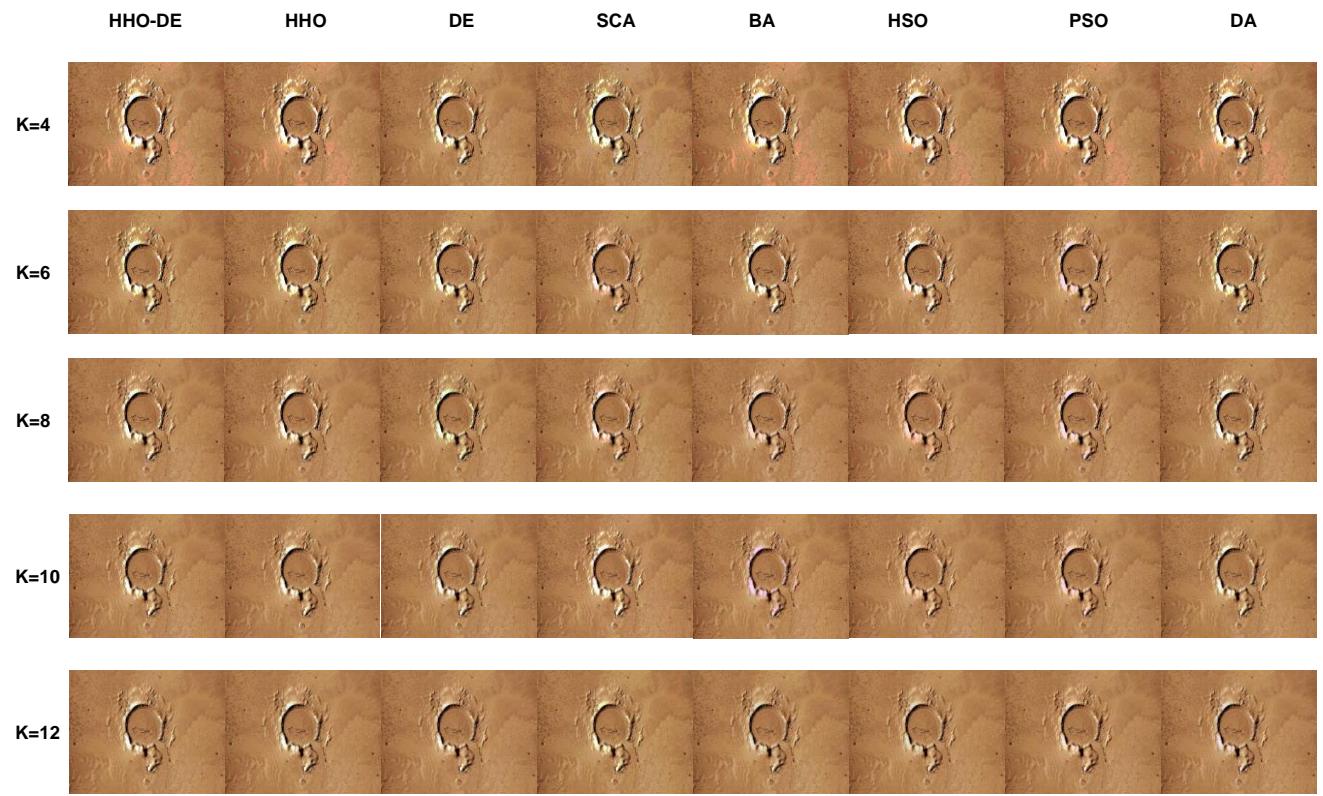
(d) Image4



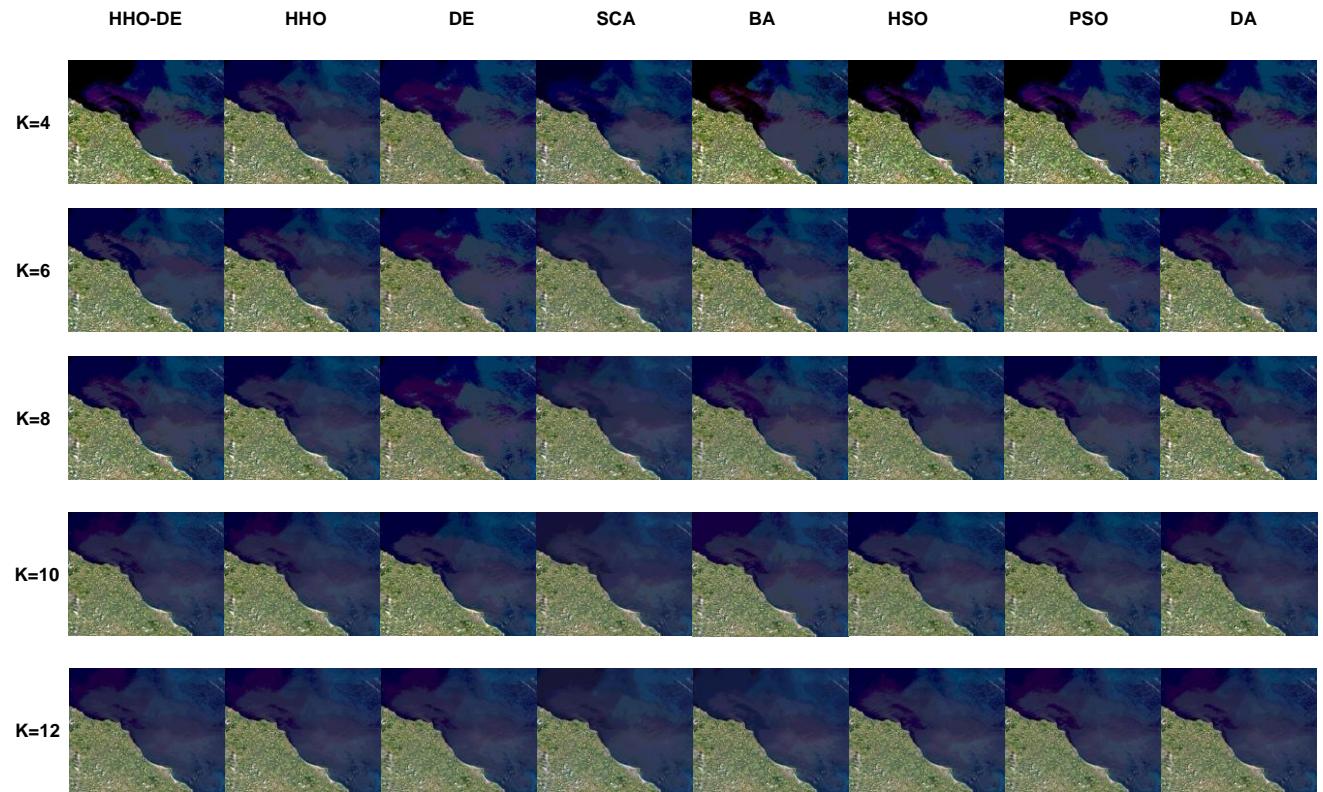
(e) Image5



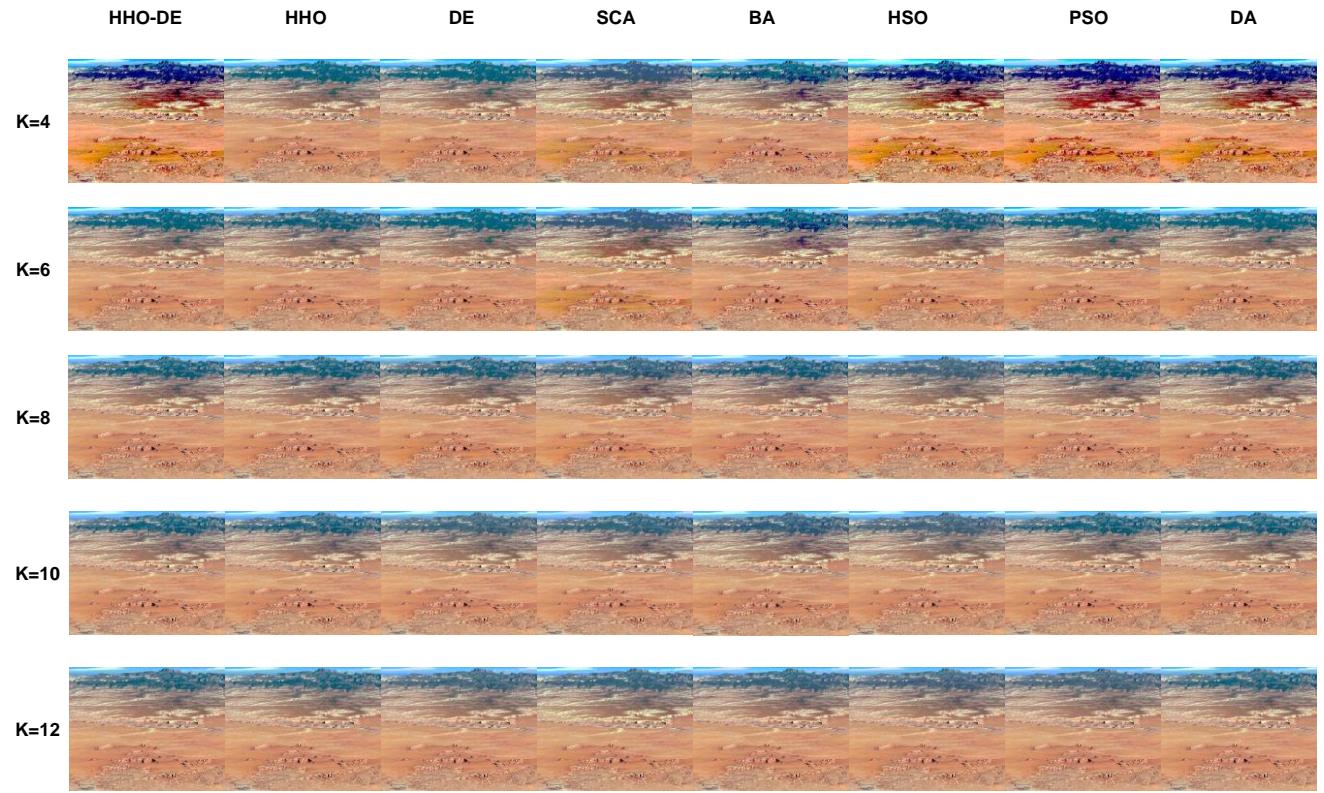
(f) Image6



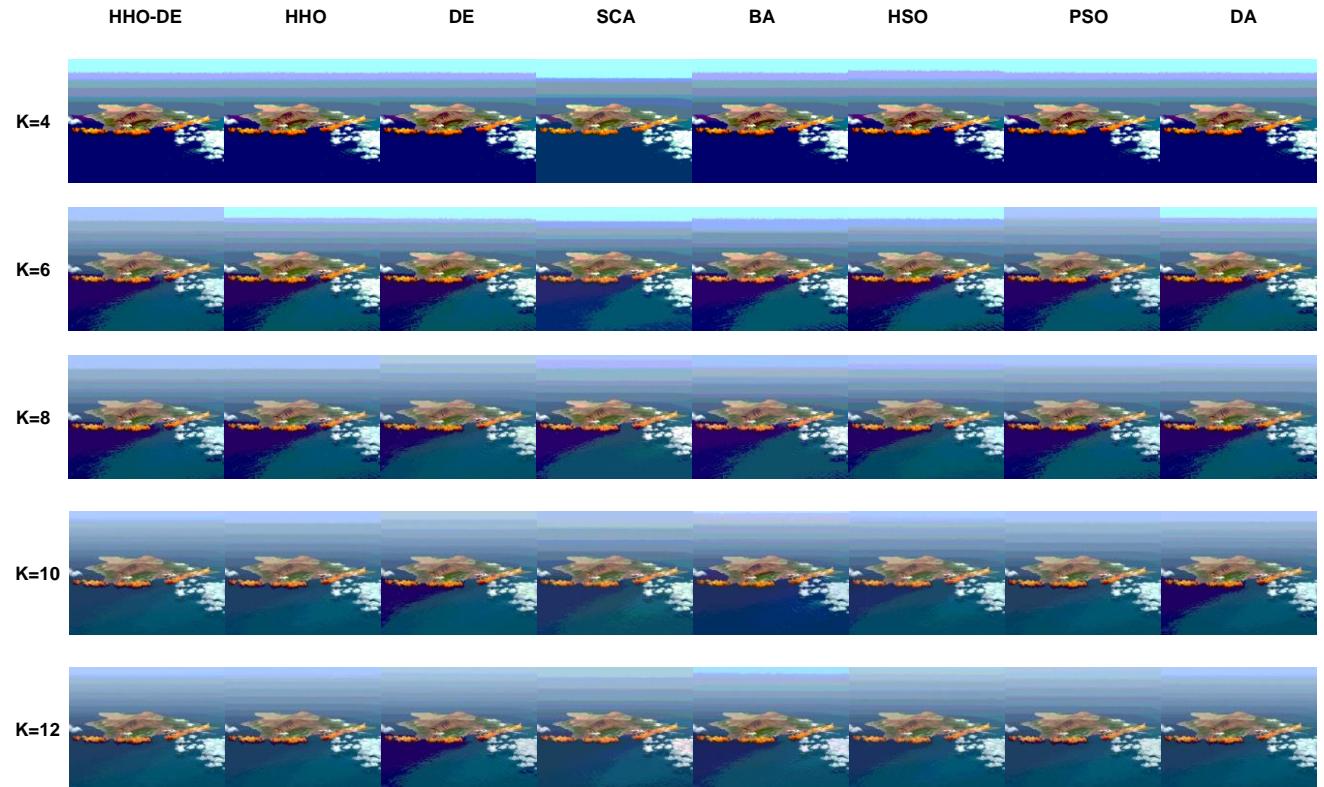
(g) Image7



(h) Image8

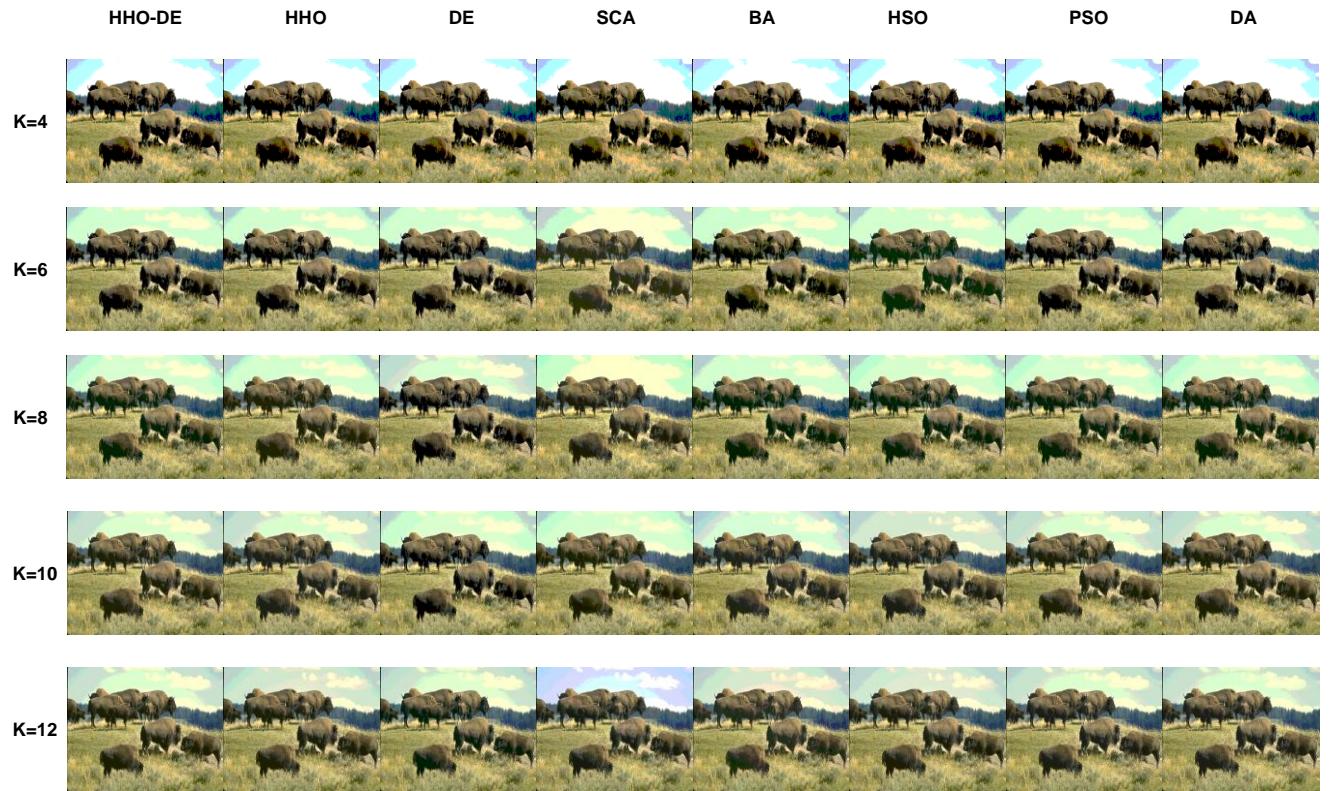


(i) Image9



(j) Image10

**Fig. 1.** The segmented images using Otsu's method by the HHO-DE, HHO,DE,SCA,BA,HSO,PSO, and DA.at K=4,6,8,10, and 12.



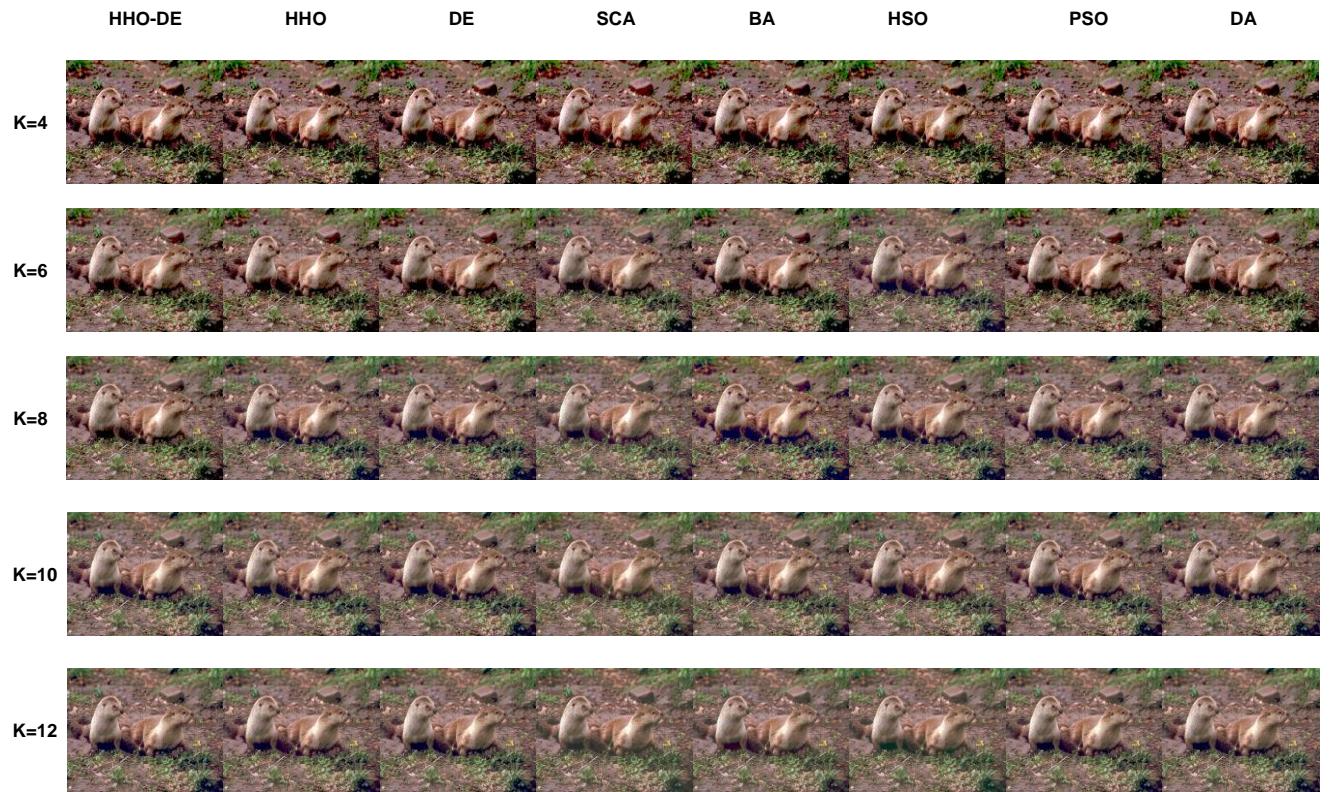
(a) Image1



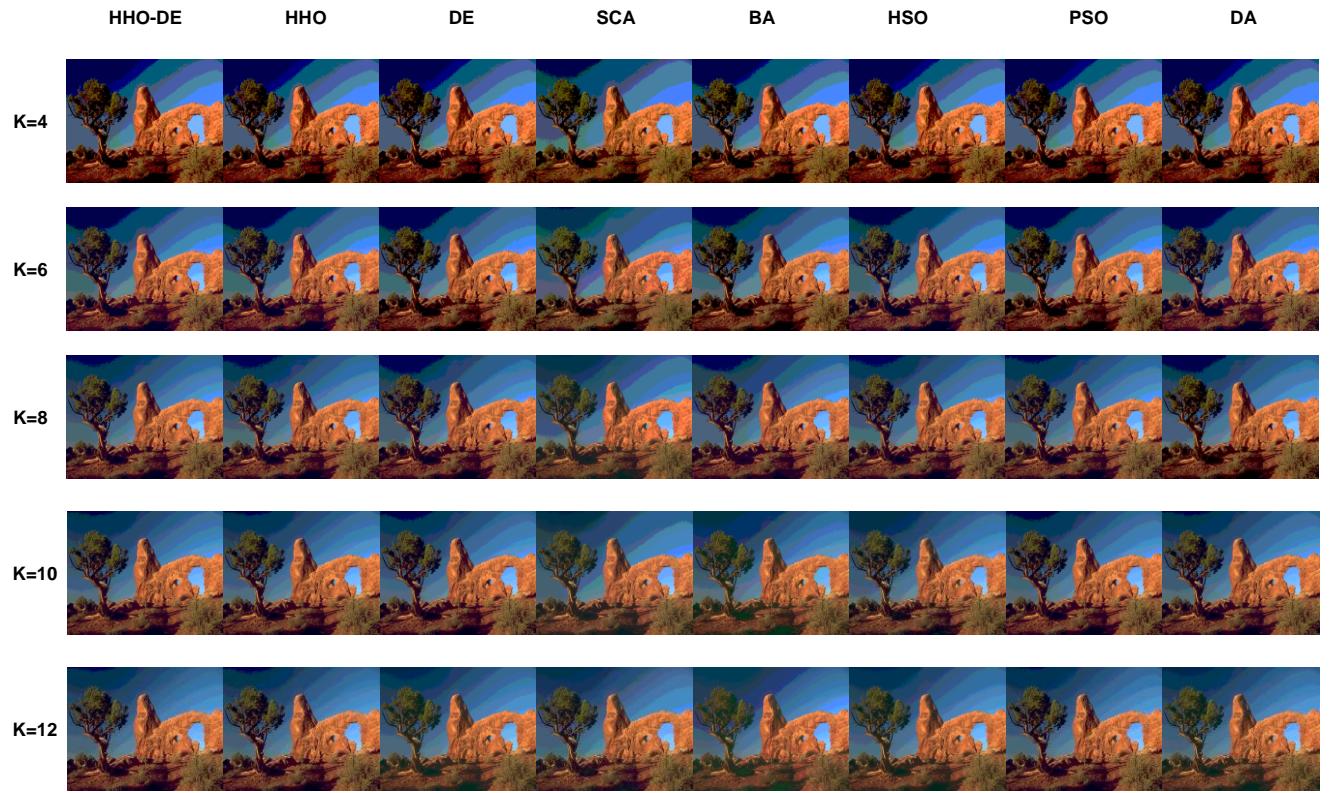
(b) Image2



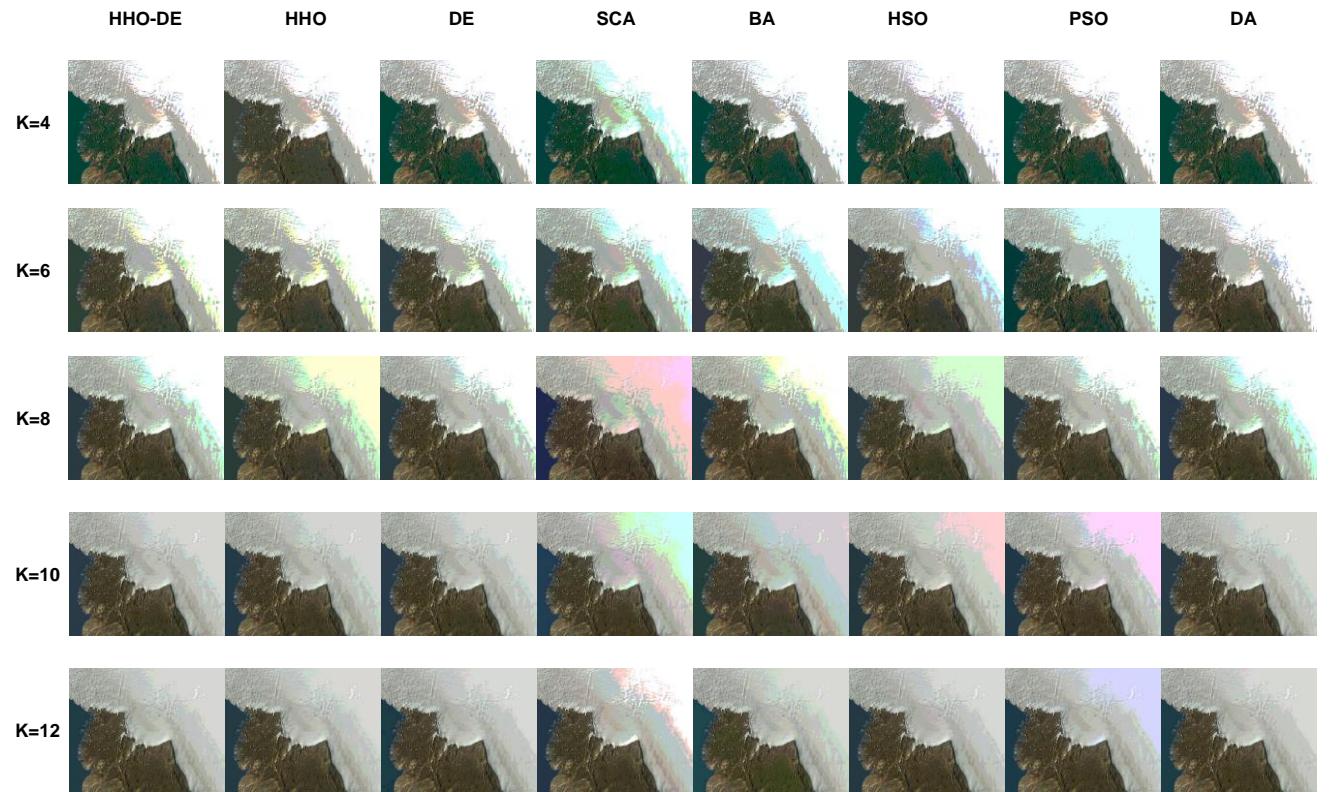
(c) Image3



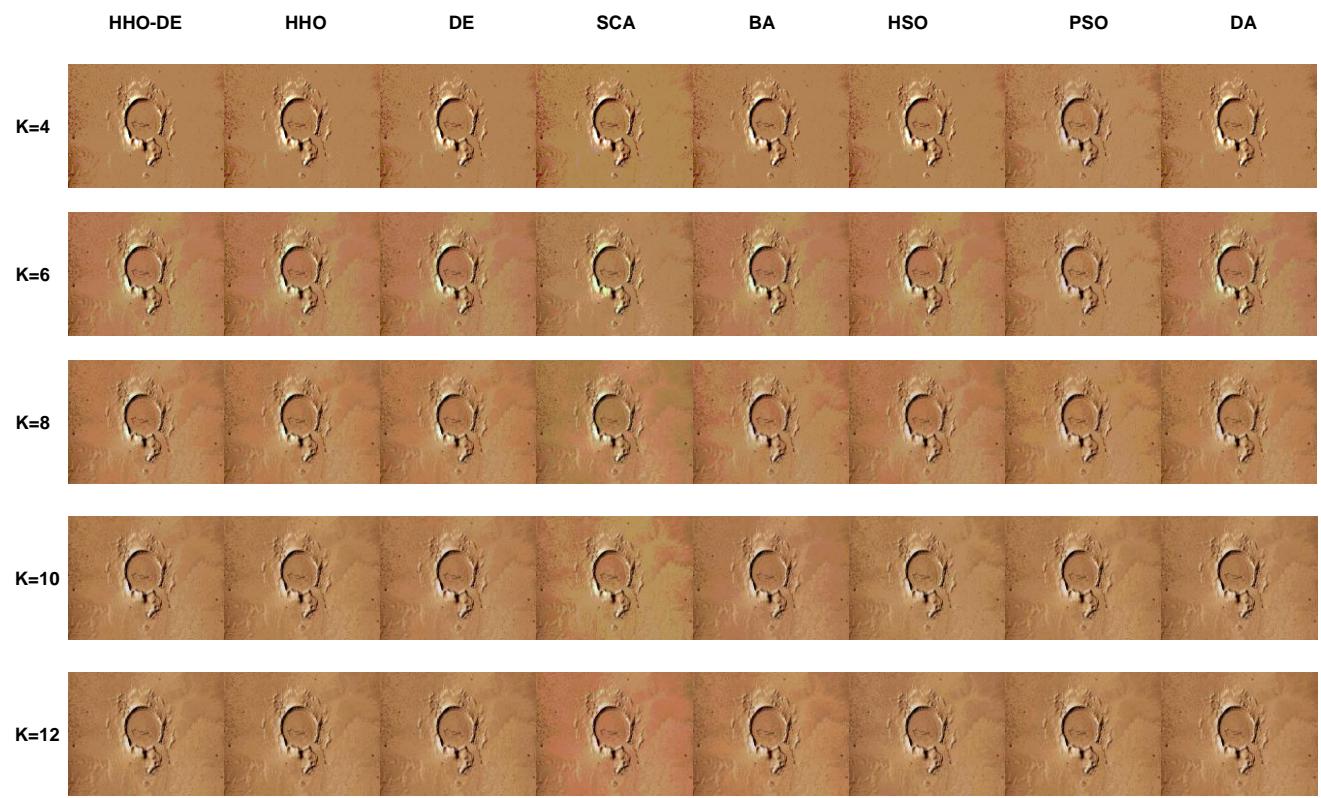
(d) Image4



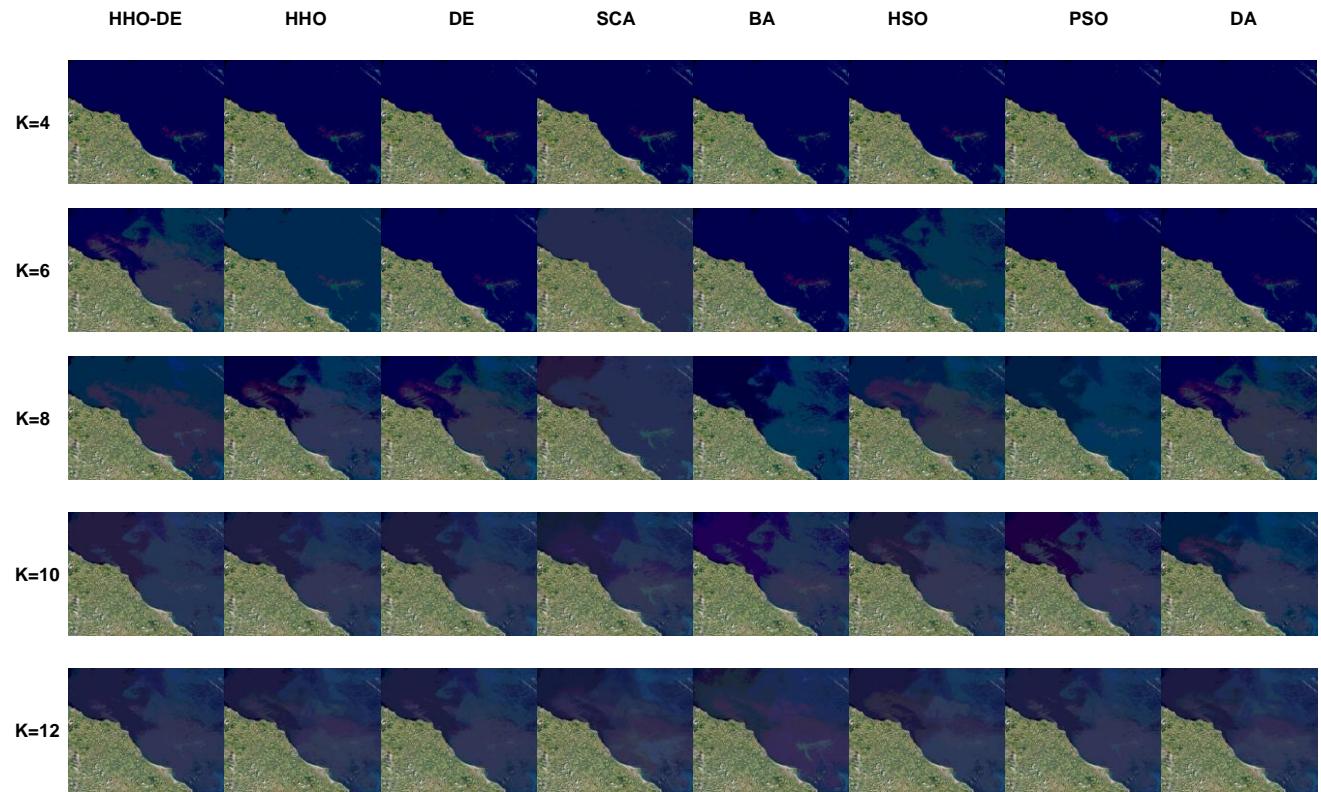
(e) Image5



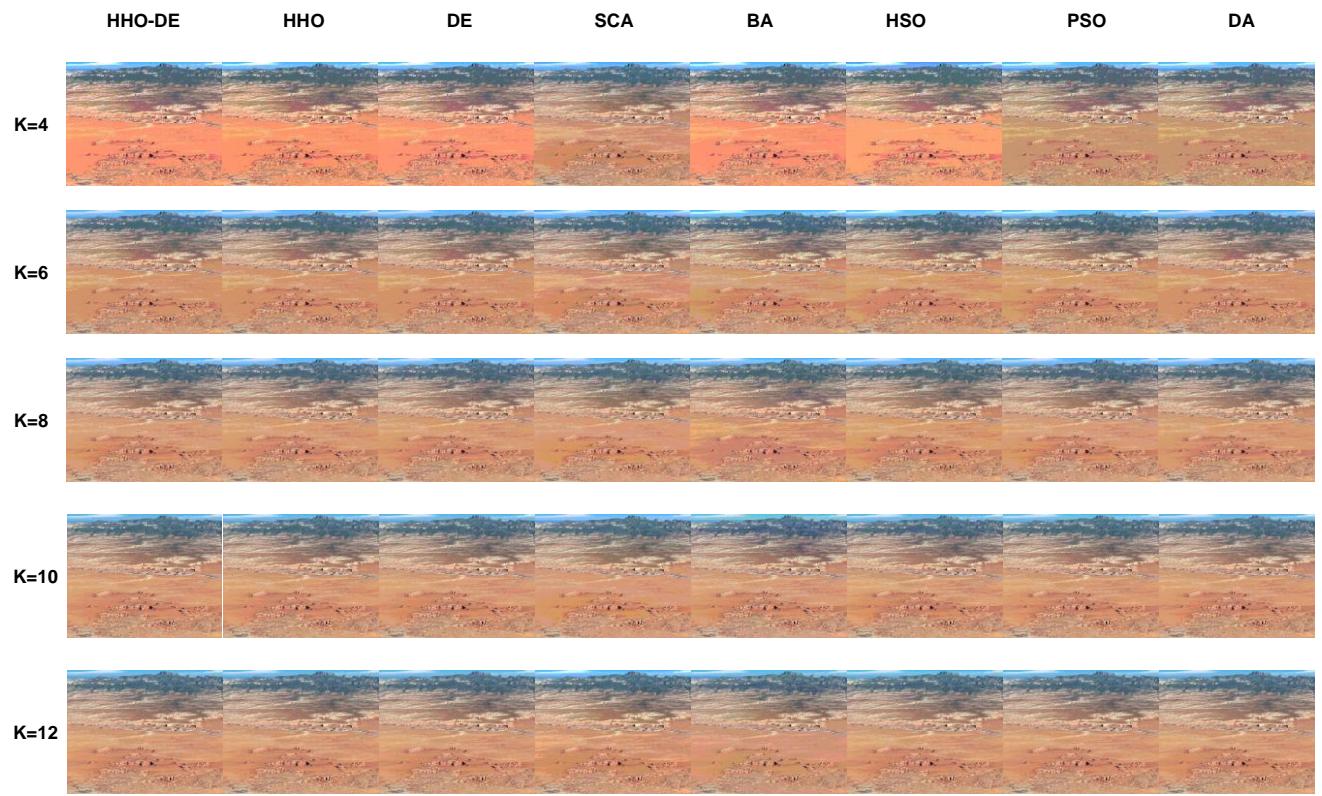
(f) Image6



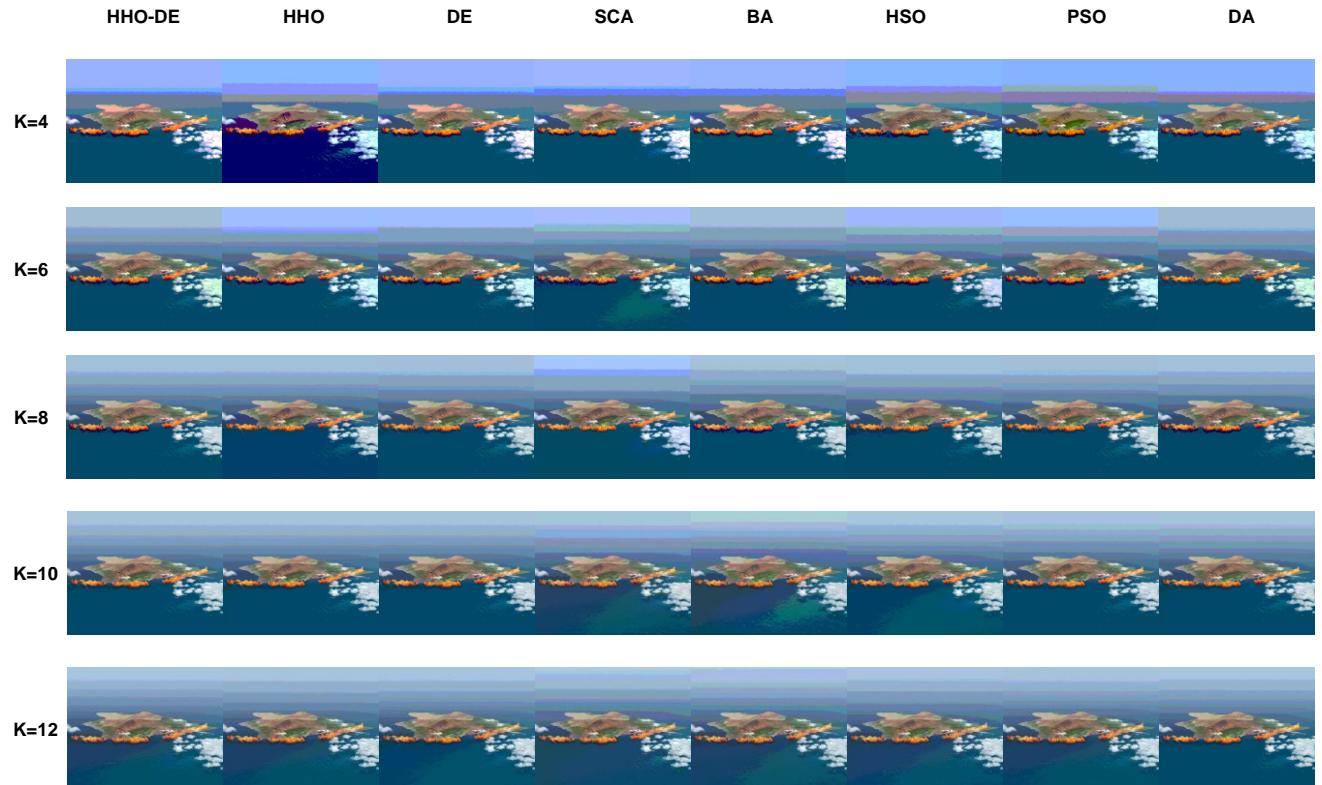
(g) Image7



(h) Image8



(i) Image9



(j) Image10

**Fig. 2.** The segmented images using Kapur's entropy by the HHO-DE, HHO, DE, SCA, BA, HSO, PSO, and DA at K=4, 6, 8, 10, and 12.

**TABLE I**  
COMPARISON OF OPTIMAL THRESHOLDS FOR DIFFERENT ALGORITHMS USING OTSU'S METHOD AT 4, 6, 8, 10, AND 12 LEVELS

COMPARISON OF THREE THRESHOLDING ALGORITHMS USING OTSU'S METHOD AT 4, 6, 8, 10, AND 12 LEVELS																												
Images	K	HHO-DE			HHO			DE			SCA			BA			HSO			PSO			DA					
		R	G	B	R	G	B	R	G	B	R	G	B	R	G	B	R	G	B	R	G	B	R	G	B	R	G	B
Image1	4	69 121	68 116	49 84	69 121	68 116	49 84	69 121	68 116	49 84	68 109	67 107	47 80	68 120	68 116	49 84	71 123	69 116	49 84	69 121	68 116	49 84	44 87	51 91	44 87	38 72		
	6	168 208	158 205	115 168	168 208	158 205	115 168	168 208	158 205	115 168	161 206	151 199	112 167	169 209	157 205	116 169	166 205	158 205	115 168	168 208	158 205	115 168	136 188	110 151	136 188	27 50 47		
	8	59 100	58 96	38 64	58 99	58 96	37 63	59 100	58 99	38 64	43 87	60 98	24 6	58 95	36 62	52 86	55 89	40 67	55 93	38 64	40 69	55 89	38 64	40 69	55 89	38 64	40 69	55 89
	10	138 170	130 162	87 108	136 169	130 162	86 107	137 169	120 148	87 107	119 160	123 145	64 93	130 157	130 160	83 105	117 147	121 149	87 108	121 149	130 160	131 167	103 130	103 130	131 167	25 46 47		
	12	200 227	197 228	132 175	197 228	132 175	131 175	199 227	149 227	131 175	197 207	120 175	104 212	121 213	104 212	101 212	121 213	122 215	122 215	122 215	122 215	122 215	122 215	122 215	122 215	122 215	122 215	
	14	47 79	47 79	47 87	49 23	47 79	47 87	49 23	47 79	47 87	47 79	47 87	47 79	47 87	47 79	47 87	47 79	47 87	47 79	47 87	47 79	47 87	47 79	47 87	47 79	47 87	47 79	
	16	106 134	105 128	71 88	107 135	104 129	72 89	105 133	112 136	86 107	98 113	103 138	38 67	100 133	125 141	75 91	98 127	94 125	78 94	104 132	71 88	104 132	105 130	101 151	105 130	101 151	105 130	101 151
Image2	8	158 181	152 175	104 121	159 181	152 175	104 121	158 181	152 175	104 121	160 206	203 232	188 232	138 232	188 232	118 184	202 230	205 232	166 180	145 178	148 173	145 178	145 178	145 178	145 178	145 178	145 178	
	10	205 230	205 231	142 180	206 231	142 180	140 179	205 231	142 180	140 179	140 179	206 231	142 180	140 179	140 179	140 179	140 179	140 179	140 179	140 179	140 179	140 179	140 179	140 179	140 179	140 179	140 179	
	12	112 135	88 109	75 89	117 131	88 109	72 89	92 116	100 121	65 82	46 74	71 110	46 69	85 113	79 79	87 111	65 87	91 114	80 111	67 87	87 109	92 113	101 121	100 118	78 100	70 86	78 100	
	14	129 149	129 149	104 121	129 149	104 121	110 130	129 149	104 121	110 130	129 149	104 121	110 130	129 149	104 121	110 130	129 149	104 121	110 130	129 149	104 121	110 130	129 149	104 121	110 130	129 149		
	16	176 196	166 185	130 150	176 196	166 185	130 150	176 196	166 185	130 150	176 196	166 185	130 150	176 196	166 185	130 150	176 196	166 185	130 150	176 196	166 185	130 150	176 196	166 185	130 150	176 196		
	18	241	241	236	238	256	256	238	256	238	223	190	237	238	223	237	238	223	237	238	223	237	238	223	237	238	223	
	20	44 87	51 91	37 71	44 87	51 91	38 72	44 87	51 91	37 71	39 83	53 100	40 72	44 87	52 92	38 74	42 86	50 91	37 73	44 87	51 91	38 72	42 86	50 91	37 73	44 87	51 91	
Image3	4	136 192	136 188	109 150	136 192	136 188	110 151	136 188	137 188	109 150	148 186	137 187	107 144	148 186	135 187	113 149	136 188	135 187	113 149	148 186	135 187	113 149	148 186	135 187	113 149	148 186	135 187	
	6	35 68	40 69	27 53	35 68	40 69	27 53	35 68	40 69	27 53	30 57	41 73	24 61	35 67	42 73	24 61	35 67	36 64	27 50	35 68	40 69	27 53	35 67	42 73	24 61	35 67	40 69	
	8	104 151	131 167	74 101	104 151	131 167	74 101	104 151	131 167	74 101	104 151	131 167	74 101	104 151	131 167	74 101	104 151	131 167	74 101	104 151	131 167	74 101	104 151	131 167	74 101	104 151		
	10	167 212	206	130 161	167 212	206	130 161	167 212	206	130 161	167 212	206	130 161	167 212	206	130 161	167 212	206	130 161	167 212	206	130 161	167 212	206	130 161	167 212		
	12	28 52	33 68	20 71	28 52	33 68	20 71	28 52	33 68	20 71	28 52	33 68	20 71	28 52	33 68	20 71	28 52	33 68	20 71	28 52	33 68	20 71	28 52	33 68	20 71	28 52	33 68	
	14	191 230	189 226	148 188	191 230	189 226	148 188	191 230	189 226	148 188	191 230	189 226	148 188	191 230	189 226	148 188	191 230	189 226	148 188	191 230	189 226	148 188	191 230	189 226	148 188	191 230		
	16	244 44	28 48	21 39	244 44	28 48	21 39	244 44	28 48	21 39	244 44	28 48	21 39	244 44	28 48	21 39	244 44	28 48	21 39	244 44	28 48	21 39	244 44	28 48	21 39	244 44		
Image4	8	105 131	105 131	63 81	75 105	110 151	130 159	130 159	105 131	105 131	105 131	105 131	105 131	105 131	105 131	105 131	105 131	105 131	105 131	105 131	105 131	105 131	105 131	105 131	105 131	105 131		
	10	170 231	226	130 161	170 231	226	130 161	170 231	226	130 161	170 231	226	130 161	170 231	226	130 161	170 231	226	130 161	170 231	226	130 161	170 231	226	130 161	170 231		
	12	80 93	79 93	73 93	80 93	79 93	73 93	80 93	79 93	73 93	79 93	80 93	73 93	80 93	79 93	73 93	80 93	79 93	73 93	80 93	79 93	73 93	80 93	79 93	73 93	80 93		
	14	147 203	133 186	145 202	147 203	133 186	145 202	147 203	133 186	145 202	147 203	133 186	145 202	147 203	133 186	145 202	147 203	133 186	145 202	147 203	133 186	145 202	147 203	133 186	145 202	147 203		
	16	72 96	72 96	62 98	72 96	72 96	62 98	72 96	72 96	62 98	72 96	72 96	62 98	72 96	72 96	62 98	72 96	72 96	62 98	72 96	72 96	62 98	72 96	72 96	62 98	72 96		
	18	122 144	112 133	95 104	122 144	112 133	95 104	122 144	112 133	95 104	122 144	112 133	95 104	122 144	112 133	95 104	122 144	112 133	95 104	122 144	112 133	95 104	122 144	112 133	95 104	122 144		
	20	87 141	113 149	104 121	87 141	113 149	104 121	87 141	113 149	104 121	87 141	113 149	104 121	87 141	113 149	104 121	87 141	113 149	104 121	87 141	113 149	104 121	87 141	113 149	104 121			
Image5	8	68 87	68 87	54 86	68 87	68 87	54 86	68 87	68 87	54 86	68 87	68 87	54 86	68 87	68 87	54 86	68 87	68 87	54 86	68 87	68 87	54 86	68 87	68 87	54 86	68 87		
	10	141 166	145 166	143 155	141 166	145 166	143 155	141 166	145 166	143 155	141 166	145 166	143 155	141 166	145 166	143 155	141 166	145 166	143 155	141 166	145 166	143 155	141 166	145 166	143 155			
	12	145 174	133 166	123 156	145 174	133 166	123 156	145 174	133 166	123 156	145 174	133 166	123 156	145 174	133 166	123 156	145 174	133 166	123 156	145 174	133 166	123 156	145 174	133 166	123 156			
	14	145 174	133 166	123 156	145 174	133 166	123 156	145 174	133 166	123 156	145 174	133 166	123 156	145 174	133 166	123 156	145 174	133 166	123 156	145 174	133 166	123 156	145 174	133 166	123 156			
	16	145 174	133 166	123 156	145 174	133 166	123 156	145 174	133 166	123 156	145 174	133 166	123 156	145 174	133 166	123 156	145 174	133 166	123 156	145 174	133 166	123 156	145 174	133 166	123 156			
	18	148 183	121 182	185 221	148 183	121 182	185 221	148 183	121 182	185 221	148 183	121 182	185 221	148 183	121 182	185 221	148 183	121 182	185 221	148 183	121 182	185 221	148 183	121 182	185 221			
	20	222	221	211	222	221	211	222	221	211	222	221	211	222	221	211	222	221	211	222	221	211	222	221	211	222	221	
Image6	4	84 117	84 117	77 104	84 117	84 117	77 104	84 117	84 117	77 104	84 117	84 117	77 104	84 117	84 117	77 104	84 117	84 117	77 104	84 117	84 117	77 104	84 117	84 117	77 104	84 117		
	6	84 117	84 117	77 104	84 117	84 117	77 104	84 117	84 117	77 104	84 117	84 117	77 104	84 117	84 117	77 104	84 117	84 117	77 104	84 117	84 117	77 104	84 117	84 117	77 104	84 117		
	8	65 91	65 91	59 81	65 91	65 91	59 81	65 91	6																			



**TABLE II**  
COMPARISON OF OPTIMAL THRESHOLDS FOR DIFFERENT ALGORITHMS USING KAPUR'S ENTROPY METHOD AT 4, 6, 8, 10, AND 12 LEVELS

Images	K	HHO-DE			HHO			DE			SCA			BA			HSO			PSO			DA			
		R	G	B	R	G	B	R	G	B	R	G	B	R	G	B	R	G	B	R	G	B	R	G	B	
Image1	4	66 114 159 205	71 121 171 217	58 107 152 188	66 114 159 205	72 123 171 217	62 115 157 198	66 114 159 206	71 121 157 198	61 102 145 198	64 116 161 206	63 108 157 217	66 114 159 206	71 125 157 217	61 112 157 204	63 110 171 217	59 105 159 215	66 114 159 205	71 121 171 217	62 115 159 205	66 114 159 205	71 121 171 217	62 115 159 205	66 114 159 205	71 121 171 217	62 115 159 205
	5	53 98 69 95	47 85 71 104	54 87 68 99	48 83 65 89	52 86 70 95	54 87 68 98	49 84 66 95	48 85 65 96	50 86 62 100	52 87 67 94	50 86 62 100	52 87 67 94	50 86 62 100	52 87 67 94	50 86 62 100	52 87 67 94	50 86 62 100	52 87 67 94	50 86 62 100	52 87 67 94	50 86 62 100	52 87 67 94	50 86 62 100	52 87 67 94	
	6	123 157 191 226	123 157 191 226	124 160 198 214	123 157 191 226	124 154 198 214	125 160 198 214	122 156 198 214	120 153 198 214	124 160 198 214	107 147 190 222	103 145 190 222	109 151 190 222	126 153 198 214	109 151 190 222	135 162 198 214	109 145 190 222	126 153 198 214	123 157 191 226	120 153 198 214	123 157 191 226	120 153 198 214	123 157 191 226	119 152 191 226	124 160 198 214	
	7	97 123 150 176	97 123 133 162	99 123 148 171	97 123 148 171	99 123 148 171	97 123 148 171	99 123 148 171	97 123 148 171	99 123 148 171	107 147 188 214	104 147 188 214	101 139 188 214	108 147 188 214	105 147 188 214	102 139 188 214	109 147 188 214	106 147 188 214	103 139 188 214	109 147 188 214	106 147 188 214	103 139 188 214	109 147 188 214	106 147 188 214	103 139 188 214	
	8	44 70 150 176	18 49 133 162	38 67 94 113	16 47 94 113	18 50 94 113	37 65 94 113	44 70 94 113	47 75 94 113	35 63 94 113	18 42 94 113	11 39 94 113	25 41 94 113	50 80 94 113	16 42 94 113	39 69 94 113	46 72 93 94 113	19 43 76 94 113	43 70 94 113	18 48 94 113	34 61 94 113	44 71 94 113	19 52 94 113	38 67 94 113		
	9	202 223 190 210	190 210 121 140	190 210 133 147	202 223 121 140	201 223 132 144	198 214 132 144	201 223 132 144																		
	10	159 173 191 226	159 173 191 226	162 178 191 226	197 213 198 214	196 213 198 214	198 213 198 214	196 213 198 214	197 213 198 214	196 213 198 214	197 213 198 214	196 207 197 213	196 207 197 213	202 222 191 222	196 207 197 213	208 226 197 213	196 207 197 213	208 226 197 213	196 207 197 213							
	11	120 138 169 210	121 140 169 210	133 147 196 216	127 145 198 214	116 136 198 214	125 161 198 214	123 166 198 214	120 153 198 214	123 166 198 214	123 166 198 214	120 153 198 214	123 166 198 214	123 166 198 214	120 153 198 214	123 166 198 214	123 166 198 214	120 153 198 214								
	12	157 173 190 210	159 173 190 210	162 178 190 210	197 213 198 214	196 213 198 214	198 213 198 214	196 213 198 214	197 213 198 214	196 213 198 214	197 213 198 214	196 207 197 213	196 207 197 213	202 222 191 222	196 207 197 213	208 226 197 213	196 207 197 213	208 226 197 213	196 207 197 213							
	13	54 104 154 202	57 100 158 207	45 90 153 180	53 102 152 201	57 107 152 201	53 102 152 201	57 107 152 201	53 102 152 201	57 107 152 201	198 214 153 180															
	14	35 70 106 142	42 79 105 142	32 63 98 133	37 72 104 142	42 78 104 142	32 64 98 133	37 72 104 142	42 78 104 142	32 64 98 133	106 142 105 142	101 139 105 142	101 139 105 142	106 142 105 142												
	15	88 113 140 167	97 125 152 178	99 125 157 187	88 113 140 167	97 125 152 178	99 125 157 187	88 113 140 167	97 125 152 178	99 125 157 187	121 140 121 140	113 134 121 140	113 134 121 140	121 140 121 140												
	16	140 167 193 213	152 178 193 213	159 186 193 213	140 167 193 213	152 178 193 213	159 186 193 213	140 167 193 213	152 178 193 213	159 186 193 213	193 213 193 213	187 209 193 213														
	17	80 113 140 167	87 125 152 178	89 125 157 187	80 113 140 167	87 125 152 178	89 125 157 187	80 113 140 167	87 125 152 178	89 125 157 187	121 140 121 140	113 134 121 140	113 134 121 140	121 140 121 140												
	18	86 113 140 167	97 125 152 178	99 125 157 187	86 113 140 167	97 125 152 178	99 125 157 187	86 113 140 167	97 125 152 178	99 125 157 187	121 140 121 140	113 134 121 140	113 134 121 140	121 140 121 140												
	19	78 97 140 167	83 113 140 167	85 113 140 167	78 97 140 167	83 113 140 167	85 113 140 167	78 97 140 167	83 113 140 167	85 113 140 167	121 140 121 140	106 134 121 140	106 134 121 140	121 140 121 140												
	20	116 133 153 174	116 135 153 174	118 135 153 174	116 133 153 174	116 135 153 174	118 135 153 174	116 133 153 174	116 135 153 174	118 135 153 174	197 213 198 214	102 118 102 118	101 139 102 118	101 139 102 118	102 118 102 118	101 139 102 118										
	21	74 107 142 176	97 139 142 176	98 141 142 176	74 107 142 176	97 139 142 176	98 141 142 176	74 107 142 176	97 139 142 176	98 141 142 176	172 207 172 207	170 210 172 207														
	22	73 105 142 176	77 108 142 176	78 108 142 176	73 105 142 176	77 108 142 176	78 108 142 176	73 105 142 176	77 108 142 176	78 108 142 176	172 207 172 207	102 118 172 207	101 139 102 118	101 139 102 118	102 118 172 207	101 139 102 118										
	23	62 108 142 176	65 108 142 176	66 108 142 176	62 108 142 176	65 108 142 176	66 108 142 176	62 108 142 176	65 108 142 176	66 108 142 176	237 237 237 237	235 237 237 237														
	24	60 80 142 176	63 80 142 176	64 80 142 176	60 80 142 176	63 80 142 176	64 80 142 176	60 80 142 176	63 80 142 176	64 80 142 176	237 237 237 237	235 237 237 237	236 237 237 237	235 237 237 237												
	25	65 72 89 142 176	69 72 89 142 176	70 72 89 142 176	65 72 89 142 176	69 72 89 142 176	70 72 89 142 176	65 72 89 142 176	69 72 89 142 176	70 72 89 142 176	172 207 172 207	170 184 1														

4	72.107	35.99	28.82	-22.97	41.92	28.82	72.107	35.87	28.82	84.116	33.90	35.89	72.109	39.91	28.87	72.113	44.91	30.82	72.107	34.98	50.102	73.103	34.98	28.82				
4	146.184	152.188	134.186	147.184	150.188	138.186	146.184	150.188	151.187	152.184	139.179	149.184	148.187	138.178	148.185	146.189	143.178	146.184	153.228	154.216	149.185	152.188	134.186	130.186				
6	18.727	24.473	25.79	21.67	24.47	25.79	18.706	21.441	23.518	22.71	23.41	18.81	28.549	21.58	21.57	20.76	39.5	31.79	68.90	39.74	25.79	39.75	25.53	17.117	17.117	17.117		
6	122.157	141.152	101.139	95.121	80.118	102.134	130.155	111.156	118.146	103.132	116.149	114.147	71.102	84.112	108.140	107.157	123.153	101.134	94.129	103.138	103.138	103.138	103.138	103.138	103.138	103.138		
8	21.6281	21.4777	23.55 79	21.58	24.46	28.79	21.59	17.45	23.54	17.45	23.54	18.81	20.41	11.34	13.65	20.68	25.45	23.52	23.61	17.45	23.80	17.45	27.47	17.45	17.45	17.45		
8	107.131	97.120	102.126	83.108	73.96	106.125	88.108	73.103	82.110	76.2	76.94	55.99	64.82	78.104	87.116	81.103	83.108	73.94	82.100	82.102	73.94	61.85	73.94	11.133	11.133	11.133		
8	153.178	145.169	149.175	128.153	121.149	149.173	128.158	133.152	130.154	100.114	126.150	134.156	105.140	117.144	124.160	141.168	118.151	134.178	123.154	124.144	114.132	114.132	114.132	114.132	114.132	114.132		
Image6	198	196	199	196	195	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	196	
22.59	21.46	23.40	22.49	23.40	22.55	23.40	22.44	8.21	13.23	6.76	6.76	46.44	80.84	47.76	36.75	64.84	62.89	74.98	57.80	69.71	57.80	82.106	69.92	50.83	69.92	50.83		
76.102	70.94	59.87	74.95	71.91	61.90	80.102	70.94	61.82	43.83	51.73	46.64	80.84	47.76	36.75	64.84	62.89	74.98	57.80	69.71	57.80	82.106	69.92	50.83	69.92	50.83			
12	121.140	117.141	101.125	134.154	108.133	121.142	118.141	106.130	103.119	91.111	100.112	96.121	106.124	106.133	108.135	119.138	107.121	105.130	121.145	115.138	106.130	106.130	106.130	106.130	106.130	106.130		
10	160.180	154.176	146.177	178.199	154.177	164.181	154.177	160.180	156.180	156.180	156.180	157.199	145.163	157.199	157.199	157.199	157.199	157.199	157.199	157.199	157.199	157.199	157.199	157.199	157.199	157.199	157.199	
20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242	20.242			
21.39.56	19.33.52	21.50.69	19.35.53	22.32.53	17.36.52	22.42.62	13.24.43	8.12.23	6.22.76	80.105	91.115	62.94	66.73	72.92	64.84	52.22	33.22	22.53	13.30.45	18.34.55	21.33.42	18.34.55	21.33.42	18.34.55	21.33.42	18.34.55	21.33.42	
78.102	71.88	82.97	89.109	69.88	82.96	74.94	73.93	82.101	82.101	82.101	82.101	82.101	82.101	82.101	82.101	82.101	82.101	82.101	82.101	82.101	82.101	82.101	82.101	82.101	82.101			
112.132	106.127	116.134	128.149	109.127	114.133	112.142	121.140	121.140	163.169	107.117	119.142	124.154	108.187	108.187	108.187	108.187	108.187	108.187	108.187	108.187	108.187	108.187	108.187	108.187	108.187	108.187		
147.161	145.163	153.169	159.163	145.163	145.163	145.163	145.163	145.163	145.163	145.163	145.163	145.163	145.163	145.163	145.163	145.163	145.163	145.163	145.163	145.163	145.163	145.163	145.163	145.163	145.163			
181.232	180.232	180.232	180.232	180.232	180.232	180.232	180.232	180.232	180.232	180.232	180.232	180.232	180.232	180.232	180.232	180.232	180.232	180.232	180.232	180.232	180.232	180.232	180.232	180.232				
240	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225		
4	64.110	74.108	61.107	61.105	70.108	57.107	61.100	70.104	57.109	61.105	80.100	54.106	67.116	65.109	62.108	65.110	75.106	53.107	60.104	65.116	74.108	57.109	60.104	74.108	57.109	60.104		
4	149.207	154.183	153.174	148.207	154.188	143.173	149.207	154.188	153.204	164.190	148.207	154.170	151.207	150.206	161.188	144.175	150.207	149.207	154.188	153.207	149.207	154.188	153.207	149.207	154.188	153.207		
55.92	48.66	51.85	47.92	55.94	47.92	48.71	44.85	46.69	38.67	54.97	44.77	50.84	46.83	46.69	59.94	56.86	51.94	44.75	47.96	51.94	56.86	51.94	44.75	47.96	51.94	56.86	51.94	
6	130.145	103.132	158.155	158.152	160.152	103.133	103.133	94.117	103.133	103.133	103.133	103.133	103.133	103.133	103.133	103.133	103.133	103.133	103.133	103.133	103.133	103.133	103.133	103.133	103.133	103.133		
200.235	158.193	155.190	105.233	162.190	160.187	202.233	158.193	161.187	192.234	151.181	159.195	205.233	159.199	201.233	163.198	158.199	202.233	158.199	160.187	205.233	158.199	202.233	158.199	160.187	205.233	158.199	202.233	
41.67	36.62	44.65	40.76	36.59	44.71	41.69	34.61	44.66	43.57	9.35	32.56	39.57	40.58	36.54	34.56	36.54	35.57	35.55	40.66	44.71	44.65	40.66	44.71	44.65	40.66	44.71	44.65	
96.125	86.111	89.109	93.123	92.107	89.109	97.124	85.108	81.102	87.124	76.104	92.127	85.108	81.102	87.124	85.108	81.102	87.124	85.108	92.127	85.108	92.127	85.108	92.127	85.108	92.127	85.108		
145.166	138.154	130.157	148.170	139.153	148.170	139.153	148.170	148.170	148.170	148.170	148.170	148.170	148.170	148.170	148.170	148.170	148.170	148.170	148.170	148.170	148.170	148.170	148.170	148.170	148.170	148.170		
200.232	170.193	170.193	170.193	170.193	170.193	170.193	170.193	170.193	170.193	170.193	170.193	170.193	170.193	170.193	170.193	170.193	170.193	170.193	170.193	170.193	170.193	170.193	170.193	170.193	170.193			
237	223	219	237	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226	
4	56.109	52.101	56.109	63.113	52.101	52.101	52.101	52.101	52.101	63.113	52.101	52.101	52.101	52.101	52.101	52.101	52.101	52.101	52.101	52.101	52.101	52.101	52.101	52.101	52.101	52.101		
6	163.217	162.197	162.197	167.214	152.197	163.217	162.205	162.205	171.215	162.205	171.215	162.205	171.215	171.215	162.205	162.205	171.215	162.205	162.205	171.215	162.205	162.205	171.215	162.205	162.205	171.215	162.205	
36.56	37.66	27.57	18.64	27.57	18.64	27.57	18.64	27.57	18.64	27.57	18.64	27.57	18.64	27.57	18.64	27.57	18.64	27.57	18.64	27.57	18.64	27.57	18.64	27.57	18.64	27.57	18.64	
6	175.216	174.217	174.217	174.217	174.217	174.217	174.217	174.217	174.217	174.217	174.217	174.217	174.217	174.217	174.217	174.217	174.217	174.217	174.217	174.217	174.217	174.217	174.217	174.217	174.217	174.217		
35.58	29.58	34.57	34.57	34.57	34.57	34.57	34.57	34.57	34.57	34.57	34.57	34.57	34.57	34.57	34.57	34.57	34.57	34.57	34.57	34.57	34.57	34.57	34.57	34.57	34.57	34.57		
12	77.96	84.104	78.96	68.90	75.94	75.95	75.95	75.95	75.95	75.95	75.95	75.95	75.95	75.95	75.95	75.95	75.95	75.95	75.95	75.95	75.95	75.95	75.95	75.95	75.95	75.95	75.95	
12	114.134	123.144	111.134	113.134	121.143	122.145	107.141	123.145	124.145	103.134	124.145	124.145	118.141	103.139	118.141	117.139	103.139	118.141	117.139	103.139	118.141	117.139	103.139	118.141	117.139	103.139	118.141	117.139
10	155.179	178.194	170.194	166.188	158.194	179.194	170.194	170.194	170.194	170.194	170.194	170.194	170.194	170.194	170.194	170.194	170.194	170.194	170.194	170.194	170.194	170.194	170.194	170.194	170.194	170.194	170.194	
204.230	214.236	216.239	205.230	205.230	213.236	214.236	207.230	213.236	213.236	208.230	213.236	213.236	209.230	213.236	213.236	208.230	213.236	213.236	208.230	213.236	213.236	208.230	213.236	213.236	208.230	213.236		
20.63	20.63	27.44	27.44	27.44	27.44	27.44	27.44	27.44	27.44	27.44	27.44	27.44	27.44	27.44	27.44	27.44	27.44	27.44	27.44	27.44	27.44	27.44	27.44	27.44	27.44	27.44		
12	119.139	98.117	109.133	92.121	109.133	92.121	88.110	90.109	90.109	112.126	88.110	90.109	90.109	79.94	80.94	80.94	79.94	80.94	80.94	79.94	80.94	80.94	79.94	80.9				

TABLE III  
THE PSNR VALUES OF OTSU'S METHOD IN COMPARISON WITH OTHER ALGORITHMS

Images	K	HHO-DE	HHO	DE	SCA	BA	HSO	PSO	DA
Image1	4	<b>19.7023</b>	<b>19.7023</b>	19.6940	19.6186	19.6601	19.5234	19.600	<b>19.7023</b>
	6	<b>21.6626</b>	21.6246	21.6412	21.6041	21.4816	21.4611	21.655	21.6606
	8	<b>23.5771</b>	23.5228	23.4781	23.2054	22.6285	23.2486	23.1208	23.1839
	10	<b>25.4548</b>	24.5071	25.3511	25.148	24.5879	25.4305	25.1624	25.2335
	12	<b>28.2219</b>	28.1571	28.0950	27.8617	27.9112	27.0671	26.9885	28.0731
Image2	4	<b>19.7517</b>	19.7514	19.7442	19.3290	19.2107	19.4322	19.5352	19.6017
	6	<b>23.1749</b>	23.1720	23.0066	22.5877	22.885	23.0804	22.9732	23.0052
	8	<b>26.2381</b>	26.2367	26.1873	24.1305	24.8595	25.9982	24.9794	25.9845
	10	<b>28.3581</b>	28.3098	28.4927	27.879	27.7862	28.0375	28.2119	28.2902
	12	<b>29.9265</b>	29.9220	29.8646	28.5135	29.7677	29.0032	29.8094	29.7802
Image3	4	<b>17.7278</b>	17.7244	17.7236	17.2833	17.4849	17.2554	17.2685	17.4278
	6	<b>20.0423</b>	<b>20.0423</b>	19.9450	19.9086	20.0239	19.8524	19.9476	20.0389
	8	<b>22.8814</b>	22.8759	22.0185	20.946	21.3404	21.5033	20.9691	21.3036
	10	<b>24.3542</b>	23.9542	24.0621	23.9914	23.7254	23.9112	24.054	23.9133
	12	<b>28.4237</b>	27.5077	28.1496	27.493	25.6114	27.4125	26.4214	26.4174
Image4	4	17.9432	<b>17.9433</b>	17.9409	17.8483	17.8859	17.9023	17.8881	17.9079
	6	<b>21.2477</b>	20.9517	21.1251	20.2104	20.6978	20.3277	20.8772	20.9412
	8	<b>23.2950</b>	23.1801	23.2725	23.0061	22.9611	22.2352	22.690	23.1969
	10	<b>25.0240</b>	24.8096	24.3782	24.6716	24.7947	24.3622	24.6908	24.9032
	12	<b>28.6126</b>	28.5925	26.6398	27.0034	27.5504	28.1566	28.0143	28.4995
Image5	4	19.6629	19.5959	<b>19.7049</b>	19.4531	19.4549	19.413	19.6629	19.0959
	6	<b>23.2550</b>	23.0100	23.2046	23.0648	22.8631	22.9148	22.5352	23.1646
	8	<b>25.5514</b>	25.4696	25.1502	25.0543	25.0796	25.1999	25.0672	25.1607
	10	<b>27.2532</b>	27.2531	27.1841	27.1081	26.3639	27.0202	26.3669	27.0939
	12	<b>29.1500</b>	29.0604	29.1075	29.0485	28.9539	28.930	29.0715	28.8226
Image6	4	<b>17.6124</b>	<b>17.6124</b>	17.6121	17.5095	17.6014	17.5674	17.5529	17.6073
	6	<b>20.0731</b>	20.0452	20.0432	20.0384	20.3344	19.8205	20.0042	20.0533
	8	<b>22.3480</b>	22.2090	22.1008	20.7311	22.0532	22.2023	22.1837	22.1185
	10	<b>23.1033</b>	23.0943	23.0578	23.0746	22.6797	22.8543	22.5185	23.1005
	12	<b>27.9267</b>	27.7509	27.0845	26.5071	27.6791	27.5150	25.7584	27.6188
Image7	4	<b>22.6041</b>	<b>22.6041</b>	22.5985	21.0068	22.5522	22.5035	<b>22.6041</b>	<b>22.6041</b>
	6	<b>26.8735</b>	26.8712	26.7390	26.1711	26.7124	26.2978	26.6470	26.8390
	8	<b>29.3691</b>	29.3175	28.9929	28.3229	28.5833	28.8777	28.6740	29.1171
	10	<b>31.2570</b>	31.2489	31.0841	30.2852	30.3874	31.1641	31.1287	31.0865
	12	<b>32.7944</b>	32.7351	32.3693	31.6261	32.6245	32.5151	32.1022	32.4041
Image8	4	<b>19.0308</b>	19.0308	19.1145	18.2423	18.9016	18.7453	19.0687	<b>19.0308</b>
	6	<b>23.7089</b>	23.7000	23.6203	21.9332	23.4253	23.4808	23.1339	23.6484
	8	<b>26.1404</b>	25.9311	26.1102	26.0393	26.0740	26.0072	26.0598	26.0459
	10	<b>28.9245</b>	28.3600	28.8105	28.6474	28.6423	27.9611	27.9448	28.4189
	12	<b>30.9748</b>	30.6762	30.6355	30.0041	30.0288	30.1992	30.1137	30.6728
Image9	4	<b>16.1589</b>	<b>16.1589</b>	16.0279	16.0452	16.1196	16.1086	15.7157	16.1500
	6	<b>24.8867</b>	24.8386	24.7738	23.6091	23.2611	24.5150	24.7850	24.8517
	8	<b>27.3076</b>	27.3040	27.1038	27.0926	27.2667	26.9405	27.1768	27.2208
	10	<b>29.8408</b>	29.6025	29.7439	29.5151	29.1262	29.3505	29.6393	29.7638
	12	<b>31.7353</b>	31.5312	31.4834	31.0397	30.7308	31.4442	31.1156	31.1255
Image10	4	<b>18.8019</b>	<b>18.8019</b>	<b>18.8019</b>	18.1855	18.7900	18.7978	<b>18.8019</b>	<b>18.8019</b>
	6	<b>21.5348</b>	21.2234	21.5269	21.0419	21.0981	21.4096	21.1786	21.4356
	8	<b>24.2839</b>	24.0639	24.2233	24.1608	23.8714	24.1568	24.1766	24.1436
	10	<b>28.8074</b>	28.0157	27.3524	26.2830	25.7814	28.0073	28.2898	28.3114
	12	<b>30.6910</b>	29.2541	29.9172	30.5896	27.5040	29.9098	30.3456	29.2884

TABLE IV  
THE PSNR VALUES OF KAPUR'S METHOD IN COMPARISON WITH OTHER ALGORITHMS

Images	K	HHO-DE	HHO	DE	SCA	BA	HSO	PSO	DA
Image1	4	<b>19.3706</b>	<b>19.3706</b>	19.3700	19.3606	19.2689	19.3444	19.3506	19.3656
	6	<b>24.3936</b>	23.9011	23.9305	23.3457	23.3029	23.4661	23.8193	23.8085
	8	<b>26.6260</b>	25.9639	26.4733	25.6860	26.0663	26.3664	26.4632	26.3995
	10	<b>29.7426</b>	29.5440	29.5649	27.7523	28.2441	29.2968	27.3546	29.5593
	12	<b>31.1616</b>	31.0088	31.0022	29.0523	30.4961	30.4026	30.5617	30.5130
	4	<b>20.7439</b>	<b>20.7439</b>	<b>20.7439</b>	20.5676	20.6287	20.7049	20.7039	20.7057
Image2	6	<b>24.6209</b>	24.6009	24.6062	23.4359	24.5080	24.0609	24.6003	24.6151
	8	<b>27.1959</b>	27.1657	27.1534	25.6847	26.9416	26.9123	26.9355	26.0753
	10	<b>29.3308</b>	29.2172	29.2113	28.9242	28.2416	28.4495	28.2014	28.9932
	12	<b>30.8536</b>	30.8182	30.7659	30.8369	30.7237	30.7580	30.0524	30.4342
	4	<b>15.9046</b>	15.9040	15.8519	15.2550	15.0207	15.6000	15.8046	15.8500
	6	<b>20.3591</b>	20.0773	19.2738	19.2672	19.0172	18.8515	19.3511	19.3237
Image3	8	<b>24.5773</b>	24.4041	24.4314	23.9021	23.6011	23.7920	21.0652	23.3676
	10	<b>29.5296</b>	29.4947	29.3920	28.1633	28.0198	28.7127	26.5681	28.2481
	12	<b>30.9546</b>	30.8624	30.8215	30.1170	29.9916	29.3663	30.2453	30.2954
	4	<b>17.5402</b>	<b>17.5402</b>	17.5400	17.4082	17.4320	17.5064	17.5388	17.5394
	6	<b>21.1477</b>	21.0435	21.0962	21.0111	21.0027	21.0224	20.9463	20.8622
	8	<b>25.9766</b>	25.8477	25.7344	23.2311	23.2877	23.5594	24.5741	24.8057
Image4	10	<b>28.0821</b>	27.6820	27.7420	27.2996	27.4253	27.3368	27.3663	27.3158
	12	<b>29.1372</b>	29.1039	28.8094	29.0050	29.0546	29.1017	29.1172	29.1068
	4	19.5452	<b>19.5459</b>	<b>19.5459</b>	19.5360	19.9356	19.5399	19.5450	19.5456
	6	<b>23.2941</b>	22.2389	23.2225	23.2746	22.6859	23.2530	22.3092	23.2897
	8	<b>26.6132</b>	26.4937	26.3270	26.3282	25.7686	26.2365	25.8872	26.1589
	10	<b>30.3673</b>	30.2583	29.0095	28.8923	28.8778	28.7056	28.6461	29.8632
Image5	12	<b>32.1688</b>	31.6811	31.5644	30.2346	30.6683	30.7299	30.9139	31.6018
	4	<b>17.2846</b>	16.8260	16.8683	16.6168	16.7257	16.7675	16.8260	16.8489
	6	<b>20.2269</b>	20.2211	20.2206	20.1743	20.0438	20.1912	20.1545	20.1816
	8	<b>23.9792</b>	23.6382	23.1812	22.0356	22.2289	21.8975	22.0176	23.2377
	10	<b>31.8924</b>	31.4407	31.5284	30.8992	28.7958	28.4691	29.2129	31.5374
	12	<b>33.3567</b>	33.1239	33.3035	32.0754	31.9291	32.6908	31.6748	33.0399
Image6	4	<b>24.7273</b>	24.6929	24.6929	24.3200	24.6927	24.6898	<b>24.7273</b>	24.7091
	6	<b>27.6527</b>	27.4289	27.5417	27.5812	27.5852	27.4064	27.2110	27.5302
	8	<b>29.7186</b>	29.6372	29.6410	28.2435	28.9485	28.9561	29.3904	29.6960
	10	<b>31.0918</b>	30.7996	31.0180	30.2937	31.0040	31.0380	30.9399	31.0900
	12	<b>33.4240</b>	33.3353	33.4086	31.9212	32.4009	32.7118	33.2318	33.3785
	4	20.2196	20.2196	20.2196	<b>20.3080</b>	20.1754	20.2645	20.2196	20.2191
Image7	6	<b>24.7134</b>	24.3793	21.9330	24.2960	21.1669	23.5099	23.5911	24.6674
	8	<b>26.5956</b>	26.0375	25.4401	26.1147	23.5097	26.5184	26.3255	25.4206
	10	<b>31.7758</b>	30.7833	31.6567	31.5216	26.7111	31.5584	29.4051	29.0713
	12	<b>33.1388</b>	32.6569	32.4698	31.9731	30.5251	32.5467	32.4053	32.9759
	4	<b>22.3120</b>	<b>22.2446</b>	22.2320	21.1790	22.1493	21.3051	22.0617	22.2617
	6	<b>27.3687</b>	27.3048	27.3648	27.1444	27.1147	27.1742	27.3539	27.3395
Image9	8	<b>29.4775</b>	29.2409	29.3223	28.7359	28.5331	28.8674	29.3173	29.3714
	10	<b>31.2534</b>	31.0285	31.2054	29.7678	30.2524	31.1180	31.1991	30.8327
	12	<b>32.8598</b>	32.7262	32.1705	31.9254	31.5102	32.1126	32.7184	32.5685
	4	<b>21.7069</b>	18.3363	21.7000	21.6648	21.6833	21.6365	21.6306	21.6309
	6	<b>26.8226</b>	24.5332	25.1409	25.1897	26.4652	25.0046	24.9043	26.8089
	8	<b>28.6293</b>	28.4547	28.4584	27.8292	27.8992	28.3605	28.4916	28.6187
Image10	10	<b>30.2817</b>	30.0178	30.1158	30.0756	29.2094	30.0187	30.0447	29.9066
	12	<b>32.7680</b>	32.6802	31.9596	31.2011	31.3658	32.1406	32.3051	31.8059

TABLE V  
THE SSIM VALUES OF OTSU'S METHOD IN COMPARISON WITH OTHER ALGORITHMS

Images	K	HHO-DE	HHO	DE	SCA	BA	HSO	PSO	DA
Image1	4	<b>0.7231</b>	0.7221	0.7218	0.7203	0.7211	0.7223	0.7230	0.7230
	6	<b>0.8059</b>	0.8058	0.8039	0.8004	0.7948	0.7997	0.8044	0.8058
	8	<b>0.8465</b>	0.8452	0.8309	0.8394	0.8255	0.8416	0.8349	0.8463
	10	<b>0.8903</b>	0.8740	0.8530	0.8753	0.8769	0.8667	0.8664	0.8758
	12	<b>0.9019</b>	0.9016	0.8933	0.8854	0.8896	0.8898	0.8904	0.8912
	4	<b>0.6655</b>	<b>0.6655</b>	0.6638	0.6606	0.6629	0.6627	0.6667	0.6643
Image2	6	0.7750	<b>0.7753</b>	0.7677	0.7428	0.7673	0.7557	0.7753	0.7749
	8	<b>0.8385</b>	0.8378	0.8297	0.8319	0.8360	0.8354	0.8350	0.8354
	10	<b>0.8787</b>	0.8776	0.8709	0.8717	0.8578	0.8699	0.8785	0.8780
	12	<b>0.9047</b>	0.9030	0.9018	0.9005	0.8817	0.8979	0.8775	0.9004
	4	<b>0.6178</b>	0.6108	0.6145	0.6034	0.6160	0.6162	0.6166	0.6165
	6	<b>0.7287</b>	0.7280	0.7214	0.7249	0.7256	0.7225	0.7231	0.7283
Image3	8	<b>0.8214</b>	0.8019	0.8010	0.8006	0.7829	0.7927	0.7959	0.8105
	10	<b>0.8597</b>	0.8539	0.8588	0.8492	0.8332	0.8326	0.8459	0.8469
	12	<b>0.9006</b>	0.8956	0.9000	0.8838	0.8768	0.8835	0.8718	0.8856
	4	<b>0.6450</b>	0.6442	0.6437	0.6370	0.6441	0.6441	<b>0.6450</b>	0.6448
	6	<b>0.7861</b>	0.7700	0.7794	0.7577	0.7606	0.7680	0.7678	0.7800
	8	<b>0.8397</b>	0.8375	0.8389	0.8339	0.8321	0.8117	0.8246	0.8382
Image4	10	<b>0.8790</b>	0.8768	0.8677	0.8701	0.8673	0.8644	0.8760	0.8767
	12	<b>0.9217</b>	0.9148	0.9022	0.9037	0.9024	0.9014	0.9116	0.9123
	4	<b>0.6726</b>	0.6557	0.6516	0.6517	0.6473	0.6479	0.6757	0.6712
	6	<b>0.7575</b>	<b>0.7575</b>	0.7546	0.7561	0.7549	0.7539	0.7510	0.7573
	8	<b>0.8311</b>	0.8300	0.8100	0.8295	0.8055	0.8174	0.8177	0.8300
	10	<b>0.8650</b>	0.8646	0.8562	0.8536	0.8386	0.8419	0.8434	0.8596
Image5	12	<b>0.8894</b>	0.8857	0.8833	0.8755	0.8725	0.8777	0.8705	0.8791
	4	<b>0.5909</b>	<b>0.5909</b>	0.5900	0.5767	0.5896	0.5881	0.5906	0.5904
	6	<b>0.7050</b>	0.7037	0.7001	0.6964	0.6980	0.6977	0.7000	0.7030
	8	<b>0.8085</b>	0.8000	0.7894	0.7761	0.7806	0.7814	0.7901	0.7896
	10	<b>0.8296</b>	0.8288	0.8257	0.8185	0.8235	0.8166	0.8213	0.8235
	12	<b>0.8668</b>	0.8497	0.8586	0.8479	0.8437	0.8631	0.8423	0.8638
Image6	4	<b>0.7378</b>	0.7367	0.7377	0.7253	0.7281	0.7237	0.7348	0.7359
	6	<b>0.8747</b>	0.8721	0.8744	0.8171	0.8709	0.8725	0.8729	0.8736
	8	<b>0.9249</b>	0.9235	0.9189	0.8790	0.8985	0.8960	0.9172	0.9232
	10	<b>0.9495</b>	0.9493	0.9441	0.9226	0.9112	0.9305	0.9333	0.9439
	12	<b>0.9642</b>	0.9620	0.9617	0.9489	0.9490	0.9499	0.9466	0.9591
	4	<b>0.5291</b>	<b>0.5291</b>	0.5288	0.5274	0.5155	0.5090	0.5186	0.5216
Image8	6	<b>0.7101</b>	0.7021	0.6756	0.6118	0.6810	0.6550	0.6518	0.7078
	8	<b>0.7928</b>	0.7721	0.7632	0.7422	0.7613	0.7696	0.7591	0.7915
	10	<b>0.8469</b>	0.8450	0.8455	0.8454	0.8382	0.8146	0.8048	0.8661
	12	<b>0.8855</b>	0.8814	0.8849	0.8810	0.8811	0.8694	0.8533	0.8801
	4	<b>0.6001</b>	<b>0.6001</b>	0.6000	0.5929	0.5990	0.6000	0.5980	0.5933
	6	<b>0.8444</b>	0.8440	0.8435	0.7698	0.8248	0.8309	0.8426	0.8428
Image9	8	<b>0.8977</b>	0.8959	0.8844	0.8574	0.8849	0.8965	0.8904	0.8918
	10	<b>0.9281</b>	0.9259	0.9237	0.9159	0.9079	0.9261	0.9202	0.9208
	12	<b>0.9450</b>	0.9445	0.9442	0.9402	0.9331	0.9404	0.9412	0.9429
	4	<b>0.6217</b>	<b>0.6217</b>	<b>0.6217</b>	0.6065	0.6211	0.6199	<b>0.6217</b>	<b>0.6217</b>
	6	<b>0.7193</b>	0.7145	0.7172	0.7106	0.7189	0.7132	0.6861	0.7155
	8	<b>0.7617</b>	0.7510	0.7577	0.7357	0.7334	0.7531	0.7567	0.7524
Image10	10	<b>0.8366</b>	0.8207	0.8059	0.8003	0.8036	0.8342	0.8232	0.7926
	12	<b>0.8657</b>	0.8468	0.8520	0.8575	0.8566	0.8574	0.8438	0.8429

TABLE VI  
THE SSIM VALUES OF KAPUR'S METHOD IN COMPARISON WITH OTHER ALGORITHMS

Images	K	HHO-DE	HHO	DE	SCA	BA	HSO	PSO	DA
Image1	4	<b>0.6847</b>	0.6826	0.6830	0.6809	0.6800	0.6836	0.6813	0.6822
	6	<b>0.7846</b>	0.7819	0.7823	0.7745	0.7705	0.7801	0.7802	0.7812
	8	<b>0.8562</b>	0.8357	0.8504	0.8400	0.8427	0.8474	0.8349	0.8523
	10	<b>0.8924</b>	0.8895	0.8907	0.8783	0.8834	0.8913	0.8702	0.8914
	12	<b>0.9147</b>	0.9133	0.9138	0.8932	0.9008	0.9075	0.9066	0.9059
Image2	4	<b>0.6286</b>	<b>0.6286</b>	<b>0.6286</b>	0.6162	0.6233	0.6250	0.6266	0.6268
	6	<b>0.7657</b>	0.7598	0.7585	0.7440	0.7610	0.7621	0.7646	0.7650
	8	<b>0.8341</b>	0.8327	0.8327	0.8241	0.8269	0.8289	0.8226	0.8212
	10	<b>0.8784</b>	0.8762	0.8717	0.8641	0.8645	0.8645	0.8661	0.8652
	12	<b>0.9041</b>	0.9030	0.9013	0.8978	0.8906	0.8998	0.9026	0.9013
Image3	4	<b>0.5063</b>	0.5022	0.5044	0.5008	0.5015	0.4963	0.5013	0.5026
	6	<b>0.7107</b>	0.7041	0.6980	0.6859	0.6643	0.6730	0.6607	0.6968
	8	<b>0.8134</b>	0.8051	0.8108	0.7972	0.7891	0.7917	0.7347	0.8000
	10	<b>0.8756</b>	0.8755	0.8722	0.8551	0.8522	0.8684	0.8700	0.8646
	12	<b>0.9015</b>	0.9005	0.9002	0.8725	0.8861	0.8858	0.8895	0.8968
Image4	4	<b>0.5896</b>	0.5890	<b>0.5896</b>	0.5852	0.5880	0.5806	0.5884	0.5894
	6	<b>0.7412</b>	0.7377	0.7352	0.7316	0.7279	0.7289	0.7330	0.7303
	8	<b>0.8476</b>	0.8498	0.8438	0.8142	0.8079	0.8189	0.8202	0.8307
	10	<b>0.9005</b>	0.8970	0.8898	0.8744	0.8798	0.8806	0.8827	0.8928
	12	<b>0.9131</b>	0.9120	0.9089	0.8963	0.9074	0.8906	0.8965	0.9005
Image5	4	<b>0.6034</b>	0.6006	0.6012	0.5992	0.6012	0.6001	<b>0.6034</b>	0.6032
	6	<b>0.7481</b>	0.7133	0.7450	0.7390	0.7271	0.7473	0.7159	0.7479
	8	<b>0.8306</b>	0.8299	0.8255	0.8040	0.8247	0.8247	0.8088	0.8235
	10	<b>0.8878</b>	0.8849	0.8551	0.8512	0.8428	0.8529	0.8485	0.8515
	12	<b>0.9075</b>	0.9025	0.9013	0.8708	0.8719	0.8710	0.8729	0.8998
Image6	4	<b>0.6764</b>	0.6438	0.6457	0.6312	0.6446	0.6421	0.6464	0.6476
	6	<b>0.7309</b>	<b>0.7309</b>	0.7234	0.7215	0.7247	0.7268	0.7163	0.7232
	8	<b>0.7994</b>	0.7943	0.7905	0.7843	0.7848	0.7917	0.7976	0.7951
	10	<b>0.8764</b>	0.8745	0.8743	0.8750	0.8457	0.8561	0.8492	0.8748
	12	<b>0.8994</b>	0.8983	0.8982	0.8880	0.8718	0.8944	0.8834	0.8942
Image7	4	<b>0.6541</b>	0.6505	0.6505	0.6537	0.6527	0.6528	<b>0.6541</b>	0.6531
	6	0.7639	0.7585	0.7614	0.7579	0.7634	0.7622	0.7438	<b>0.7643</b>
	8	<b>0.8250</b>	0.8240	0.8229	0.7784	0.7876	0.7859	0.8145	0.8165
	10	<b>0.8742</b>	0.8638	0.8632	0.8167	0.8433	0.8504	0.8700	0.8734
	12	<b>0.8968</b>	0.8948	0.8904	0.8512	0.8881	0.8808	0.8929	0.8936
Image8	4	<b>0.4632</b>	<b>0.4632</b>	<b>0.4632</b>	0.4627	0.4622	0.4606	<b>0.4632</b>	0.4630
	6	<b>0.6418</b>	0.6413	0.6350	0.6079	0.6258	0.6262	0.5814	0.5940
	8	<b>0.7199</b>	0.6998	0.6990	0.7001	0.7036	0.6996	0.6720	0.7084
	10	<b>0.8465</b>	0.8413	0.8406	0.8424	0.7751	0.8433	0.8074	0.7713
	12	<b>0.8885</b>	0.8759	0.8776	0.8814	0.8580	0.8804	0.8760	0.8832
Image9	4	<b>0.7084</b>	<b>0.7033</b>	0.7034	0.6656	0.7040	0.6740	0.7039	0.7069
	6	<b>0.8012</b>	0.7782	0.8002	0.7893	0.7963	0.8000	0.8004	0.8004
	8	<b>0.8573</b>	0.8437	0.8481	0.8056	0.8059	0.8392	0.8487	0.8520
	10	<b>0.8855</b>	0.8780	0.8815	0.8569	0.8790	0.8843	0.8796	0.8798
	12	<b>0.9133</b>	0.9112	0.9102	0.9063	0.9070	0.8999	0.9097	0.9072
Image10	4	0.7629	0.7493	0.7639	0.7595	<b>0.7637</b>	0.7606	0.7499	0.7633
	6	<b>0.7834</b>	0.7783	0.7796	0.7757	0.7796	0.7746	0.7793	0.7815
	8	<b>0.8068</b>	0.8043	0.8067	0.7991	0.8066	0.8038	0.8058	0.8043
	10	<b>0.8234</b>	0.8115	0.8111	0.8088	0.8104	0.8140	0.8135	0.8193
	12	<b>0.8733</b>	0.8661	0.8695	0.8660	0.8609	0.8678	0.8671	0.8605

TABLE VII  
THE FSIM VALUES OF OTSU'S METHOD IN COMPARISON WITH OTHER ALGORITHMS

Images	K	HHO-DE	HHO	DE	SCA	BA	HSO	PSO	DA
Image1	4	<b>0.7988</b>	0.7983	0.7976	0.7977	0.7987	0.7984	0.7983	<b>0.7988</b>
	6	<b>0.8694</b>	0.8693	0.8690	0.8598	0.8638	0.8665	0.8680	0.8684
	8	<b>0.9029</b>	0.9018	0.8792	0.8821	0.8878	0.8997	0.8940	0.9015
	10	<b>0.9270</b>	0.9217	0.9170	0.9089	0.9191	0.8988	0.9186	0.9213
	12	<b>0.9341</b>	0.9339	0.9312	0.9179	0.9224	0.9306	0.9224	0.9321
	4	0.7572	<b>0.7574</b>	0.7573	0.7535	0.7562	0.7567	0.7568	0.7570
Image2	6	<b>0.8340</b>	0.8334	0.8314	0.8212	0.8289	0.8329	0.8331	0.8327
	8	<b>0.8829</b>	0.8825	0.8814	0.8568	0.8661	0.8792	0.8800	0.8809
	10	<b>0.9138</b>	0.9131	0.9129	0.8933	0.8989	0.9100	0.9108	0.9121
	12	<b>0.9346</b>	0.9316	0.9307	0.9163	0.9108	0.9300	0.9324	0.9331
	4	<b>0.7567</b>	0.7559	0.7552	0.7514	0.7564	0.7566	0.7563	0.7563
	6	<b>0.8163</b>	0.8121	0.8116	0.8143	0.8140	0.8143	0.8151	0.8160
Image3	8	<b>0.8739</b>	0.8603	0.8599	0.8516	0.8484	0.8571	0.8560	0.8599
	10	<b>0.8911</b>	0.8895	0.8903	0.8888	0.8671	0.8850	0.8897	0.8899
	12	<b>0.9228</b>	0.9155	0.9207	0.9156	0.8990	0.9203	0.8986	0.9028
	4	<b>0.7512</b>	<b>0.7512</b>	0.7500	0.7484	0.7503	0.7510	<b>0.7512</b>	0.7502
	6	<b>0.8399</b>	0.8376	0.8343	0.8166	0.8291	0.8320	0.8316	0.8310
	8	<b>0.8795</b>	0.8781	0.8783	0.8743	0.8749	0.8646	0.8711	0.8785
Image4	10	<b>0.9071</b>	0.9049	0.8995	0.9021	0.8945	0.8968	0.9004	0.9061
	12	<b>0.9386</b>	0.9319	0.9252	0.9247	0.9246	0.9171	0.9253	0.9277
	4	<b>0.7855</b>	0.7730	0.7721	0.7783	0.7708	0.7701	<b>0.7855</b>	0.7730
	6	<b>0.8418</b>	0.8400	0.8403	0.8372	0.8390	0.8412	0.8411	0.8401
	8	<b>0.8792</b>	0.8778	0.8751	0.8760	0.8694	0.8765	0.8761	0.8778
	10	<b>0.9063</b>	0.9062	0.9007	0.8953	0.8844	0.8921	0.8915	0.8954
Image5	12	<b>0.9226</b>	0.9218	0.9119	0.9200	0.9178	0.9193	0.9149	0.9140
	4	<b>0.7086</b>	<b>0.7086</b>	0.7086	0.7017	0.7073	0.7006	0.7027	0.7042
	6	<b>0.7947</b>	0.7943	0.7946	0.7910	0.7912	0.7931	0.7932	0.7942
	8	<b>0.8563</b>	0.8541	0.8513	0.8252	0.8319	0.8463	0.8527	0.8517
	10	<b>0.8801</b>	0.8799	0.8783	0.8486	0.8812	0.8704	0.8762	0.8789
	12	<b>0.8952</b>	0.8931	0.8937	0.8878	0.8916	0.8897	0.8947	0.8916
Image6	4	0.7979	0.7979	<b>0.7981</b>	0.7913	0.7967	0.7907	0.7979	0.7979
	6	<b>0.8961</b>	0.8932	0.8900	0.8615	0.8939	0.8885	0.8908	0.8944
	8	<b>0.9328</b>	0.9323	0.9307	0.9154	0.9239	0.9323	0.9323	0.9315
	10	<b>0.9522</b>	0.9513	0.9500	0.9381	0.9332	0.9490	0.9498	0.9511
	12	<b>0.9638</b>	0.9630	0.9606	0.9409	0.9512	0.9610	0.9618	0.9626
	4	<b>0.7503</b>	<b>0.7499</b>	0.7497	0.7313	0.7409	0.7437	0.7488	<b>0.7503</b>
Image8	6	<b>0.8485</b>	0.8432	0.8463	0.8231	0.8424	0.8478	0.8393	0.8474
	8	<b>0.8908</b>	0.8888	0.8888	0.8899	0.8860	0.8900	0.8905	0.8888
	10	<b>0.9211</b>	0.9160	0.9193	0.9208	0.9066	0.9087	0.9093	0.9150
	12	<b>0.9404</b>	0.9384	0.9400	0.9389	0.9322	0.9274	0.9309	0.9344
	4	<b>0.7203</b>	<b>0.7203</b>	0.7201	0.7165	0.7184	0.7172	0.7083	0.7200
	6	<b>0.8754</b>	0.8750	0.8739	0.8339	0.8551	0.8733	0.8743	0.8751
Image9	8	<b>0.9099</b>	0.9022	0.9043	0.9024	0.9070	0.9000	0.9005	0.9077
	10	<b>0.9307</b>	0.9301	0.9290	0.9286	0.9204	0.9294	0.9261	0.9274
	12	<b>0.9416</b>	0.9403	0.9390	0.9240	0.9339	0.9404	0.9406	0.9401
	4	<b>0.7943</b>	0.7920	0.7913	0.7929	0.7934	0.7929	0.7921	0.7933
	6	<b>0.8168</b>	0.8102	0.8126	0.8128	0.8024	0.8110	0.8101	0.8138
	8	<b>0.8460</b>	0.8431	0.8454	0.8362	0.8268	0.8417	0.8412	0.8423
Image10	10	<b>0.8782</b>	0.8671	0.8678	0.8591	0.8627	0.8722	0.8766	0.8662
	12	<b>0.8925</b>	0.8914	0.8827	0.8760	0.8717	0.8800	0.8878	0.8911

TABLE VIII  
THE FSIM VALUES OF KAPUR'S METHOD IN COMPARISON WITH OTHER ALGORITHMS

Images	K	HHO-DE	HHO	DE	SCA	BA	HSO	PSO	DA
Image1	4	<b>0.7726</b>	<b>0.7726</b>	0.7721	0.7701	0.7691	0.7699	0.7702	0.7720
	6	<b>0.8537</b>	0.8519	0.8529	0.8424	0.8429	0.8486	0.8517	0.8528
	8	<b>0.9024</b>	0.8914	0.9013	0.8837	0.8931	0.8948	0.8958	0.9003
	10	<b>0.9262</b>	0.9253	0.9237	0.9115	0.9024	0.9242	0.9181	0.9243
	12	<b>0.9425</b>	0.9420	0.9412	0.9285	0.9277	0.9392	0.9300	0.9334
Image2	4	<b>0.7443</b>	<b>0.7443</b>	<b>0.7443</b>	0.7392	0.7330	0.7329	0.7423	0.7437
	6	<b>0.8334</b>	0.8324	0.8332	0.8221	0.8324	0.8301	0.8311	0.8331
	8	<b>0.8846</b>	0.8840	0.8839	0.8695	0.8774	0.8806	0.8815	0.8820
	10	<b>0.9172</b>	0.9159	0.9148	0.8958	0.8963	0.9120	0.9113	0.9129
	12	<b>0.9368</b>	0.9364	0.9357	0.9238	0.9226	0.9320	0.9355	0.9363
Image3	4	<b>0.7359</b>	<b>0.7359</b>	0.7355	0.7332	0.7330	0.7319	0.7339	0.7349
	6	<b>0.8102</b>	0.8002	0.7890	0.7868	0.7956	0.7970	0.7939	0.7925
	8	<b>0.8651</b>	0.8553	0.8612	0.8549	0.8522	0.8550	0.8277	0.8539
	10	<b>0.9139</b>	0.9136	0.9122	0.8862	0.8994	0.8998	0.8968	0.9076
	12	<b>0.9363</b>	0.9340	0.9351	0.9037	0.9024	0.9240	0.9230	0.9339
Image4	4	<b>0.7243</b>	0.7240	0.7233	0.7210	0.7208	0.7217	0.7240	0.7241
	6	<b>0.8228</b>	0.8206	0.8194	0.8127	0.8133	0.8175	0.8178	0.8166
	8	<b>0.8928</b>	0.8917	0.8893	0.8724	0.8431	0.8738	0.8732	0.8737
	10	<b>0.9230</b>	0.9159	0.9224	0.9099	0.9068	0.9137	0.9178	0.9109
	12	<b>0.9389</b>	0.9380	0.9364	0.9264	0.9161	0.9264	0.9213	0.9273
Image5	4	0.7476	<b>0.7478</b>	0.7476	0.7473	0.7431	0.7468	0.7476	0.7474
	6	<b>0.8380</b>	0.8294	0.8368	0.8135	0.8340	0.8322	0.8302	0.8377
	8	<b>0.8839</b>	0.8836	0.8832	0.8673	0.8718	0.8791	0.8773	0.8773
	10	<b>0.9192</b>	0.9169	0.9015	0.8961	0.8920	0.8947	0.9000	0.9029
	12	<b>0.9375</b>	0.9284	0.9316	0.9102	0.9136	0.9217	0.9271	0.9264
Image6	4	<b>0.7143</b>	0.7123	0.7140	0.7075	0.7124	0.7124	0.7133	0.7140
	6	<b>0.7696</b>	0.7606	0.7594	0.7555	0.7530	0.7607	0.7662	0.7652
	8	<b>0.8350</b>	0.8266	0.8280	0.8250	0.8175	0.8178	0.8320	0.8251
	10	<b>0.9113</b>	0.9096	0.9095	0.8460	0.8742	0.8923	0.8805	0.9106
	12	<b>0.9342</b>	0.9313	0.9322	0.8630	0.9057	0.9273	0.9127	0.9284
Image7	4	<b>0.7347</b>	0.7305	0.7305	0.7326	0.7290	0.7299	0.7307	0.7329
	6	<b>0.8560</b>	0.8457	0.8486	0.8508	0.8514	0.8498	0.8331	0.8478
	8	<b>0.9041</b>	0.9035	0.9021	0.8706	0.8767	0.8820	0.8969	0.8995
	10	<b>0.9390</b>	0.9357	0.9350	0.9051	0.9203	0.9279	0.9374	0.9328
	12	<b>0.9556</b>	0.9550	0.9515	0.9222	0.9396	0.9471	0.9506	0.9514
Image8	4	<b>0.7982</b>	<b>0.7982</b>	<b>0.7982</b>	0.7971	0.7920	0.7960	0.7902	0.7979
	6	<b>0.8379</b>	0.8356	0.8255	0.8343	0.8277	0.8289	0.8222	0.8251
	8	<b>0.8640</b>	0.8611	0.8531	0.8575	0.8380	0.8615	0.8622	0.8525
	10	<b>0.9183</b>	0.9106	0.9169	0.9101	0.8581	0.9169	0.8962	0.8949
	12	<b>0.9336</b>	0.9275	0.9260	0.9295	0.9052	0.9278	0.9251	0.9314
Image9	4	<b>0.7789</b>	0.7720	0.7720	0.7387	0.7721	0.7430	0.7745	0.7745
	6	<b>0.8677</b>	0.8659	0.8629	0.8582	0.8618	0.8550	0.8564	0.8667
	8	<b>0.9175</b>	0.9068	0.9082	0.8725	0.8763	0.9018	0.9085	0.9099
	10	<b>0.9386</b>	0.9355	0.9373	0.8990	0.9164	0.9353	0.9322	0.9324
	12	<b>0.9548</b>	0.9536	0.9523	0.9115	0.9250	0.9455	0.9522	0.9521
Image10	4	<b>0.8066</b>	0.7956	0.8063	0.8001	0.8016	0.8018	0.7936	0.7994
	6	<b>0.8335</b>	0.8327	0.8329	0.8283	0.8287	0.8328	0.8302	0.8308
	8	<b>0.8508</b>	0.8507	0.8486	0.8462	0.8437	0.8486	0.8502	0.8537
	10	<b>0.8724</b>	0.8653	0.8713	0.8620	0.8545	0.8654	0.8720	0.8646
	12	<b>0.8924</b>	0.8905	0.8874	0.8724	0.8709	0.8799	0.8860	0.8800

